Scaling up Pathways for Climate-Smart Agriculture Technologies and Practices in Nepal

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EXECUTIVE SUMMARY

The document presents the policy provisions, opportunities and challenges for scaling up and implementation plan for champion climate-smart agriculture (CSA) technologies and practices in Nepal. This was achieved through applied qualitative method especially a combination of desk study, consultation and field observation/visit. **Desk study** was carried out by collecting the relevant documents and reviewed them. While reviewing the documents special attention was given to find out the policies pertinent to particular CSAs. For example, desk review of annual plans and budgets of the government for champion CSAs. **Consultation** with experts from government officers, especially District Agriculture Development Office (DADO) Kaski, was conducted with an objective to identify strengths and barriers in existing policy provisions and to understand the extent to which sectoral and other policies have integrated CSAs. **Field observation** was conducted in order to collect primary information in Hemja and Majhthana of Kaski and Chormara, Agyouli and Rajhar in Nawalparasi. The main objective of field observation is to validate and fine tune study findings as well as listen farmers experience on CSAs.

Key findings:

- Despite greater recognition of climate-smart technologies in policies and strategies, CSAs have not received adequate attention in planning and implementation.
- CSAs are not well documented, disseminated and widely shared, and are not adequately incorporated into extension guidelines and manuals.
- CSAs are not always backed with scientific evidences. More research is warranted for the various agro-ecological zones, soil types, rainfall patterns and farming systems.
- The coordination among governmental departments, institutions and organizations involved in CSA can be improved for avoiding duplication and conflict with one another while implementing CSA practices.
- Many projects and programmes are promoting CSAs. However, these projects and programmes are being implemented in project-based approach without adequate attention to sustainability of these practices.
- Weak capacity on climate change adaptation and mitigation at all levels including public sector, civil society organization and the private sector remain a key challenge.
- Due to lack of service provider, materials and inputs required to adopt CSAs are not always available at local market.
- Economically poor smallholder farmers are not able to adopt some of expensive CSAs such as solar-pump based irrigation and machine based zero-tillage.

Recommendations for scaling up CSAs:

Following actions would lead to effective scaling up of CSA practices.

- Mainstreaming CSAs into core government strategies, guidelines and annual action plans, including its inclusion into district and local development plans
- Adopting an inter-sectoral approach and consistent policies across agricultural, food security and climate change sector at all levels
- Replacing the scheme-based subsidy schemes by performance based subsidy schemes on some of

the CSAs such as improved cattle-shed, plastic ponds, plastic-house, agriculture tools and practices, would greatly improve the effectiveness of subsidy.

- There is greater need to develop the skilled manpower and service providers who can help scaling up CSAs. CSAs such as plastic house, improved cattle-shed, plastic pond, drip irrigation, conservation agriculture (zero-tillage machine), water harvesting ponds etc. can be effectively promoted through private sector by building the capacity of the service providers.
- Few knowledge intensive champion CSAs such as mixed farming (legume integration), rhizobium and nitrogen management, conservation agriculture (mulching, residue retention part); improved home-garden; package of plastic pond, plastic house, drip irrigation, and improved cattle-shed; system of rice intensification; water harvesting ponds; plantation and agro-forestry; dissemination of new varieties and seeds, needs to be scaled up by integrating them into agriculture development plans. For that, higher investment on capacity building of frontline extension staffs is suggested.
- Few CSAs requires push from government polices. More research, policy works and increased investment is needed for scaling up CSAs such as weather index-based insurance, ICT based agro-advisory and solar-energy based irrigation systems.
- Smallholder farmers always cannot afford the initial investment for CSAs such as plastic house, hand tools and equipment, drip irrigation, plantation and agro-forestry. Provision of collateral-free loan support would increase the chance of adoption of these technologies.
- CSAs such as solar-based irrigation, water harvesting through community ponds and zero-tillage machines. Provision of subsidies and support through group or cooperatives would enable them to co-finance the initial investment and sustainably implement the technology.
- Capacity building of farmers, extension staffs and stakeholders; and strengthening local institutions is essential for scaling up of CSA technologies. Therefore, higher investment on this areas would lead to scaling up of CSAs.

LIST OF ABBREVIATIONS

ADB/N	Agricultural Development Bank of Nepal
AICC	Agriculture Infomration and Communication Center
BNF	Biological Nitrogen Fixation
CCAFS	Climate Change, Agriculture and Food Security
CDKN	Climate and Development Knowledge Network
CGIAR	Consortium of International Agricultural Research Centers
CSA	Climate smart agriculture
DADO	District Agricultural Development Office
GHG	Greenhouse gas
GOs	Governmental Organizations
ICIMOD	International Center for Integrated Mountain Development
ICT	Information and Communication Technology
LIBIRD	Local Initiatives for Biodiversity, Research and Development
NGOs	Non-governmental organizations
IDE	Intenrational Development Enterprise
INGOs	International non-governmental organizations
MoAD	Ministry of Agricultural Development
NARC	Nepal Agricultural Research Council
SDC	Swiss Development and Cooperation
SISP	Small Irrigation Special Program
SSMP	Sustainable Soil Management Program
VDC	Village Devleopment Committee

Introduction

1.1 Background

In the 21st century, agriculture continues to be a fundamental instrument for securing livelihood and sustainable development in developing countries (Jonasova & Cooke, 2012). However, there is a dire need to ensure food security for all and avoid of detrimental effects of climate change (Curtin & Arnold, 2016). Therefore, it is wise to recognize the limitations that accompany the benefits of the past agricultural development. In recent years, reorientation of agricultural development in the wake of climate change is considered as an effective measure for ensuring food security and reducing poverty in developing countries (Jonasova & Cooke, 2012; Curtin & Arnold, 2016). The present challenge is not only to increase availability and access to nutritious food but also to increase resilience through sustainable use of land and water resources, and contribute to greenhouse gas mitigation (GHG) for slowing-down climate change (Neufeldt et al., 2015; Beddington et al., 2012, Curtin & Arnold, 2016). To tackle current food deficit and climate change challenges, climate smart agriculture (CSA) approach shows a great promise. CSA is an integrative approach with goal to address food insecurity at the time of climate change, while productivity and incomes, adaptation and mitigation are identified as three interlinked pillars necessary for achieving these goals (Curtin & Arnold, 2016; FAO, 2013). According to the Food and Agriculture Organization of the United Nations, CSA can be defined as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals" (FAO, 2013).

Nepal is predominantly an agricultural country where 2/3 of the total population rely on agriculture for securing their livelihood (MOF, 2016). Despite 65% of the country's total population involved in agriculture, Nepal is struggling to fulfill its food requirements in terms of nutritional value. Although agricultural sector contributes 32% to its national gross domestic product, majority of the poor peasants do not have access to modern agricultural technology, improved seeds, market opportunities, and are compelled to rely on traditional unproductive technology in their production system (MOF, 2016). Generally, Nepal's agricultural sector is characterized by unproductive, labor intensive, and not mechanized. In addition, due to continuous fragmentation of land, the land holding capacity per household across Nepal is found to be relatively low; estimated average size of parcel is to be less than 0.3 ha (CBS, 2002; CBS, 2003). The agricultural sector is further worsened due to its increasing stress on water resources and other climatic-sensitive resources such as increased temperature, erratic rainfall patterns, extreme events and so on (Bartlett et al., 2010; MOF, 2016).

Due to widespread poverty, Nepali farmers have limited technical and financial capability to respond to increase food security in context of increased climate-risks. There are several potential adaptation options available to manage moderate to severe climate-risks in agriculture. Changes in agronomic practices (altering inputs, timing and location of cropping activities), adoption of new technologies (improvement in input use efficiency, conservation of water and energy, and pest/disease/weed management) and the use of relevant information (climatic information based agro-advisories and weather-index based insurance) at the farm level can be key components in improving adaptability of agriculture to climate change. These options also significantly improve crop yields, increase input-use efficiencies and net-farm incomes, and reduce greenhouse gas emissions wherever possible. Many of these interventions have been successful individually in raising production and income and in building resilience of farming communities in several locations. Therefore, it is high time for Nepal to attract international research and development

partners, advanced research institutes and policy makers. In this regard, CSA has been a topic of discussion for government, policy makers and researcher in Nepal.

1.2 Purpose of the review/study

With the objective to provide a pathway for scaling up CSAs in Nepal, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), in collaboration with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and ministry of Agriculture Development (MoAD) started a project titled "Scaling up Climate Smart Agriculture in Nepal" with financial support from Climate and Development Knowledge (CDKN) (Khan, 2015). Since it is crucial to analyse local poverty, and vulnerability context, short-term planning cycles and government policies for addressing the challenges for scaling up agricultural technologies and practices (Jonasova & Cooke, 2012), this project conducted systematic identification, piloting, evaluation and screening of CSAs for Nepal. This report aims to provide scaling up and provide recommendations for actions. The recommendations are targeted to bring factorable policy changes contribute better integration of the CSAs in agriculture extension and local development plans and increase private sector engagement for scaling up CSAs, wherever possible for successful scaling up of CSAs in Nepal.

Methodology

In keeping with the scope of work and with the understanding of the objectives of the study, the review applied qualitative method, especially a combination of desk study and consultation and field observation/visit for information collection.

Desk study was carried out by collecting the relevant documents and reviewed them. While reviewing the documents special attention was given to find out the policies pertinent to CSA practices and technologies in Nepal. For example, desk review of annual plans and budgets of the government for CSA champions were conducted. The main objective of desk study was to identify existing provisions pertinent to CSA, opportunities provided by these provision, gaps and challenges on the existing policies, and state of implementation in Nepal.

Consultation with experts from government officers, especially District Agricultural Development Office (DADO) Kaski, District Agricultural Office Nawalparasi, Regional Agricultural Directorate, Kaski was conducted with an objective to identify strengths and barriers in existing policy provisions and to understand the extent to which sectoral and other policies are implemented.

Evidences generated through piloting of CSAs by LI-BIRD is important input for scaling up pathways. The evidences, both qualitative and quantitative, were collected through shared reports and data by project staffs, consultation and discussion with the staffs and participant farmers.

Field observation was conducted in order to collect primary information from the field through direct observation. Field visits were conducted with the assistant of CSA experts from LIBIRD. Hemja and Majhthana were the two pockets selected from Kaski district. Three pockets selected from Nawalparasi were Chormara, Agyouli and Rajhar. The main objective of field observation is to validate and fine-tune study findings as well as listen farmers experience on CSA practices.

Scaling up Pathways

1.3 Framework for scaling up pathways of champion CSAs in Nepal

The project has identified 13 champion CSAs suitable for mountain, hill and terai region of Nepal. These champions were selected based on their potential to increase food security, support adaptation and mitigation in Nepalese agriculture. Hence, there is a need to scale up these champions to the needy farmers. The common framework considered for developing scaling up pathways can be summarized below (table 1).

Table 1 Three scaling up pathways for CSAs

Scaling up Models	CSAs Product & service	Role of government
Knowledge-transfer / extension model	Introduction of new crops, seeds, varieties, seedlings, etc.; conservation agriculture (mulching, residue retention); improved home-garden; improved cattle-shed, package of plastic pond, plastic house, drip irrigation, and improved cattle-shed; mixed farming (legume integration); system of rice intensification; water harvesting ponds, multiple use and water source protection; Plantation and agro-forestry	Support trainings, visits, demonstrations, financial supports to target beneficiaries
Commercial business model	Plastic-pond, plastic house, drip irrigation, Plastic house plus drip irrigation, Conservation agriculture (zero-tillage machine), home-garden (diversity kit); Small farm-tools and machines; plastic-house plantation and perennials	Provide subsidies, facilitation, market regulation, quality control
Policy incidence models	Solar-based irrigation; community seed banks; agriculture insurance (particularly index-based); ICT based agro-advisory	New policy, targeting, priority, investment

a. Knowledge-transfer model:

When a CSA involves knowledge intensive interventions it is more suitable for scaling up through knowledge transfer i.e. extension system. The knowledge transfer model is about scaling up the technology by affecting farmers' decision making process for adoption of new CSA. Obviously, changes or modification in CSAs does not guarantee the successful adoption of the champions (Neufeldt et al., 2015). Farmers play a vital role in either adaptation or rejection of a champion. Unless and until farmers adopt the champion or practice, it cannot be scaled up. In order to adopt a new practice, it has to through the diffusion process elements, namely: awareness, interest trail, evaluation and adaption/rejection.

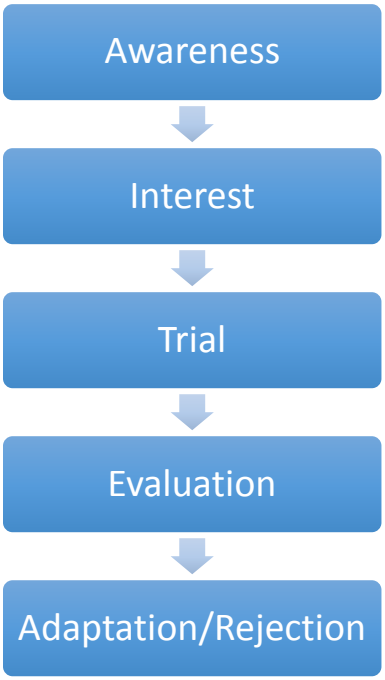

Figure 1 Flow chart showing the adaptation process for a new champion.

The adoption process can be catalyzed by various means of agriculture extension such as mentorship, peer support, promotion of innovation platforms, demonstration, exhibition visits, trainings, farmers' field schools and discussion of knowledge products. Farmers can learn a lot by observing the implementation of technology in field visit or exhibition. As they say, "Seeing is believing". For example, if they visit a farm with well-managed plastic house, it will inform and motivate them to try the technology. Trainings imparts knowledge and skills to farmers to test and pilot new technologies. Demonstrations help farmers to get firsthand experience to practice the technology, witness the benefits of the technology in their own conditions and give much needed confidence to try the technology. The knowledge-transfer model that is recommended in this scaling up pathway include all these components of the extension.

Nepal has a large agriculture extension network. It is obvious to consider that most of CSAs will be scaled up through extension system. Recent policies and strategies governing agriculture extension in Nepal have supported the idea to integrate CSA in extension. Therefore, the pathways of each CSAs has provided special attention to integrate champion CSAs into extension system.

b. Market-based scaling up:

There is always limited resource for supporting scaling up of CSAs. Therefore, while developing the scaling up pathways, it is emphasized the strategy has to be able to generate additional resources from various sectors. When a CSA involves scaling up of a product, e.g. zero-tillage machine for zero-tillage practice, market-based model of scaling up could be effective. In addition, private sector can play crucial role for scaling up CSAs, provided they are capacitated and facilitated by government. MoAD, in its current agriculture extension strategy, has targeted to increase private sector involvement in technology dissemination. Therefore, while developing scaling up pathway for champion CSAs, a critical thought has been given to possibility of involving private sector for scaling up CSA.

c. Policy-push model:

Some of the CSAs requires removing the policy bottlenecks and/or increased support from government. In this model, an evidence-based innovation is communicated to key policymakers

for its incorporation into the existing institutional framework. Then, the policymakers needs to be actively engaged and informed by showing evidences, eventually leading to favourable policy change to scale up a CSA. Ultimately, it is tried that the champion CSAs will be included in ggovernment subsidy schemes, is integrated into government plans and policies and government increased the budget and support to scale up the practice. Policy push model is necessary for technologies which are freshly developed e.g. index based insurance, ICT based agro-advisory, which needs a strong investment for boost up.

1.4 Cross-cutting issues for scaling up pathways

Training and capacity building: The need for training and capacity building of the farmers, groups, extension staffs, service providers and other stakeholders has been considered as important cross-cutting issue for scaling up pathway of all CSAs. Generally, most farmers practice farming without gaining adequate training about the technology that leads to low performance. Moreover, many extension workers and service providers also promote new technology without being adequately informed. Therefore, the need for capacity building has been considered explicitly for each CSAs.

Resource leveraging and co-finance: The scaling up pathway should appreciate the contribution farmers can make by themselves, particularly to those technologies which requires large investment for physical infrastructures. The increased resource leveraging is possible by adopting innovative mechanisms such as Climate-Adapted Village, which has shown that provision of small seed-grant to communities enable communities to generate large sum of co-investment and other resources locally. While developing the scaling up pathway for champion CSAs, high emphasis was given to in build such structure in the pathways.

Gender and social inclusion: While GESI was included as forth dimension of CSA during selection of champion CSAs, GESI was also subject of focused attention during developing scaling up pathways. The pathways for scaling up CSAs give high priority to target the scaling up efforts to most needy people, such as women and farmers from socially disadvantaged group.

1.5 Scaling up pathways of champion CSAs

1.5.1 Plastic house technology

About the CSA

CSA	Plastic house
Major vulnerability addressed	Weather-stress such as cold, extreme rainfall, and to some extent hailstone
Level of implementation	Household
Per unit investment cost	NRs 21,000
Per unit benefits	NRs 166,100 in four years

Plastic house technology was developed in Nepal by the Regional Agricultural Research Center, Lumle around 2056/57. Plastic house was first introduced in the Kaski district for tomato (*Lycopersiconesculentum*) cultivation at Hemja. Tomato is one of the main vegetable that can be commercial grown both in the plains and hills of Nepal. Generally, the normal period for the plantation and harvesting of tomato in mid hills is from March- August in Kaski. Determinate varieties such as Pusa Rubi and Roma were commonly used by the farmers. However, production

of these varieties were highly affected the heavy rainfall. Fruit rotting, stem and root rot, and late blight were the major problems that discouraged the farmers to grow tomato in this season. A water tolerant variety, i.e. CL1131 was offered to farmers and that improved the tomato cultivation up to some extent. But this variety also started to rot in onset of monsoon, hence it was realized that tomato couldn't resist heavy rainfall. Then farmers started tomato production inside a plastic house to prevent from heavy precipitation. Tomato cultivation under the plastic house was quite successful as the tomato yields till August-September. In this way, temporary use of plastic house turned into permanent structure. So many hybrid varieties were introduced in plastic house cultivation. This technology is piloted by the LI-BIRD in CSA project sites and screened as the champion CSA.

Initially normal plastics were used for constructing plastic house. Farmers experienced that normal polythene were not durable and easily damaged by strong wind and heavy rainfall. Gradually, farmers opted to use thick, elastic and transparent plastic sheet such as Silpaulin, a heat tolerant, and 45, 60, 90, 120, and 150 gram per square meter (GSM) sheets to make plastic house. Silpaulin of the size 90 GSM is the most frequently used for this this technology. The lifespan of this plastic is about 5-6 years. Plastic houses are primarily used to prevent heavy rainfall during summer/rainy season and used to maintain favorable temperature during winter season. At present plastic house technology become one of the viable alternative for quality tomato production in Nepal. Apart from tomato production, plastic house technology is also used for other high value crops and vegetables, and becoming popular among the farmers' day by day.

This technology can provide many benefits such as:

- Can cultivate high value off season crops.
- Can grow tomato successfully in mid hill at rainy season.
- Allows year round production of tomato.
- Reliability of crop increases under plastic house cultivation.
- Efficient use of water in the crop and easy to control.
- Water requirement of crops very limited and easy to control.
- Per unit production is high.
- Improve the household income.

There are some limitations of plastic house as well:

- There is lack of good disposal mechanisms for old plastic sheets. Thus, a haphazardly use could become problem for disposal and environmental pollution.
- Farmers are using ordinary plastic available in the market. The plastic sheet particularly designed for agriculture purpose are not readily available in Nepal.
- Although several other agriculture inputs are tax free, government charges high tax rate for the import of plastic sheet because there is no particular types of plastic sheet designed only for agriculture.
- The transparency of the plastic sheet gradually decreases and turns to opaque, which affects the transmission of the light. Farmers have to replace plastic sheets after it become opaque.
- Plastic has its own carbon foot-print. Hence, further study needed to evaluate the net resilience gain from use of plastic house.

During the rainy season, the heavy precipitation severely limits the type of crops that can be grown in open fields, and also restrict the production of seedlings. Plastic house technology can be used to protect crops from torrential rain or heavy rainfall, and can also provide favorable climatic conditions for high value off-seasons vegetables. Plastic house is screened as the champion CSA because it contributes the CSA pillars as summarized in **Table 2**.

Table 2 Plastic house technology contributing to CSA pillars

CSA pillars	Roles/Strengths
Food security	• This helps farmers to grow off-season vegetables and add food stuff in the food balance sheet, at the same time generate additional income by selling high value commodities which increase the purchasing power of farmers. That supports increasing food security and improve farmer's household income. This ultimately utilize the CO_2 and maintain the food sustainability and prevent out migration f prop from villagers.
Adaptation	• Farmers can cultivate high value vegetables or crops using plastic house in adverse climatic conditions. • On the other hand, this technology allows integration with other CSAs such as drip irrigation system to grow the crops effectively, which encourages farmers to grow vegetables in dry land areas where water is very scarce. • Plastic house, to some extent, also helps to reduce loss caused by hailstone. This has been the main unintended benefits in Majhthana, Kaski and Ghanapokhara, Lamjung.
Mitigation	• There is no or very minimum weathering process inside plastic house. • Additionally, this practice helps to promote greenery in barren land that assist in increasing land cover and sequester CO_2.
Gender equity and social inclusion	• Adaptation of plastic house technology reduced drudgery, especially on women since they don't have to travel far distance for farming.

Existing policies about plastic house technology

There are several governmental policies that directly or indirectly promote plastic house technology in Nepal. Government tried to popularize this technology by integrating in all District Agricultural Development Office's (DADO) regular annual program. DADOs provide training about plastic house and has made provision of 50% subsidy while purchasing plastic sheet. Department of Agriculture (DOA) has promoted plastic house in **Commercial Offseason Vegetable Production Pocket Program**, started in 2017. The program covers 17 hilly districts, and provides subsidy of NRs. 120,000 to the farmers' group/farmer cooperative who have at least 5 hectares of land. There are tremendous opportunities for poor farmers to rapidly increase their incomes though high value commodities and thus, the plastic house technology is visualized as a viable option for promotion of export of high value commodities such as tomato. Apart from government, other non-governmental organizations (NGOs) and international non-governmental organizations (INGOs) have been involved in implementation of plastic house technology in Nepal. However, the role of plastic house for climate change adaptation and reducing climatic-risks has not been adequately explored.

Scaling up pathways

Plastic house provides direct financial benefits to farmers, and has been a part of commercial agriculture production system. Therefore, there is scope for promoting this technology through a combination of knowledge-transfer and commercial business model.

Plastic house technology is an effective technology, however, it also needs some local adaptation. There are several limitations of the practice, which were realized during implementation of this

practice. Therefore, there is need for more study to improve the technology and solve few technical problems associated with this technology for its massive adoption. Following actions are suggested for removing policy, institution and financial bottlenecks, and fine-tune the technology for widespread scaling-up of the technology.

Table 3 Pathways for scaling up plastic house technology

Particulars	**Gaps/bottlenecks**	**Recommendation**
Policy	• Plastic sheet currently available in the market is not particularly designed for agricultural use. • Government does not subsidize tax rate on import of plastic sheet. • Silpaulin is expensive for poor farmers	• It is very important to produce or develop plastic sheet for agriculture use or goods. • Waiving tax on import of plastic sheet for agriculture use would help to reduce cost of investment for farmers leading to higher adoption. • Increased subsidy, particularly to poor farmers, would make plastic house more affordable to them.
Institution	• The coordination among institutions supporting plastic house technology can be enhanced. • Capacity building mechanism in delivering proper training to the government extension agents as well as farmers and service provider needs strengthening. • There are not many service providers capable to install technically sound plastic houses.	• Enhanced coordination between the promoters, led by DADOs would lead to coherence of efforts. • Inclusion of plastic house building skill in agriculture training and vocational trainings would enhance the capacity of service providers can increase numbers of local service provider. • Promotion of collateral-free loans, under group security would increase poor farmers' access to credit in invest on plastic house. • Registering service providers with DADO would help DADOs to facilitate the support schemes.
Financial	• Government provide scheme-based subsidy, not adequately targeted to results. • Subsidy scheme covers only for plastic sheet making the technology unaffordable to poor farmers. • Provision of same subsidy rate, irrespective of gender, location, and economic status, doesn't often address the diverse need of diverse farmers. • Commercial and development banks are unwilling to lend loan to smallholder farmers, primarily	• Adoption of result-based subsidy schemes would target the subsidy to needy ones. • Broadening subsidy schemes to cover other materials would make the technology affordable to poor farmers as well. • Positive discrimination towards women, disadvantaged groups, and farmers in remote locations in subsidy scheme is recommended for inclusive impacts. • Facilitation from the government is needed to increase the collateral-free loans to poor farmers.

	because of the risk that they would not pay back their loans.	Promotion of self-help groups, cooperatives, and introduction of loan-security schemes would encourage banks to invest more in commercial agriculture.
Technology	• Farmers use plastic house technology haphazardly. • More research needed for the fine-tuning of plastic house technologies to customize for local conditions and generate package of good-practices.	• Training farmers before providing support for plastic house would improve the quality and profitability.

Since plastic house is suitable for commercial agriculture, more can be done to increase contribution of private-sector to promote the technology. Few actions are offered as suggestions:

- Due to lack of service provider, materials needed for construction of plastic house is not available everywhere. The problem become more severe for those communities residing in the isolated and inaccessible rural hilly areas. Lack of service provider impede the implementation of this practice even though farmers are willing to adopt this technology. Along with materials, technical support can also be provided through service provider. At present one of the bottleneck for this technology in Nepal is lack of skilled manpower. Thus, service provider may play a vital role in providing technical assistance for the successful scaling up of this practice in Nepal.
- Unemployed youths in villages can be given special trainings to build technically sound plastic houses so that they can initiate small business for "service on payment" basis.
- Facilitation of start "contract farming" inside plastic house is reasonable prospective. Since, there is great level of risk reduction in plastic house, private investors might be ready to invest more on this technology.
- Plastic house technology has potential to transform subsistence farmer to commercial farmer. Therefore, assessment of potential farmers who are willing to invest big and increasing their access to loans would boost the adoption of this technology to another level.

Picture 1 Tomato cultivation under plastic house, Majhthana, (Note: Due to lack of service provider or skilled manpower, plastic house is built haphazardly. Farmers do not have awareness about shading effect as well as height of the plastic house)

Picture 2 Commercial tomato production at Hemja, Kaski (Note: Appropriate plastic house built by skilled farmer)

1.5.2 Plastic pond

About the CSA

CSA	Plastic pond
Major vulnerability addressed	Extreme weather-stress
Description	4x3x2 m^3 plastic pond is built for grey-water collection that can irrigate about 10 x 5 Sq. feet area for vegetable cultivation leading to higher production, consumption of vegetables, also potential for fish raising.
Level of implementation	Household
Per unit investment cost	NRs 5,000
Per unit benefits	NRs 166,100 in four years

Despite the fact that Nepal is bestowed with water resources[1], water crisis is a major issue both in terms of quantity and quality in many urban and rural areas (Pokharel, 2001; WECS, 1994). The severity of water shortages become more pronounced in the hilly regions of which more than 76.9% of the total landmass is covered by mountains and hills that make up the home of approximately 52% (CBS, 2002). The hilly areas of Nepal most often suffer from alternating heavy rainfall and scarcity of water that make the livelihood of the mountain communities more difficult. The population in hilly areas have to rely on common sources of water such as well (kuwa), spring (also tap water) or streams and ponds for drinking and other household purposes. Due to lack of constant water supply, population in hilly areas or dry land areas rely on rain-fed agriculture and hardly meet their food requirements.

During the fiscal year 2054/55, the government of Nepal started the small irrigation special program (SISP) with the overall objective of increasing agriculture production of poor peasants through maintenance support to existing small irrigation systems and development of new small (micro) irrigation systems with appropriate technology. Realizing the fact that traditional water use practices are not adequate to meet the current water demand for agriculture in water-stressed areas, the government started to support various schemes that support the conservation and preservation of water resources. Government emphasize following activities to enhance the efficient use of water resources in dry land areas:

- Preservation of water pond.
- Construction of small-scale pond.
- Canal improvement/renovation.
- Dam renovation.
- Introduction of sprinkler for micro irrigation.
- Water tank, plastic sheet (for water pound) distribution.
- Polyethylene pipe distribution, etc.

Due to geographical structure and scattered community it has been difficult and relatively expensive to construct regular irrigation canal or apply gravity fed water supply system to such

[1]Approximately 6,000 rivers (including small and big rivers) with total length of 45,000 km flow with an average water runoff of 220 billion m^3 annually in Nepal.

water-stressed areas. For example, in order to construct irrigation canal, the farming field must be minimum of 25 hectares. In this regard, plastic ponds may prove themselves as the best alternative for water supply system to assure all year round irrigation facilities.

This champion is not new but modification of traditional practice. Traditionally, farmers collected water from roof with the help of pipe in plastic or metal buckets and fed livestock. This traditional method has been modified and used for both farming and feeding livestock. Plastic ponds are cheap and easy in construction and maintenance as compared to cemented pond. Cemented ponds are replaced with Silpaulin (GSM 90, 120, 150,200, 250, 300) and widely practiced in hilly areas. Thicker the size better for plastic ponds. Blue and green sheet are better as compared to transparent sheets.

This pond plays vital role in meeting increasing water demand in Nepal owing to the rising competition for water from different sector including agriculture and livestock. Plastic ponds store water for irrigation more efficiently than cemented or traditional earthen ponds which lose much water due to seepage or leaching. Indeed, assuring all year round irrigation in dry areas will allow intensification and diversification of crops, increasing the productivity and thus prosperity. Overflow, kitchen water and waste-water can be stored and utilized for the vegetable production. This technique not only benefit the farmers but also reduced the erosion of the catchment areas. Advantages of plastic pond are summarized as follows:

- Cheap and easy to construct.
- Best for water scarce and dry land areas.
- Waste water can be tapped or harvest all possible sources of water.
- Water from ponds can provide irrigation for high value crops and have a positive effect on family nutrition.
- Increase the production of crops from small areas of land allowing farmers to generate income by supplying to the local markets.
- Increasing purchasing power of farmers.
- Reduced the dependency on large scale water supply schemes for irrigation.
- Reduces workload for collecting water, especially on women.
- Control out-migration of people form villages to cities.

There are some limitations of plastic ponds. They are:

- The amount of water that can be stored in plastic pond is not enough to start big commercial farming
- Recycle problem of the plastic itself.
- The plastic sheet is not available locally.
- Lack of trained or skilled manpower to build plastic pond.
- Silpaulin is expensive for poor farmers.
- Plastic pond is unsafe for small children.
- Plastic ponds are prone to mosquitos.

Water from ponds can provide irrigation for high value crops in the dry season allowing farmers to remain healthy. This practice has a potential to become complete champion CSA friendly. **Table 4** shows the strengths of plastic pond with respect to CSA pillars.

Table 4 Plastic pond contributes to CSA pillars

CSA pillars	Roles/Strengths
Food security	• Availability of the water increased. It increases the year-round cultivated area and ultimately add food items in food balance sheet. Utilizing water from plastic ponds can increase the production of crops even from a small piece of land and help to generate good income from sales of vegetables increasing the purchasing power of other goods.
Adaptation	• Plastic pond allows all year round high-value commodities or agricultural production through which farmers are able to intensify and diversify their crops. • Diversification of incomes from vegetables enhance food security as well as increased resilience to climate change. • This is best adaptation practice in drought vulnerable areas.
Mitigation	• This practice is neutral to mitigation.
Gender equality and social inclusion	• Prior to construction of plastic ponds, women have to travel 2-3 hours to fetch one bucket of water, and thus, construction of plastic ponds save time and reduce women drudgery. Besides, this technology doesn't require heavy investment hence affordable to poor farmers.

Existing policies about plastic pond technology

The MoAD has adopted **the plastic pond construction procedure in 2070.** The principle aim of this policy is to store excess water with the help of plastic pond and use during dry season for high value vegetables farming. This procedure envisions the sustainability in agricultural production especially those areas where irrigation facilities are limited or not available during dry season. For the proper implementation and compatibility of plastic pond system for small farm holders, the government of Nepal has declared **financial provisions** as:

- The DADO provides the maximum amount of NRs. 30,000 to the individual farmer/group of farmer/agricultural cooperative institution/consumer committee as subsidy.
- The subsidy is given to the individual farmer/group of farmer/agricultural cooperative institution/consumer committee for buying the materials once the hole for the pond has been prepared or dug out: (i) 50% before and 50% after completion of the project.

Many farmers and farmers groups have already received money to build the plastic ponds.

Scaling pathways for plastic pond

Plastic pond could be promoted through commercial-business model and knowledge-transfer model. While it is essential to demonstrate the benefits of plastic-ponds in communities, it is important to invest on developing local resource persons and service providers who can provide service to interested farmers to build plastic ponds and sell plastics. For few targeted groups of poor farmers, government can provide subsidy schemes on plastic. There are several policies promoting plastic pond, however there are some bottlenecks that impede the successful implementation of this practice. In order to increase the impact of this practice efficiently from a small to a large scale of coverage, following actions can be taken to make enabling environments (**Table 5**).

Table 5 Scaling pathways for plastic pond

Particulars	Gaps/bottlenecks	Recommendation
Policy	• Since commercial plastic is used for agricultural use, government charges high tax rate on import of plastic sheet. • Heavy duty plastic is expensive.	• Waiving tax on import of plastic for agriculture use would help to offset investment cost for farmers leading to higher adoption of plastic pond. • Increased subsidy, particularly to poor farmers, would make plastic pond more affordable to them.
Institution	• Silpaulin is not available at the local market due to lack of service provider. • Lack of capacity building mechanism in delivering proper training to the government mobilizers as well as farmers and service provider. • No authentic institutions to regulate and quality control of Silpaulin.	• Registering service providers with DADO would help DADOs to facilitate the support schemes about adoption of plastic pond. • Training on management of plastic ponds to the mobilizer as well as farmers and service provider would increase chances of adoption. • Designation of particular institution that take responsibility about Silpaulin would maximize the opportunity of adoption at a larger scale.
Financial	• Current scheme based subsidy for plastic pond doesn't necessitate farmers to proper utilization of subsidy. • Government provides flat rate of subsidy irrespective of gender, location, and caste, without proper acknowledgement of poor and disadvantaged.	• Adoption of result-based subsidy would be helpful. • Positive discrimination towards gender/caste and locations in financial scheme would encourage inclusive impacts.

Picture 3 Plastic pond, Majhthana, Kaski (Note: Farmers generate additional income by cultivating vegetables on the roof that used to cover plastic pond)

Since plastic house is suitable for growing vegetables in home-garden. Due to simplicity of the technology, this technology can be promoted through local vendors and service providers. Few actions are offered as suggestions to facilitate the process:

- Materials needed for construction of plastic house can be supplied through local vendors and service providers. Along with materials, technical support can also be provided through service provider.
- Government can provide subsidy to plastics based on receipts provided by farmers, so that the subsidy schemes can be effective and utilized for agriculture.

1.5.3 Drip irrigation

About the CSA

CSA	**Plastic pond**
Major vulnerability addressed	Water scarcity
Description	This is one of micro-irrigation technology. Irrigation is done though perforated pipes, which drops waters at the root areas of plans, allowing irrigation in larger areas with limited amount of water
Level of implementation	Plots
Per unit investment cost	NRs. 4500 for pipe to irrigate 80 plants
Per unit benefits	Up to NRs 163,600 in one year

Efficient use of water is very useful in dry land areas where there is limited rainfall for long periods of the year. Scarcity of water severely limit the growing of crops in dry land areas, especially on steep slopes of hilly areas where conventional irrigation practices can be difficult to arrange. Thus, there is a dire need to develop technologies which ensure proper utilization of limited water resources in dry land areas. In this regard, drip irrigation (Easy drip) has been considered a most

appropriate irrigation technique which allows the slow and precise delivery of water to crops. Drip irrigation is a very water-efficient irrigation system in which water flows through a filter into special drip pipes, with emitters located at different spacing. This irrigation system can be practiced to any farmable slope, and if properly designed, installed and managed, it may help in water conservation by reducing evaporation and deep drainage. Being water-efficient technology, drip irrigation is primarily used for cultivation of high value crops, which are rarely accessible to low income peasants.

Advantage of drip irrigation system can be summarized as:

- More crops can be grown using less amount of water.
- Reduce operation and labor cost.
- High efficiency in the use of fertilizers.
- Reduce weeding problems and restricts population of potential hosts.
- Maximum use of available water by the plants resulting maximum yield.
- Allows safe use of recycled water.
- Utilization of the small source of water and waste water as well.
- The most appropriate technology for dry land agriculture.
- Can be integrated with multiple use of water.

Limitations of drip irrigation system can be summarized as:

- Fitting problem due to lack of service provider.
- Lack of skilled manpower.
- Due to lack of technical knowledge, some farmer faces problem of clogging.
- Disposal problems for lateral/probes.
- Expensive for poor farmers.

In the early 1980s, the government of Nepal assigned the Agricultural Development Bank, Nepal (ADB/N) as a leading body for the promotion of micro-irrigation in Nepal (Upadhyay et al., 2005). In the early 1990s, International Development Enterprise (IDE), an international non-government organization (INGO), signed an accord with ADB/N to promote micro-irrigation facilities in Nepal (Upadhyay et al., 2005). Thereafter, the IDE has been actively involved in dissemination and implementation of cost effective drip irrigation in rural parts of Nepal in collaboration with several other institutions and organizations. **Table 6** shows the strengths of drip irrigation in meeting the objectives of CSA pillars.

Table 6 Drip irrigation contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Drip irrigation systems are typically 90% efficient as compared to sprinkler systems, and contribute to tackle food insecurity and enhance household income. With the application of drip irrigation, farmers can significantly increase per unit production in dry land areas assuring food security that prevent out-migration of the farmers.
Adaptation	• Drip irrigation system is very efficient in those areas where water is very limited or scarce, and no other irrigations systems such as motorized system or gravity canal system are not available. • It can also be used for both in open field and plastic house, and also suitable for kitchen garden. • It helps to increase crop coverage, which ultimately save the

	erosion of the dry land.
Mitigation	• This practice is neutral to mitigation.
Gender equity and social inclusion	• Since this technology utilizes water very efficiently, less amount of water can irrigate large area of land, which reduces workload while collecting water. It saves time for irrigation. It ultimately reduces drudgery on women as women are responsible for most of the household chores in rural areas.

Existing policies about drip irrigation

The government of Nepal promulgated the **small scale irrigation special program directory** in 2061. It aims to provide reliable access to irrigation systems and technologies so that small farm holders can improve the productivity of their land enabling them to meet their food requirements as well as to generate additional income and upgrading their irrigation systems. The small scale irrigation special program covers maximum 25 hectares and 200 hectares' land in hills and terai, respectively (Irrigation Policy 2060) and provide the maximum subsidy of NRs. 150,000. This schemes also provide the maximum subsidy of NRs. 600,000 for "Sahakari Kheti". There is also 85% subsidy policy for drippers.

Scaling pathways for drip irrigation

As agriculture continues to be a fundamental instrument for sustainable development and poverty reduction, CSA technologies and practices have to be scaled up to support food security and tackle challenges of climate changes. Therefore, drip irrigation technology could be scaled up through a combination of commercial-business model and knowledge-transfer model. Drip irrigation technology could be scaled up with following ways for successful adaptation.

Table 7 Scaling pathways for drip technology

Particulars	Gaps/bottlenecks	Recommendation
Policy	• Lack of monitoring on fitting and distribution of drippers. Sustainable use of dripper remains questionable. • Lack of reliable supplier that discourages adoption of this practice.	• Development of proper monitoring mechanism led by DADOs that provide assurance/guarantee on dripper quality (durability) and implementation would help adoption of drip irrigation at a larger scale. • Formation of registered supplier who can take guarantee on drippers is recommended for successful adoption of this technology.
Institution	• Drippers are not available at local market and available only at the piloted areas. • Drippers or laterals developed by IDE Nepal is not available everywhere.	• Development of proper supply system and service provider is recommended for adoption of this technology at a larger scale. • Enhanced coordination between the government and other agencies like NGOs and INGOs lead to coherence of efforts, and

		would help to maintain consistency in quality of the materials supplied.
Financial	• At present government provide 85% subsidy for drippers.	• The provision of high subsidy rate or free drippers to ultra-poor communities would help successful scale up of this technology.
Technology	• Farmers lack knowledge about storage of drippers or laterals after harvesting. • Due to lack of technical knowledge, farmers experience problems in fitting, irrigation models and clogging of drippers.	• Circulation of proper information for storage of laterals after harvesting would benefit farmers as they can use the same drippers next cropping cycle. • Providing proper training to farmers and suppliers about drippers would improve the quality.

Drip irrigation is suitable for commercial farming. Therefore, there is ample opportunities to scale up this technology through private sector engagement. Few actions to promote business case in drip irrigation are follows:

- Installation of drip irrigation systems required skilled manpower. Providing trainings to the unemployed youths would create the business opportunities for the young people in rural areas.
- Drip irrigation schemes can be part of 'contract farming' arrangement, where the investors provide finance to the farmers to adopt drip irrigation along with their commercial farming.

1.5.4 Improved cattle shed

About the CSA

CSA	Plastic pond
Major vulnerability addressed	Improved cattle-shed
Description	The traditional muddy cattle-shed floor is replaced with cement or stones to allow separation of urine and dung. The manure is protected from water and sunshine by making a shed. Urine is collected in a collection pond and used as nitrogen fertilizer.
Level of implementation	Household
Per unit investment cost	NRs. 6,000-12,00 according to place and building materials
Per unit benefits	This is long term investment, which increases crop yields through increased nutrient content on manure.

Soil fertility management plays a vital role in increasing crop productivity and production to address the problem of food security (Regmi & Zoebisch, 2004). However, there is poor management of soil (fertilizer, pesticides, irrigation) as per its requirements, i.e. the farming pattern in Nepal, especially in hilly areas is characterized by more conventional type where farmers mostly

rely on a single option to replenish plant nutrients (Regmi & Zoebisch, 2004; Koirala et al., 2015). In this context sustainable soil management practices are critical for the productivity, particularly in the hilly areas of Nepal since they can enhance inherent soil fertility (Koirala et al., 2015).

With the overall objective of increasing soil fertility and productivity, particularly in the mid-hills of Nepal, the sustainable soil management program (SSMP) was launched in 1999. The SSMP is funded by the Swiss Agency for Development and Cooperation (SDC), and implemented by Helvetas Nepal in collaboration with participants from the government and civil society. The SSMP promotes proven, simple, and appropriate soil and farm management technologies such as cattle shed improvement for preparing, managing, and applying farmyard manure, and the collection of cattle urine for application as a fertilizer. Prior to implementation of cattle shed improvement program, the compost or the farmyard manure was prepared in traditional way, and there was high possibility of loss of nutrients due to seepage or volatilization. In traditional sheds, urine is left to be absorbed in the bedding material, while excess urine is channeled out of the shed. Whereas in improved cattle sheds, beds are cemented and urine is collected in a pit or drum. The pit or drum can be connected to the drainage channel through a pipe. The top of the pit of drum is covered with small sheet of plastic. If the urine is going to be used as liquid manure or organic pesticide than it has to be stored in a drum for fermentation. Improved cattle sheds program has following benefits:

- Nutrient retention rate will be increased.
- Helpful to maintain the soil health and fertility.
- Can replenish the organic matter in the soil.
- Quality of compost is improved.
- Reduces the dependence on chemical fertilizers.
- Provide clean environment for livestock that improved livestock health and productivity
- Improve the aesthetic value of the surrounding/clean environment.
- Contributes to improve food security and increase income for farmers.

This practice does not have prominent disadvantages. However, the program may become expensive for poor farmers. Since the sustainability of agricultural production depends on soil fertility management, the adequate application of manure and urine will replenish plant nutrients that ultimately strengthened three pillars of CSA. Improved cattle shed is screened as viable champion CSA and its features are depicted in **Table 8**.

Table 8 Improved cattle shed contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Quality compost and urine will add the stock of organic materials and enrich fertility in soil which plays an important role in increasing crop productivity and production to address the problem of food security and income generation of farming households. This helps to sustainable food production from the land.
Adaptation	• Availability of farmyard manure reduces the dependency on use of chemical fertilizers.
Mitigation	• The manure prepared through improved cattle-shed are rich in nitrogen. Hence this practice promotes mitigation by reducing the demand for nitrogenous fertilizers.
Gender equity and	• Easy to clean and collect the cow dung and urine. It takes less

social inclusion	time than traditional practice. It improves the environment of the surroundings, which ultimately fruit full for the women health.

Existing policies about improved cattle shed

In Nepal, both organic and inorganic fertilizers are being used for farming. In recent years, farmers heavily rely on inorganic fertilizers to meet the country's food demand. However, dependency on chemical or inorganic fertilizers for long run is not beneficial for soil as it does not replenish the important plant nutrients in soil. In order to meet the growing food demand owing to the population growth and climate change, Bhakaro Sudhar Management Programme was launched in 2070 with the overall objectives of:

- Quality production of organic manure and promote its use in the farm.
- Reduce the use of chemical fertilizer thereby reducing the cultivation cost.
- Development of sustainable agricultural production that leads to food security.

Government provide NRs. 5,200 as subsidy for construction of improved cattle shed. Prior to get approval for subsidy, certain criteria are to be met. For example, the shed must be cell cemented with the capacity of minimum 3 cattle, separate tan must be constructed for collecting urine, and the collection of dung or the heap must be covered with plastic sheet in order to prevent from rain and evaporation.

Scaling pathways for improved cattle shed

Despite the facts that the government of Nepal prioritized the rapid dissemination of improved cattle shed program, the scaling up of this technology is still implausible. In order to achieve sustainability in agricultural production, and transformation into commercial and competitive system from the existing subsistence farming, improved cattle shed practice technology could be promoted through knowledge-transfer model. **Table 9** summarizes the enabling environment for scaling up improve cattle shed practice in Nepal.

Table 9 Scaling pathways for improved cattle shed

Particulars	Gaps/bottlenecks	Recommendation
Policy	• This technology is not promoted in all VDCs. • The subsidy rate is not fixed. For example, earthquake affected areas will get NRs. 25,000 as subsidy whereas other areas will get NRs. 5,000.	• It is recommended to promote this practice as a campaign so that all farmers will have access to this improved cattle shed. • The provision of equal subsidy scheme would encourage farmers to adopt this practice at larger scale.
Institution	• Lack of trained or skilled manpower to implement this technology. • This program is driven by various institutions such as Ministry of Agriculture and the Ministry of Livestock. Stronger coordination among promoter is warranted. • Lack of grass root level of	• Proper institutional arrangement for providing training to the government mobilizers or farmers would help to adopt this technology. • It is recommended to drive the program by single chain of command for successful scaling up of the technology.

	promoting institutions.	• Enhanced coordination between government agencies and other organization such as NGOs and INGOs would encourage adoption of this technology. For example, DADOs can support hardware part whereas NGOs and INGOs can assist in software part.
Financial	• The subsidy or distribution of fund is not equal for this champion. • Lack of consistency on distributing budget for improved cattle shed. For example, DADOs provide NRs. 5,000 as subsidy, and Livestock Department provides NRs. 10,000 as subsidy.	• The provision of subsidy scheme according to need of the region would improve promotion of this champion. Special focus to the need of higher support for poor farmers needs to be considered. • It is recommended to maintain consistency among sectors while distributing financial assistance. • Facilitation from the government is needed to increase the collateral-free loans to poor farmers.
Technology	• Farmers are not taking 100% benefit of this practice. Combination of drip irrigation and urine application as the package would maximize the benefits of this technology.	• Proper training about this practice would assist farmers in maximizing benefit from this practice. For example, having knowledge about the mixing ratio of urine and water will give better results. • Combining this technology with other CSAs would maximize the benefits of this technology to farmers.

Picture 4 Improved cattle shed, Agyouli, Nawalparasi (Note: Cattle shed is very clean that improves the aesthetic value of the farmer's house)

Picture 5 Positive impacts of Improved Cattle Shed practice at farmer's field, Agyouli, Nawalparasi (Note: Application of urine and manure in Bari for production of off-season vegetables)

1.5.5 Combination of plastic house, plastic pond, drip irrigation and improved cattle shed

Plastic house, plastic pond, drip irrigation, and improved cattle shed champions have been developed and implemented individually. However, individual practice cannot produce better results. Therefore, there is potential of getting better result if we combine all these champions together. The combination of champions will produce synergetic effect that contributes to food

security and fight against climate change challenges. For example, a plastic house provides favorable environment for cultivation. Four elements namely: land, water, fertilizer, and seed are necessary for production of crops. Improved cattle shed practice assures the availability of quality organic manure as well as urine which enhance soil fertility. Application of compost and urine make plant nutrient supply system strong. Water is life that can be tapped in plastic pond. The collected water can be utilized whenever it is needed. With the help of drip irrigation, the limited source of water in dry land areas can be utilized optimally. In this way, combination of these practices is screened as potential champion CSA as it meets the requirement of CSA pillars.

Table 10 Combination of champion contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Water, nutrient, seed, and labor are needed for better agricultural production and this champion provide all the important elements allowing farmers to increase their food production, household income and purchasing power.
Adaptation	• This practice makes the plant nutrient supply system strong, require fewer chemical inputs and support nutrient cycling, contributing to enhanced productivity, adaptation, and building resilience to climate change. • Farmers can cultivate high value vegetables or crops using this practice in adverse climatic conditions.
Mitigation	• This package contribute to mitigation through reduced demand for Nitrogenous fertilizers on agriculture.
Gender equity and social inclusion	• The complete package of these champions not only increase the productivity but also reduce workload to women and cost. It saves time to work and increase income.

Scaling pathways for combination package

The overall objectives of CSA practices and technologies are to support food security and boost incomes, reduce dependency on chemical fertilizers, and support important ecosystem functions such as nutrient cycling, contributing to enhanced productivity, adaptation, mitigation, and building resilience to climate change. This new package technology could be promoted through combination of market facilitation and extension model.

Table 11 Scaling pathways for combination of champions (plastic house, plastic pond, drip irrigation, and improve cattle shed)

Particulars	**Gaps/bottlenecks**	**Recommendation**
Policy	• Government does not provide supports for the package of technologies. • This is completely new champion and hence there is no policy promoting this as package, although individual technologies are being promoted though various means.	• It is recommended to promote plastic house, plastic pond, drip irrigation and improved cattle shed as composite champion or practice for better results. • Promulgation of new policy for this practice would encourage farmers to adopt this practice at larger scale.
Institution	• At present all these technologies	• Promotion of all these

	are driven or controlled by different governing bodies.	technologies as a package would improve the delivery system as well as monitoring system.
Financial	• No holistic approach for budget and budget is provided individually. • Scheme based subsidy that is not so effective.	• Provision of holistic approach budget would encourage farmers to adopt this practice at larger scale. • It is recommended to facilitate result based subsidy leading to higher adoption of this practice.
Technology	• At present all technologies are developed individually.	• It is recommended to develop all individual technologies as package. More research would help in fine tuning this practice.

1.5.6 ICT based agro-advisory

About the CSA

CSA	Plastic pond
Major vulnerability addressed	Mobile-based agro-advisory
Description	Group leaders receive message in mobile phones. The message contains 3-day weather forecast and price information about nearby market. Seasonal agriculture related advisories are also disseminated through the SMS.
Level of implementation	Individual farmers
Per unit investment cost	NRs. 44,000 for 1000 HHs to send message for 52 weeks at the rate of 4 message per week.
Per unit benefits	Farmers are able to reduce the potential loss caused by weather variables and maximize the profit through getting higher price.

Nearly 70% of the world food production[2] is provided by family farmers and thus, family farms play pivotal role for agricultural production, food security, rural poverty reduction, and biodiversity conservation. However, smallholder farmers are facing a number of challenges due to climate change, uncertain market scenario, lack of service delivery, new pest and diseases occurrence, degradation of natural resource, and absence of timely information about weather.

Nepalese farmers are more vulnerable to the impact of climate change and variability[3] due to extreme weather conditions as a result of variable monsoon, fragile geology, agriculture-based economy, and poor adaptive capacity. Climate variability affects agricultural productivity making the sector more expensive and less remunerative, and thus, Nepal's agricultural sector demands greater support from communication/community media/Information and Communication

[2]For moreinformationseehere:(http://www.familyfarmingcampaign.net/en/family-farming/why-to-support).
[3] http://www.namis.gov.np/index.php.

Technologies (ICTs). Agricultural informatics is an emerging field that combines the advances in agricultural development and entrepreneurship to provide better agricultural services, enhances technology dissemination, and information delivery with the aid of ICT (Gakuro et al., 2009).
In order to reduce the risks and vulnerability in agricultural production, the government of Nepal formed the Agriculture Management Information Systems (AMIS), one of the component of Building Resilience to Climate Related Hazards (BRCH), implemented by the MoAD. The AMIS has following objectives (Sharma, 2016):

- To provide a mechanism to deliver timely relevant climate and weather information and agriculture decision support tools to farmers.
- The MoAD-managed AMIS will help bridge the gap between Department of Hydrology and Meteorology (DHM) and the farming community by creating weather and climate products that cater to the specific needs of the farming community.
- Extension network of national, sub-national and local government agriculture offices, and farmer groups to help in disseminating the information.

In recent years ICTs have become increasingly integrated into the dissemination of information to farmers that support the access to and exchange of information for smallholder farmers in Nepal. Community media like community TV, newspaper, community radio, web portals and more importantly, mobile phones have become prevalent in advisory service provision. The MoAD have attempted to integrate ICT into the delivery of information and established district information center providing agriculture information, such as information about weather, market price and subsidy schemes. Apart from government, many NGOs and INGOs have also attempted to facilitate technology transfer in the agricultural sector. Currently, there are many ICT assisted communication opportunities to strengthen the voice of the farmer on agricultural issues. They are: farmer call center, toll free number, internet/phone/SMS service and forecasting/video conferencing. Benefit of using ICT assisted communication provisions are:

- Pre/Post-harvest losses can be saved.
- The target beneficiaries get the right information about weather and agricultural sector, and have access to sources of correct information.
- Appropriate technologies for crop cultivation is available in time
- Increase awareness about biodiversity conservation.
- Save time

LIBIRD initiated "Li-Bird ko Chautari" focus on uplifting local farmers' living standard making them concern about biodiversity conservation, and community seed banks. This program is specially developed for sharing traditional knowledge and experience coupled with research extensions. "BBC Sajha Sawal" a television show featuring success story on agriculture entrepreneurs is another promising way to attracts many young farmers to pursue farming as profession. The development of android mobile application "TARKALI" helps farmers to know about daily Kalimati vegetables and fruit updated prices. Krishi Ghar initiated "Hath Hath ma Suchana" an innovative way to interact with farmers delivering agri based information in mobile message box using instant messaging system as per on subscription. **Table 12** summarizes the strengths of ICT based agro-advisory as champion CSA.

Table 12 ICT based agro-advisory contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Farmers can increase the farm productivity in the presence of

	right and timely information about weather, and other support services along with the entire agricultural value chain system. • Post-harvest losses can be controlled that ultimately enhance food security.
Adaptation	• ICT facilitates knowledge generation, documentation, and sharing in support of farmers and of farmer innovations that enhance or expand human networks for agricultural issues, increasing resilience to climate change. It helps to reduce the forth coming disaster.
Mitigation	• This is neutral to mitigation.
Gender equity and social inclusion	• Proper knowledge about weather and climate may shorten the working hour for harvesting and post harvesting that ultimately reduces drudgery on women.

Scaling pathways for ICT based agro-forestry

As it is already mentioned that farming in Nepal is becoming more expensive and less remunerative due to climate change, natural resource degradation, uncertain market scenario, absence of timely information, and other support services, ICT based communication provisions for agricultural sector could be scaled up either market facilitation or knowledge-transfer or a combination of both models.

Table 13 Scaling pathways for ICT based Agro-advisory

Particulars	Gaps/bottlenecks	Recommendation
Policy	• Government investment to develop and disseminate message is limited. • There is lack of adequate historical data to generate and provide reliable forecast. • All farmers do not have mobile phones. • Isolated and remote areas do not have access to these practice. • There is no seasonal weather forecast mechanism	• Increasing the investment to generate the climate data is crucial. • Expanding coverage of this practice to all areas, i.e. all 75 districts would make the technology accessible to all farmers. • Investment on developing seasonal forecast mechanism would be a great help for farmers
Institution	• The capacity of Department of Hydrology and Materiology is not sufficient to generate climate advisory to farmers. • Agriculture information and communication center (AICC) is limited up to regional level and private level intervention is also very limited for this practice. • There is no structure to combine the weather information with agriculture information to generate useful message	• Government should increase investment to build the capacity of DHM to generate and disseminate more reliable weather information. • It is recommended to develop or establish separate institution responsible for generating accurate information. • Enhanced coordination between the government agencies and private sector would lead to coherence of efforts. It is

	• Private sector agencies working on ICTs based agro-advisory are working as a trial basis, hence there is weak capacity of private sector to continue agro-advisory service in sustainable manner.	recommended to expand the service of AICC up to district level. • More research is essential for full implementation of the trial basis services.
Financial	• Investment is limited for developing this technology. • Community media, mobile, video, and other ICTs tools may become extra financial burdens to poor farmers who barely raise enough crops to feed themselves.	• It is recommended to allocate sufficient budget or subsidy rate to make the technology more affordable to poor farmers. • Private companies providing these technologies can be supported through loans for starting service in payment basis. • It is also very important to create an inexpensive ICT tools that can be used for free by ordinary farmers and farm workers.
Technology	• The reliability of the SMS message generated though limited data is always questionable.	• Government should invest on building national capacity to improve the reliability of the seasonal, weekly and daily weather forecast.

There is great potential for private sector investment to scale up ICT based agro-advisory. Following actions are suggested for fostering private sector investment on this technology.

- Private companies who have started to provide these technologies can be supported through loans and subsidies to expand their service to broader people.
- Strong data sharing mechanism between private sector companies and DHM is essential for generating reliable message and advisory.
- Translation of climate-weather forecast to agro-advisory requires strong multi-stakeholder cooperation. Therefore, one intra-sectoral coordination mechanisms to generate and approve advisories would help on scaling up this initiatives through private sector.

1.5.7 Water harvesting and multiple use (community ponds, plastic ponds, harvesting tanks, plus water use efficiency)

Despite the fact that Nepal is predominantly an agricultural country, only 20% of the total land is arable and of which 40% is irrigated with modern means of irrigation system. Remaining 60% of the arable land is still rain fed, whose productivity is dependent on the monsoonal activities. Generally, there is heavy rainfall from June to September. Once the summer season is over, many parts of the country receive only sparse rainfall, which is not sufficient for farming of major crops. During winter season, the dry land areas receive very limited or no rainfall at all, which severely affect the farming activities in the hilly areas. Such uneven rainfall pattern or irregularities in water sources make agriculture an unattractive career choice in mid hills.

In dry land areas, farmer rely on springs for irrigation and other household purposes. However, there is no alternative means for irrigation once the source of spring is dried. Due to lack of knowledge about water preservation techniques and practices, all season water is not secured for agriculture. Their yearly production is not enough to support their entire family, and are forced to opt other occupation to sustain their livelihood. Many active youth force are compelling to migrate to city or other areas for better livelihood opportunities. However, traditional and unscientific farming can be converted into productive farming if water sources are secured all year round. Water harvesting system or technologies could be used to make agriculture appealing to youth to take up farming. There are various approaches to conserve water, such as community ponds, plastic ponds, harvesting tanks and so on. All year round water availability allows farmer to diversify their cropping patterns. These practices are best fitted for irrigation in the hilly areas of Nepal and hence screened as potential CSAs practice. There are many benefits of these approaches.

- A reliable water supply for both the domestic and irrigation purposes in dryland areas.
- Waste water can be tapped and utilized.
- Off-season high value crops can be grown.
- Do not have to carry water from long distance reducing workload.
- In the presence of good technique, the water collected in the rain jar can be utilized for drinking and then for irrigation.
- Fish farm can be initiated in the ponds allowing farmers to earn additional income.
- Improves climatic conditions.

Limitations of water harvesting systems are:

- Expensive for poor farmers.
- Conflict in benefit sharing for the community pond.
- Negligence in maintenance/repair.
- Lack of water user group for raising fund.

Table 14 Water harvesting and multiple use contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Availability of water helps to grow high value crops and add food stuff in food balance sheet. • Fish farming could become additional income that increase the food security and alleviate poverty.
Adaptation	• Splash action of rainfall is reduced as well as acceleration rate of water is reduced; increasing crop and grassland productivity and support adaptation. • Barren land come into cultivation due to availability of water for irrigation.
Mitigation	• Improvement of water harvesting practices can reduce GHG emissions, contributing to mitigation. • Plastic it is a non-degradable item, and thus, proper disposal method has to be developed.
Gender equity and social inclusion	• Does not have to travel long distance to fetch water. Efficient use of water reduces the time for collection of water that ultimately reduces women drudgery.

Scaling pathways for water harvesting and multiple use

Due to fragmentation of land, majority of the farmers are at subsistence level with small land holding capacity. Additionally, out-migration process is becoming lucrative business for young and energetic family members, resulting abandonment of agricultural land. In the long run, out-migration process may turn to negative action for agriculture. Therefore, there is scope for promoting this technology through a combination of interventions knowledge-transfer and market facilitation or extension model. Water harvesting practices could be scaled up by following actions to remove policy, institution and financial bottlenecks.

Table 15 Scaling pathways for water harvesting system

Particulars	**Gaps/bottlenecks**	**Recommendation**
Policy	• These practices are in use but not implemented massively. • These practices are implemented on the basis of community approach, which could lead into distribution problem. In addition, more land is needed for community pond. • At present these schemes are not location specific and subsidy is given to whoever want to adopt this practices. • Conservation of water pond in hill areas is not prioritized.	• It is recommended to adopt these practices as campaign to have better or inclusive impacts. • Adoption of these practices at individual level would help in resolving the land problem as well as dispute in benefit sharing. • It is better to design location specific schemes for successful scaling up of these practices. For example, vulnerable areas must get high priority while implementing these practices. • Provision of construction and rehabilitation of traditional water pond is very essential.
Institution	• Government prioritize to construct medium and mega irrigation projects, and thus these schemes are getting less priority from government. • Lack of government engineer at DADO. For example, IDE Nepal trained man power for construction and repairing of Thai Jar.	• Facilitation from the government is needed to prioritize these schemes for successful adoption in hilly areas. • It is essential to create either engineer or overseer position at DADO to scale up these practices effectively.
Financial	• Limited budget for this scheme as more priority is given to canal construction. • Dry land irrigation system does not fall under government priority list. • At present government provide scheme-based subsidy, not adequately targeted to results. • Subsidy is given at proposal based. • Banks do not provide loans easily	• It is recommended to allocate sufficient budget for these schemes to scale up successfully. • Facilitation from the government is needed to initiate dryland irrigation concept allocating separate budget for this region. • It is essential to adopt result based subsidy that could benefit the needy ones. • It is recommended to increase the collateral-free loans to poor

	to poor farmers even though they keep their land as collateral.	farmers.
Technology	• Lack of crop wise research method is limited.	• More research is essential in recommending farmers with different crop patterns for different climatic conditions.

Picture 6 Community pond, Majhthana, Kaski (Note: Water from this pond used for feeding livestock and cultivation of off-season vegetables)

1.5.8 Conservation agriculture production system (zero/minimum tillage, residue retention and crop rotation management i.e. intercropping)

Persistent use of conventional farming practices based on extensive tillage, degradation of natural resource base, high rates of soil erosion, increased cropping intensity, and poor management of soil nutrients are responsible for decline in soil fertility (Regmi & Zoebisch, 2004; Montgomery, 2007; Verhulst, 2010). Soil fertility is a critical issue to the farmers, particularly where population pressure is high, and agriculture is the main source of livelihood as nutrient depletion and poor soil management threaten food security (Koirala et al., 2015). Owing to its low adaptive capacity to climate change, Nepal is more vulnerable due to climatic variability and extreme weather conditions, such as heavy rain, hailstorm, droughts, floods, pest and crop diseases. Climate variability or extreme weather conditions affect agricultural productivity, and poses challenges to food security, threatening livelihood of the marginalized groups.

Nevertheless, there are practices that can maintain sustainable agricultural system. Conservation agriculture (CA) is a widely adapted set of management principles that can promote sustainable agricultural production (Verhulst, 2010). CA can be defined as a sustainable agriculture production system (CAPS) comprising a set of soil management practices that minimize the disruption of the soil's structure, composition, and natural biodiversity (Gonzalez-Sanchez et al., 2015). All forms of CA share three basic principles irrespective in the types of crops grown and specific management regimes. These are:

i. Minimum soil disturbance through tillage. It can be achieved through zero tillage, just enough to get the seed into the ground. It may involve controlled tillage seeding systems that normally do not disturb more than 20-25% of the soil surface (Verhulst, 2010).
ii. Maintenance of permanent or semi-permanent soil cover using either a previous crop residues or specifically growing a cover crop for this purpose. The main purpose of maintenance of permanent soil covers is to protect the soil from water and wind erosion, to reduce water run-off and evaporation, to enhance soil physical, chemical and biological properties associated with sustainable productivity.
iii. Cropping system diversity, crop rotations. The objective is to employ diversified crop rotations to help moderate/mitigate possible weed, combat the various biotic constraints such as disease and pest, and to utilize the beneficial effects of some crops on soil conditions.

CAPS has many advantages. These are:

- Provide and maintain an optimum environment of the root-zone to maximum possible depth. Roots are able to function effectively to capture high amounts of plant nutrients and water.
- Ensure that water enters the soil so that (i) plants never suffer water stress that will limit the expression of their potential growth: and (ii) so that residual water passes down to groundwater and stream flow, not over the surface as runoff.
- Avoid physical or chemical damage to roots that disrupts their effective functioning.
- Favor beneficial biological activity in the soil in order to: maintain and rebuild soil structure, compete with potential in-soil pathogens, contribute to soil organic matter, and contribute to capture, retention and slow release of plant nutrients.
- Emission of GHG reduced due to the zero or minimum tillage practice.

Table 16 Conservation Agriculture Production System contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Conservation agriculture practices help to promote soil nutrients, soil health, soil micro flora and soil moisture, which maintains sustainable soil. Maintenance of sustainable soil can increase crop yields ensuring food security sustainably.
Adaptation	• Slope land are more vulnerable to erosion. However, sustainable soil increases moisture retention and water holding capacity. • Green coverage reduces soil erosion and convert barren land into productive land contributing to adaptation and building resilience to climate change. • Reduced GHG emission create positive impact on CSAs.
Mitigation	• Use of herbicides has less emission levels of GHG as compared to ploughing. For example, the ploughing action emits GHGs 10 times higher than that of using herbicides in the fields. Judicious use of herbicides is recommended.
Gender equity and social inclusion	• Farmers do not have to plough the field which saves both time and money.

Scaling pathways for conservation agriculture production

Proper adoption of CAPS can increase crop yields while reducing production costs, decrease labor cost, and increase soil fertility without damaging the environment. Therefore, this practice could be promoted either intervention of knowledge-transfer or extension model. Table 17 shows some

of the actions that can be taken to scale up conservation agriculture.

Table 17 Scaling pathways for Conservation Agriculture Production

Particulars	**Gaps/bottlenecks**	**Recommendation**
Policy	• Lack of demonstration and piloting for this practice. So far demonstrative effect has not come. • Soil acidity management or agricultural lime is not available at local market. • Government does not allocate any budget for this practice (not compulsory practice or does not fall under government priority list) • Fragmentation of the agricultural land impede successful adoption of this practice.	• This practice is a viable option for many farmers to earn livelihood and hence it is recommended to promote this practice as campaign. • Nepalese soil is highly acidic in nature and agricultural lime has to be applied to maintain soil fertility. Provision of local market for agricultural lime would help to adopt this practice effectively. • Facilitation from the government is needed to prioritize this practice and allocate separate budget through DADO. • It is recommended to have consolidation of the agricultural land as per crop requirement for successful adoption of this practice.
Institution	• Since it is controlled by engineering directorate there is lack of network at grass root level. • Lack of extension system for successful implementation of these technologies. • Due to fragmentation of land, low land holding capacity, and subsistence level farmers, this technology is expensive for poor farmers. • Equipment for minimum and zero tillage are not available.	• Enhanced coordination between government and local farmers would lead to coherence of efforts. • Provision of good extension systems would assure the availability of materials and services leading to higher adoption. • It is recommended to broaden subsidy schemes to cover other materials that would improve farmers access to these technologies. • Provision of skilled manpower and supplier would encourage adoption of this technology effectively.
Financial	• Simply demonstration but doesn't have subsidy scheme for this practice. This practice is not compulsory/mandatory for government organizations.	• Adoption of subsidy scheme would increase the implementation of these practices. It is recommended that government could prioritize

	• Some national and international organizations are piloting the champions.	these practices by including these practices in its annual programs. • Provision of good coordination between government and other organizations would increase the adoption of these practices.
Technology	• Proper technology is not generated and farmers are not convinced.	• Development/generation of proper technology would help in adoption of these practices.

1.5.9 Climate resilient seeds, varieties and breeds

Global warming is resulting in less and more erratic rainfall placing unprecedented pressure on food pressure, especially in regions where food security is very low (Tirado & Cotter, 2010). The extreme weather conditions or changing environmental conditions, such as droughts or torrential precipitation will alter agricultural conditions, that severely affect the poor, particularly poor farmers reliant on traditional crops (Cho, 2013). Therefore, it is necessary to develop seeds that are higher yielding, more nutritious, and drought and climate resilient to meet current global challenges. The development of climate resilient seeds, crop varieties and hybrids, harnessing the latest genomics, breeding and biotechnology tools, enhance fertilizer use efficiency, tolerance to heat, drought and salinity, and pest and diseases.

Nepalese farmers are highly benefitted by the development of improved varieties of seed or climate resilient seed as it provides opportunity to improve food security by planting new varieties of crops that capable of withstanding the impact of both severe droughts and floods. Nepal Agricultural Research Council (NARC) has approved six drought-tolerant varieties of rice, under the name Sukkha (meaning dry) Generally, ordinary rice varieties couldn't tolerate drought dry out and water logged. However, these new climate resilient seeds can tolerate drought even in the early stage of growth. NARC also approved two rice varieties capable of surviving under flooding conditions for up to two weeks. NARC also established gene bank to preserve the seeds, as well as propagating materials of Indigenous as well as exotic cultivars.

Table 18 Climate resilient seeds, varieties and breeds contribute to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• Climate resilient seeds are adapted to less favored areas and production systems, producing food with higher nutritional value, and help to improve the provision of food security.
Adaptation	• Climate resilient seeds are better adapted to ecologically based production practices, have greater resistance to insect pests and diseases, are more tolerant to drought, flood, frost and higher temperatures. • Preservation and multiplication of the endanger breed and seeds help to produce food in crisis.
Mitigation	• No mitigation is needed.
Gender equity and social inclusion	• Saving of these climate resilience breed and seed not only benefited to women but all.

Scaling pathways for climate resilient seeds

Despite the experts are backing the introduction of the new or improved varieties of seeds in order to combat an extreme weather conditions, persuading farmers to change their traditional cultivation methods is still a difficult task in Nepal. It is therefore, this technology could be promoted through an interventions of market facilitation and extension model. In order to scale up this practice action in the policy, institutional and technical arenas is needed (Table 19).

Table 19 Scaling pathways for climate resilient seeds

Particulars	Gaps/bottlenecks	Recommendation
Policy	• NARC developed limited resilient crops. So far only rice breeds are developed. In addition, the developed varieties are not available easily. • Seeds are not developed according to the farmers' choice. • CSAs policy of government not yet formulated.	• Use of genetically diverse varieties and breeds would contribute to adaptation and resilience. Therefore, it is recommended to develop more high yielding crops with resilient varieties. • Extensive research about seeds, varieties, and breeds in collaboration with NGOs, INGOs and government organizations would help to adopt this technology effectively. • It is essential to formulate and mainstream CSAs policy into core government policies and programs including policy expenditure and planning frameworks from the local to national level.
Institution	• Lack of networking about development and extension of seeds. • Research is very weak. For each crop, improved breeds are not available. • Community seed banks are not available everywhere.	• Cross-sectoral coherence, coordination and integration among NARC, NGOs and INGOs would facilitate the development of high yielding varieties, seeds and breeds. • It is important to strengthen capacity building creating a new generation of skilled practitioners to support enhanced breeding, work with farmers, and explore the ways in which crops and varieties contribute to successful intensification. • It is recommended to establish community seed banks in all 75 districts in order to preserve local genetic resources and to ease seed delivery systems leading

		higher adoption of this practice.
Financial	• Limited budget in research and development. • No particular budget for seed varieties has been allocated.	• It is recommended to increase the financial back up substantially for the research and development sector that would help to adopt this practice successfully. • It also necessary to allocate substantial budget for seed varieties program and DADOs could internalize this practice in their annual programs.
Technology	• Lack of research on climate resilient seeds.	• Extensive research need to be taken by NGOs, INGOs and government organizations for successful scaling up of this practice.

1.5.10 Solar based irrigation system

The irrigation system is the method that distributes a controlled amount of water to plants or targeted area at regular intervals. It is used to assist in growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soil in dry areas and during periods of inadequate rainfall. The efficiency of the irrigation is highly influenced by the type of system used (Sawant et al., 2015). There are many types of irrigation tools or system available all over the world. Solar power, the most abundant source of renewable energy in the world, is not only a solution to current energy crisis but also an environmental friendly form of energy. Photovoltaic generation is an efficient approach for tapping solar energy, and are extensively used for running household appliances, running street lights, and for powering water heaters (Harishankar et al., 2014). Solar energy can be incorporated in irrigation systems for agriculture. Solar based irrigation system can become a suitable alternative for isolated and rural areas. Solar based irrigation systems are used primarily for three applications:

- Irrigation for farming.
- Drinking water for human being and livestock.

Although 67% of Nepalese engage in agriculture, Nepal is a net importer of food as most of the productions are only at subsistence level. Similarly, most of the poor farmers are unable to grow crops during the 7-8 months' dry season due to lack of irrigation systems. In order to boost agricultural productions, regular means of irrigation tools or systems are necessary. At present there are different irrigation system in Nepal, such as:

- Human power for pumping (only small scale).
- Diesel powered (expensive, unavailability).
- Electricity (load shedding, unavailability, low voltage).
- Solar (Department of irrigation has not installed any solar pump so far).

Diesel water pumps are most efficient means for irrigation, however, in the long run they are not sustainable. Diesel water pumps are very expensive, and fuel is not always available, and also diesel motors can break down. In this regard, diesel pumps can be replaced by solar pumps. Although solar based irrigation system can be cost effective over several growing seasons, the solar pump

technology currently available in Nepal is expensive for poor farmers as the initial investment is very high. So far, the department of irrigation has not installed any solar pump for irrigation purposes. First pilot project on solar pump was installed by International Centre for Integrated Mountain Development (ICIMOD) in Saptari and Chitwan districts. In Saptari, a 2 horse-power (HP) solar powered irrigation pump (SPIP) for the water seller and three 1 HP for other farmers to demonstrate the value of SPIP, raise awareness, and promote alternative energy for irrigation was installed in 2015. Recently, LI-BIRD has piloted SPIP in different parts of the Terai belts.

Table 20 Solar based irrigation contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• With the help of solar power, groundwater can be withdrawn or lifted. • Availability of water increase the cropping intensity leading to food security. • Dry land come in to cultivation and add food grain to the food balance sheet.
Adaptation	• This system can be used at any place. • Once set up it doesn't need any fuel.
Mitigation	• This technology is neutral to GHGs.
Gender equity and social inclusion	• Reduces women drudgery since they don't have to travel long distance to carry water for irrigation.

Scaling pathways for solar based irrigation

Solar based irrigation technology has a potential to provide direct financial benefits to farmers, and has been a part of commercial agricultural production system. This technology is quite new in the context of Nepal, and thus, there is scope for promoting this technology through a combination of interventions policy-push model, knowledge-transfer and market facilitation. **Table 21** summarizes the scaling up pathways for solar based irrigation in Nepal by removing policy, institution and financial bottlenecks.

Table 21 Scaling pathways for solar based irrigation

Particulars	**Gaps/bottlenecks**	**Recommendation**
Policy	• Solar based irrigation technology awareness is very low among the farmers. • So far, subsidy scheme is not available if this technology is used for irrigation. And also if solar power is used in those area where there is national grid then no subsidy is given for this technology.	• It is very important to have institutional arrangements that support solar based irrigation technology awareness in Nepal. • Government need to amend existing policies about solar technology and make new policies in favor of solar based irrigation that would help to improve farmers' access to this technology. • Provision of subsidy for the irrigation purpose, no matter where it is installed would help to adopt this practice.
Institution	• No institutional set up for promotion of solar based irrigation. • Lack of service provider.	• Provision of proper institutional arrangement that support collaborative action of solar based irrigation technology would help to adopt this technology.

		• Provision of capacity building to impart knowledge and awareness through training is very essential in promotion of this technology.
Financial	• Relatively new technology and thus, no subsidy for this scheme.	• Government need to promote solar based irrigation technology under small scale irrigation program allocating subsidy scheme for this practice.
Technology	• This technology has not developed in full fledge.	• Government need to increase investment in building knowledge base and developing robust and proven technology that would support poor farmers.

Picture 7 Solar based irrigation system supported by LIBIRD, Chormara, Nawalparasi

Picture 8 Positive impacts of Solar based Irrigation Technology at Chormara, Nawalparasi

1.5.11 Rhizobium and nitrogen management

Although the atmosphere represents 80% nitrogen gas (N_2), it is a major limiting factor in agricultural production (Lebrazi &Benbrahim, 2014; Abd-Alla et al., 2014). Due to the high stability of N_2 molecule, it is unusable by most living organism, and only some prokaryotic organisms are able to reduce it in an available form. Since it is not readily available, plants, animals, and micro-organisms can die of N_2 deficiency. Thus, effective management of N_2 in the soil environment is crucial for agricultural sustainability.

The biological nitrogen fixation (BNF)is a natural process that convert inert atmospheric nitrogen into biologically useful ammonia by the nitrogenase enzyme complex.This phenomenon is mediated in nature only by N-fixing bacteria, and in agricultural settings, about 80% of BNF come from symbioses formed between leguminous plants and species of *Rhizobium, Sinorhizobium, Bradyrhizobium, Azorhizobium, Mesorhizobium* and *Allorhizobium* (Vance, 1998).*Rhizobium* can infect some root cortex cells of leguminous plants and initiate the formation of a new plant organ, the root nodule (Lebrazi&Benbrahim, 2014). These bacteria proliferate within root nodule cells then differentiate into a nitrogen fixing form known as bacteroid, which can convert inert atmospheric nitrogen into biologically useful (Chanway et al., 2014). Legumes and rhizobia symbiosis can fix the atmosphere nitrogen, and thus often introduced to manage the agricultural ecosystems to improve organic fertility (Table 22).

Table 22 Rhizobium and nitrogen management contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• *Rhizobium treatment* in the leguminous crop helps in soil nutrient management, nitrogen fixation and soil fertility. Healthy soil helps to increase food productivity.
Adaptation	• Sustainable soil leads to increase crop productivity which is positive for adaptation. • Because of the deep rooted crop (Leguminous) it binds the soil, add organic matter to the soil and increases the crop canopy coverage.
Mitigation	• No side effect at all.
Gender equity and social inclusion	• It reduces drudgery on women since they don't have to carry and apply manure in large doses.

Scaling pathways for Rhizobium and nitrogen management

Rhizobium plays vital role in maintaining soil fertility. This technology could be promoted through a combination of interventions market facilitation and knowledge-transfer. This technology could be scaled up effectively by following actions to remove policy, institution and financial bottlenecks (Table 23).

Table 23 Scaling up pathways for rhizobium and nitrogen management

Particulars	**Gaps/bottlenecks**	**Recommendation**

Policy	• Pure quality not available. Due to lack of skilled practitioner most of the *rhizobium* cultures are dead. There is no specified culture. • No awareness campaign for this practice.	• Inoculation of stress tolerant strains of rhizobia could enhance the nodulation and nitrogen fixation ability of legumes under stressed conditions. Therefore, provision of healthy *rhizobium* culture would help to adopt this practice at larger scale. • It is recommend to promote this practice as campaign.
Institution	• Soil management directorate gives low priority to this practice. In addition, institutional set up is very weak for this practice. • Supply mechanism is very weak and not available in the market.	• Cross-sectoral coherence, coordination and integration among government and agencies such as NGOs, and INGOs are very crucial for adoption of this practice. • Provision of service provider would help to improve the access of this practice in all 75 districts of Nepal.
Financial	• No financial program for this practice has been allocated. • DADOs office are not compel to include this practice in their annual programs.	• Allocation of proper subsidy scheme could benefit the needy and poor farmers. • Government need to increase collateral-free loans to poor farmers.
Technology	• The available *rhizobium* culture is not reliable and crop specific.	• Extensive research is needed to make this technology more reliable and verifiable.

1.5.12 Weather-index based insurance

Increasing incidents of frequent occurrence of heavy rain, hailstorm, droughts, floods, heat waves, cold waves, and crop diseases impacts on a large cross-section of poor, small, and marginal farmers in Nepal. The extreme weather conditions affect the agriculture sector the hardest, particularly in dryland areas. Weather uncertainty ultimately affect the income of agricultural producers and agribusinesses. It affects the variations in market prices for agricultural commodities and production inputs; and also bring variations in the volume or quality of the commodity produced. From insuring against such uncertainties, a variety of index-based insurance schemes offer ways for farmers to mitigate the risks associated with price of commodities and production.

Banks in Nepal are unwilling to lend to smallholder farmers, primarily because of the risk that they would not pay back their loans if there is a drought or erratic rainfall. Additionally, mostly smallholder farming is at subsistence level. Without access to loans, farmers could not purchase high quality seeds and other production inputs that would increase productivity and enhance their living standard. In this regard, weather-based index insurance scheme may become effective strategy as a way of transferring risk and protecting small farmers in Nepal and especially mid hills. It may become an alternative solution for developing agricultural economics in dryland areas of Nepal. For example, with the protection of insurance, when a drought hits, farmers receive automatic insurance pay-outs preventing poor farmers from selling off productive assets like

livestock to support their livelihood. Weather-index based insurance has potential to become champion CSA.

Table 24 Weather index based insurance contributes to CSA pillars

CSA pillars	Roles/Strengths
Food security	• Farmers are lucrative to do farming that ultimately provide opportunity to grow more food, and hence increase the food balance.
Adaptation	• Insurance reduces the risk of loss of production from disasters. Even if farmers' loss their products, they can manage their living as they will get money from insurance.
Mitigation	• No mitigation majors are needed.
Gender equity and social inclusion	• Everybody is benefited.

Scaling pathways for weather index based insurance

Weather-index based insurance could help smallholders' farmers to manage disaster such as drought risk. Thus, this technology could be promoted via market facilitation, knowledge-transfer and extension model. Following actions can be done to improve policy, institutional and financing environment for index-based insurance in Nepal (Table 25).

Table 25 Scaling pathways for weather index based insurance

Particulars	Gaps/bottlenecks	Recommendation
Policy	• So far no explicit policy about weather-index based insurance is available in Nepal.	• Formulation of explicit policy about weather-index based insurance would help to promote adoption of this practice.
Institution	• Few insurance schemes are available but centered only in city areas. • Lack of knowledge about insurance mechanism. • Registered insurance company are less in number and out of reach to the farmers.	• An enabling legal and regulatory framework is necessary for the expansion of the program. • Client/stakeholder education and outreach is essential to establish successful micro-level insurance programs. • Government need to increase the registered insurance companies.
Financial	• At present insurance scheme covers only cost of production. • Allocated funds for insurance is not fully utilized.	• Adoption of insurance scheme that covers total production costs would benefit the farmers leading to higher adoption. • Majority of the farmers are not well educated and hence, it is necessary to make insurance claiming process farmers friendly to popularize this practice.

Technology	• Proper technology is not developed.	• It is essential to allocate sufficient budget in technological innovations.

1.5.13 Small hand tools, equipment and machines

In the context of Nepal, development of agriculture is not only important for ensuring food security but also important for poverty reduction since most of the vulnerable groups including pastoralists, landless, and subsistence farmers rely on agriculture as their main source of livelihood. The growth of the sector is therefore expected to have a greater impact on a larger section of the population as compared to any other sector. Agricultural mechanization is one of the major agricultural inputs that contributes to the viability of the farm by enhancing production efficiency. Proper mechanization has the potential to expand production, improve timeliness of operations, widen the application of power to crop processing, irrigation and infrastructure improvement, compensate for labor shortage, and reduce drudgery (Pressman, 2011).

The main types of mechanization in the country include the use of human, animal-drawn, and motorized machinery, implements and equipment. Despite agricultural mechanization being vital for agricultural production, most Nepalese farming communities lack machines to undertake their operations efficiently and effectively. For example, still hand and animal draught power are important means for agricultural production in mid hills. The relatively low level of mechanization is due to a number of challenges facing the sub-sector:

- Inadequate research and technology development.
- Weak local manufacturing and distribution.
- Insufficient agricultural mechanization quality assurance.
- Low level of investments in mechanization services.
- Lack or no provision of custom hiring services.
- Poor extension and technology adoption.
- Weak institutional and legal framework.
- Smallholder farmers often lead precarious lives and so incomes are erratic and low.

Although agriculture mechanization can increase the emission, however, the provision of small hand tools, machines would lead to increased resilience of households, particularly with reduced drudgery to women (Table 26)

Table 26 Small hand tools, equipment and machines contributes to CSA pillars

CSA pillars	**Roles/Strengths**
Food security	• The use of appropriate agricultural equipment and tools contributes to the viability of the farm by enhancing production efficiency and reducing food insecurity.
Adaptation	• Fallow as well as uncultivated land can bring in to cultivation. Cost of cultivation decreases. Cost benefit ratio could increase. • Applicable to all areas which help to reduce climatic hazards. • This practice help farmers to cope with changing climate.
Mitigation	• Misuse of the machinery should be avoided.
Gender equity and social inclusion	• It reduces women drudgery. For example, introduction of millet thresher, corn sheller significantly reduces the working hours for women. Zero tillage machine reduces the time of cultivation.

Scaling pathways for small hand tools, equipment and machines

Agricultural mechanization plays a key role in increasing efficiency and effective utilization of the production resources. Nepalese agricultural sector is important in contributing to food security, production of agro-based raw materials, employment creation, income generation and earning of foreign of exchange. Therefore, there is scope for promoting this technology through a combination of interventions market facilitation, knowledge-transfer and extension model. However, a number of reasons have hindered enhanced adoption of the technology along the production value chain. **Table 26** summarizes the scaling up pathways for agricultural mechanization by removing policy, institution and financial bottlenecks.

Table 27 Scaling pathways for small hand tools, equipment and machines

Particulars	Gaps/bottlenecks	Recommendation
Policy	• Government started agricultural mechanization but not available everywhere. • Lack of implementation. Appropriate machines are not developed.	• Government need to establish an agricultural mechanization research institute that could develop and encourage capacity for the local manufacturing and processing. • It is necessary to develop clearly defined agricultural mechanization policy that would help to proper implementation of machines. • It is recommended to design agricultural mechanization strategies for location specific.
Institution	• Agricultural engineering does not have network at district level. • Only one agricultural industry but not functioning. • NGOs and INGOs promoted without coordination which is not effective. • No responsible institute for agri-equipment distributer in the district level. • Private sector selling imported farm machinery without any research and verification. • Repair and maintenance work shop is lacking.	• Provision of cooperation in areas of mechanization, resource mobilization and technical support among the promoters and farmers would increase the chances of successful scaling up of the technology. • It is essential to put more emphasis on private sector development as well as public private partnership in terms of agricultural mechanization vehicles, tools and equipment as well as small mechanization enterprise development by small-scale farmers for small-scale farmers. • It is recommended to adopt custom hiring as well as availably of reliable work shop services at the local levels.
Financial	• 50% subsidy is given to agricultural machines. However, the subsidy is in quota system. • Affordability of	• It is recommended to provide subsidy according to the demand of the poor farmers, leading higher adoption of the technology. • The subsidy must be provided according

	mechanization inputs is often beyond the reach of the smallholder family.	to the demand of the poor farmers. • Broadening subsidy rate for needy and poor farmers would make the technology more affordable to them.
Technology	• Repair and maintenance is very weak. Invest in technological innovations is very low.	• It is essential to increase field level capacity building and capacity development for smallholders with agricultural mechanization integration into farmer field schools and farmer business schools.

Picture 9 Seed cum fertilizer drill, supported by LIBIRD, Rajhar, Nawalparasi


Picture 10 Millet sheller, supported by LIBIRD, Majhthana, Kaski

1.5.14 Plantation and agro-forestry (livestock management)

In Nepal, the rural landscape that encompasses an agrarian economy, fragile ecology, and a complex and differentiated society is changing rapidly, with creation of new opportunities as well as challenges (Pandit et al., 2014). Agriculture[4] remains the backbone of rural economy, despite this rapidly changing environment, and thus, majority of its population in the rural areas are compelled to derive their livelihood directly or indirectly from agriculture. In the mid-hills, the agro-forestry system, particularly the integration of fodder and grasses with livestock system, has been an integral component of farming as well as source of livelihood for poor and smallholder farmers (Gurung et al., 2010; Pandit et al., 2014).

Livestock rearing is the second major economic activity in rural areas contributing to 20-30% of the total annual farm income and has potential to become a steady source of income for poor people (Amatya, 1999). Generally, there are two livestock rearing systems: (i) a major part of animal production takes place on open pasture and forests especially in the high mountain areas, and (ii) a small number of animal are fed by cut and carry of fodder and farm residues (Amatya, 1999). Nepalese heavily dependent on forests for the supply of fuelwood, fodder and timber. Consequently, most of the accessible forest is degraded. The pressure on forest and grassland has reached unsustainable high levels beyond their sustainable capacity, resulting in a sharp decrease in area and productivity of these lands. Unsustainable management of forest resource ultimately affect livestock production due to acute shortage of feed and fodder.

In Nepal, planting of trees on farms is a traditional practice under which farmers' plant trees for meeting their household needs including fuel, fodder, timber, and fruit. Often trees are also raised on farmlands, in association with agricultural crops which is known as agro-forestry. Agro-forestry[5]can be defined as the concurrent use of land for agriculture, forestry, horticulture, and for raising livestock. Agroforestry systems and practices may become prominent solution for several agricultural and ecological problems: exploitation of forest resources, soil degradation, increasing population pressure and insecurity of land tenure. Proper agroforestry systems can meet the present and future requirements of fuelwood, fodder, timber, and environmental protection. This is a suitable CSA technology for hills and mountain regions (Table 28).

Table 28 Agro-forestry contributes to CSA pillars

CSA pillars	Roles/Strengths
Food security	• Agro-forestry helps in maintenance of soil organic matter and nutrient cycling, increasing production of food item. • Marginal land can bring into agro-forestry and food item can be added.
Adaptation	• Tree crop could play a role in diversifying farm production, promoting soil stability and maintaining an acceptable stock carrying capacity. • Agro-forestry has been recognized as one of the important systems for supporting the livelihoods of a large number of rural farmers in the hills in addition to the climate change adaptation.

[4]There are two cropping systems: onebasedon riceproduction on irrigated flat land, and the otherbased on the production of mazie and millet on rainfed land.

[5]Agroforestry is the land use science which deals with the interaction between trees and crops, and of both with animals in the same unit of land. It can also be defined as land used commercially for tree production and agriculture where trees are planted in blocks of more than one hectare.

	• Reduce soil erosion and preserve water resources.
Mitigation	• Forest cover can sequester more CO_2.
Gender equity and social inclusion	• Reduces women drudgery as they can collect fodder and fuel wood from nearby areas.

Scaling pathways for agro-forestry

Agro-forestry provides direct financial benefit to farmers. There is great scope for promotion of this technology either knowledge-transfer or extension model. This technology could be scaled up successfully by amending bottlenecks in policy, institution and financial sector (Table 29).

Table 29 Scaling pathways for agro-forestry

Particulars	Gaps/bottlenecks	Recommendation
Policy	• Explicit policy for this practice does not exist although there is a good prospect of agro-forestry meeting the livelihood needs of rural households, reducing the pressure on forest resources and conserving biodiversity. • Conflict between the policies of the line ministry.	• It is recommended to formulate explicit policy for agro-forestry that would help to adopt this technology. • Enhanced coordination and integration between MoAD and Forestry would help to adopt this practice at larger scale.
Institution	• No institutional commitment for this practice. Only NGOs are supporting this practice.	• Government need to set up separate department to support information exchange and partnership building with other agencies and farmers.
Financial	• No financial program for agro-forestry.	• Provision of subsidy scheme would improve the adoption of this technology.
Technology	• Lack of research.	• Extensive research is needed for on-farm agro-forestry species.

Enabling environments needed for scaling CSA technologies and practices in Nepal

The main objective of CSA technologies and practices is to sustainably raise the level of agricultural practices for increased productivity and income of agricultural produces. These can be achieved through research and technology development, agricultural mechanization quality assurance, investments in mechanization services, extension and technology adoption and improved and legal frameworks.

Table 30 Summarizes the enabling environment for scaling up CSAs in Nepal

Action	Enabling environment
To change the attitude of adaptor	• Improved communication networks and emerging media interest around climate change is essential for continued public support and to improve chances of adoption

	• Create awareness of CSA technologies and practices through: training, demonstration, visit, campaign • Cross-sectoral coherence, coordination and integration among government, NGOs and INGOs to motivate farmers to adapt CSA technologies and practices • Promotion of public-private-partnership in CSA technologies and practices
Support system	• For adoption and scaling up of CSA practices and technologies, provision of proper seed supply system, nutrient supply system, marketing of value chain support are essential • NGOs and INGOs can act software: provide training, visit, demonstration, etc, • Government can act as hardware: build infrastructure • Public support focused on research, developing human capital, sustainable management of soil and land, social protection and safety nets • Stimulate mobilization of resources for investment in agricultural mechanization • Promote and regulate agricultural mechanization quality and standards • Promote agricultural mechanization technologies that are gender responsive • Inputs related to the application of the champion CSAs could be supported by the government in the hardware and software where as other promoter in software part
Minimum price	• Provision for fixation of minimum price to the agricultural products • Buy back guarantee system • Partnership with non-government stakeholders
Insurance	• CSAs integrated with disaster risk management and social safety net programs • Access to different forms of insurance: crop, livestock, index
Input supply system	• Fertilizer, irrigation, seeds and seeds support cooperative • Generation of location specific tools and technologies • Agricultural business hub • Information and communication technologies to improve agricultural information access • Allocate more budget in agricultural education and training institution • Provision of machinery and equipment suppliers • Integrate management and reduced competition with livestock or other uses e.g. through increased forage and fodder crops in rotation • Use of various cover crops, especially multi-purpose crops, like nitrogen-fixing, soil-restoring, pest repellent
Value addition	• Strengthened formal and information agricultural markets for value addition products
Subsidy	• Flat subsidy system could be replaced result oriented subsidy scheme • Subsidy must be loan specific, gender specific and marginalized specific
Credit	• Adoption of highly subsidized interest rate with easy access in production credit

	• Provision of the project as a collateral for the credit is to be accepted • Provision of collateral-free loans to poor farmers

Conclusions and Recommendations

Nepal's government is aware and strongly committed to tackling climate change by formulating various policies that are directly and indirectly support CSAs in Nepal. However, the current policies, strategies and laws related to climate change are not adequate. There is a lack of systematic efforts to identify champions and are not adequately incorporated into extension guidelines, manuals, government plans, budget and human resource planning for scaling up CSAs at larger scale. CSAs are not always backed with scientific evidences. More research is warranted for the various agro-ecological zones, soil types, rainfall patterns and farming systems. Due to lack of service provider, materials are not available at local market. In addition, due to poor economic conditions smallholder farmers are not able to adapt to some of resource needy practices e.g. rainwater harvesting jar, improved cattle shed, solar based irrigation, etc. Most farming communities lack machines to undertake their operations effectively and efficiently. The relatively low level of mechanization is due to a number of challenges facing the sub-sector, such as inadequate research and development, weak local manufacturing and distribution, low level of investments in mechanization services, poor extension and technology adoption, weak institutional and legal framework.

Recommendations for scaling up each CSAs:

Successful adoption of CSAs requires either appropriate technologies, practices or models within favorable enabling environments including supportive institutional set up, policies and financial investments at local to international levels. Additionally, it is essential to understand biophysical, socioeconomic and institutional issues at different scales, and integrating these dimensions to planning, implementing and monitoring CSAs scaling. Mainstreaming of CSAs into core government strategies, guidelines and annual action plans, including its inclusion into district and local development plans is a promising pathway for scaling up CSAs. Adoption of an inter-sectoral approaches and consistent policies/bylaws across agricultural, food security and climate change sectoral at all levels would improve effectiveness of CSA promotion and implementation. CSA practices and technologies can be scaled up successfully if following conditions are met.

Plastic house

- The bottlenecks for scaling up plastic house technology could be removed by waiving tax on import of plastic sheets for agriculture use; increasing subsidy, particularly to poor farmers; increasing result-based subsidy scheme; and investment to develop skilled manpower through training.

Plastic pond

- Plastic pond could be scaled up successfully by adopting result based subsidy scheme; waiving tax on import of plastic sheets for agriculture use; formation of plastic pond user group, in order to solve problems in benefit sharing; and promotion of collateral-free loans to poor farmers.

Drip irrigation

- The bottlenecks for scaling up drip irrigation technology could be removed by assuring quality of the drip materials; training to the service provider and extension agents; and good coordination among the promoters, farmers and other agencies.

Improve cattle shed

- Improve cattle shed technology could be scaled up effectively by adopting result based subsidy; demand based programme; and proper training to develop skilled manpower.

Combination package of plastic house, plastic pond, drip irrigation and improve cattle shed

- This champion could be adopted successfully by waiving tax on import of plastic sheets; development of skilled manpower via training; adoption of result based subsidy scheme; and material supply with quality assurance.

ICT based agro-advisory

- This practice could be scaled up successfully by expanding beyond piloting phase; provision of authentic certification of the technology, increasing subsidy scheme; developing inexpensive ICT tools; and provision of reliable means of power supply and internet facilities.

Water harvesting and multi-use of water

- This practice could be scaled up successfully by promoting as campaign; design location specific schemes; and allocating sufficient budget.

Conservation agriculture production system

- The bottlenecks for scaling up conservation agriculture production system could be removed by adopting custom hiring approach; enhancing coordination between government and local farmers; provision of good extension systems; and broadening subsidy schemes.

Climate resilient seeds, varieties and breeds

- This practice could be scaled up effectively by development of high yielding crops with resilient varieties; extensive research about seeds, varieties and breeds in collaboration with NGOs, INGOs and government organizations; and establishment of community seed banks.

Solar based irrigation system

- The solar based irrigation system could be scaled up successfully by adopting higher subsidy scheme; formulating explicit policy for this technology; capacity building, strengthen local organizations, create networks and information exchange; and collaborate and network with stakeholders.

Rhizobium and nitrogen management

- The bottlenecks for scaling up rhizobium and nitrogen management technology could be removed by inoculation of stress tolerant strains of rhizobia to enhance nodulation and nitrogen fixation; adopt as campaign; providing high subsidy rate; and institutional arrangement for extensive research and network.

Weather-index based insurance

- This practice could be scaled up effectively by adopting insurance for total production costs; making insurance claiming process farmers' friendly; and expanding insurance coverage to whole nation.

Agricultural mechanization

- The bottlenecks for scaling up agricultural mechanization could be removed by establishing an agricultural mechanization training institute; strengthening research-extension-industry linkages; and promoting appropriate gender friendly mechanization technologies.

Plantation and agro-forestry

- This practice could be scaled up successfully by developing community based agro-forestry program; adopting subsidy scheme for the technology; and formulating explicit policy for this practice.

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Annex 1 List of experts, government officers and farmers working on CSA in Nepal

SNo	Name	Organization
1	Sukdev Subedi	District Agriculture Development Office, Kaski
2	Lokendra Bohara	District Agriculture Development Office, Kaski
3	Sanjay Adhikari	District Agriculture Development Office, Kaski
4	Narayan Jung Khatri	District Agriculture Development Office, Kaski
5	Indra Oil	Regional Soil Laboratory, Kaski
6	Dhan Bahadur Rana	Regional Plant Protection Laboratory, Kaski
7	Shiv Raj Baral	Regional Plant Protection Laboratory, Kaski
8	Madhav Lamsal	Regional Engineering Directorate, Kaski
9	ChitraNath Paudel	Farmer, Hemja-1, Kaski
10	Mina Gurung	Farmer, Hemja-8
11	Ima Tamang	LIBIRD, Majhthana, Kaski
12	Bhakta Bahadur Sunar	Farmer, Majhthana, Kaski
13	Indra Kumari Gurung	Farmer, Majhthana, Kaski
14	Til Kumari Gurung	Farmer, Majhthana, Kaski
15	Hari Maya Gurung	Farmer, Majhthana, Kaski
16	Ganga Bahadur	Farmer, Rajhar-4, Kuleni, Nawalparasi
17	Durga Kumari Chaudhary	Farmer, Kawasoti-14, Agyouli, Nawalparasi
18	Tara Bhattarai	Farmer, Chormara, Hardiya-1, Nawalparasi
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20	Buddhi Thapa	LIBIRD, Nawalparasi
21	Tek Sapkota	CIMMYT, Delhi
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