Assessment of Climate-Smart Agriculture (CSA) Options in Nepal

Arun Khatri-Chhetri, Bikash Poudel and Paresh B Shirsath

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), New Delhi, India
Local Initiatives for Biodiversity, Research and Development (LI-BIRD) Pokhara, Nepal

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1. Background

Nepal's agriculture sector, which accounts for around three quarters of employment and one quarter of country's Gross Domestic Products (MoAD 2015), is highly affected by current climate variability, uncertainty and extremes. The major challenges being faced by Nepalese Agriculture sector are degradation of natural resources and increasing frequency of climatic risks (Deshar, 2013; Krishnamurthy, 201; IDS-Nepal, PAC, and GCAP, 2014). Evidences indicate that climate in Nepal is already changing and the impacts are being felt (MoE, 2010; Karki and Gurung, 2012; IPCC, 2014). Rise in average temperatures, changes in rainfall patterns, increasing frequency of extreme weather events such as severe droughts and floods and shifting agricultural seasons have been observed in different agro-ecological zone of Nepal. In recent years, long drought spells during monsoon and increased temperatures and unseasonal heavy rains during winter have caused serious distress to agriculture dependent communities in many locations of the country. If the Sustainable Development Goals of ending poverty, achieving food security and promoting sustainable agriculture is to be realised, climate change adaptation interventions need to be implemented in earnest.

The impacts of climate change on agriculture are more pronounced among smallholders, who are highly exposed and sensitive to climatic threats and have poor coping capacity. The smallholder farmers with average landholding is less than 0.5 hectare accounts more than 80% (CBS, 2011). These farmers are highly vulnerable to climatic variability due high exposure to climate change and low adaptive capacity. Evidently, the national yields of major cereal crops i.e. rice, wheat, maize and millet are less than half the global average (MoAC, 2011; FAOSTAT, 2012). A study in Nepal shows that the estimated direct costs of climate change is equivalent to 1.5-2% of current GDP/year in average years, which magnifies by gender and area (IDS-Nepal, PAC, and GCAP, 2014). This is expected to hit the poor and already vulnerable households more compared to others and may pose a challenge to poverty reduction strategies. In addition to climate, social changes like outmigration of male youths have increased women's workload in agricultural activities. Women also face structural power inequalities as well as poor access to resources and information required to cope with shocks and stresses and recover from climate-induced impacts. Besides, Dalits, indigenous people and disadvantaged families, whose livelihoods are highly dependent on agriculture, constitute the highly vulnerable population. The baseline study confirmed that Dalits as well as women and

Janajati households are the most vulnerable groups compared to others (for details see: Bhatta et al., 2015). Therefore, there is an urgent need to identify and promote technologies and practices that can increase farm productivity and farmers' adaptive capacity and, as co-benefit, ability to mitigate.

1.1. Overview of Climatic Risks in Nepal

Nepalese farming systems and crop/livestock production is deeply interconnected with climate variables such as precipitation and temperature largely because agriculture is predominantly rain-fed (Figure 1). Already water scarce rainfed and dryland areas are compounded by rapid evaporation, leading to severe water deficiency in crop growth and development stages. Excessive rainfall inundates fields and reduces crop yield. Onset and termination of rainfall (e.g. delayed monsoon, early withdrawal of rainfall), intermittent dry spells, extended wet spells and heat/cold stresses also affect plant growth, phenology and grain setting in crops, vegetables, and fruits.

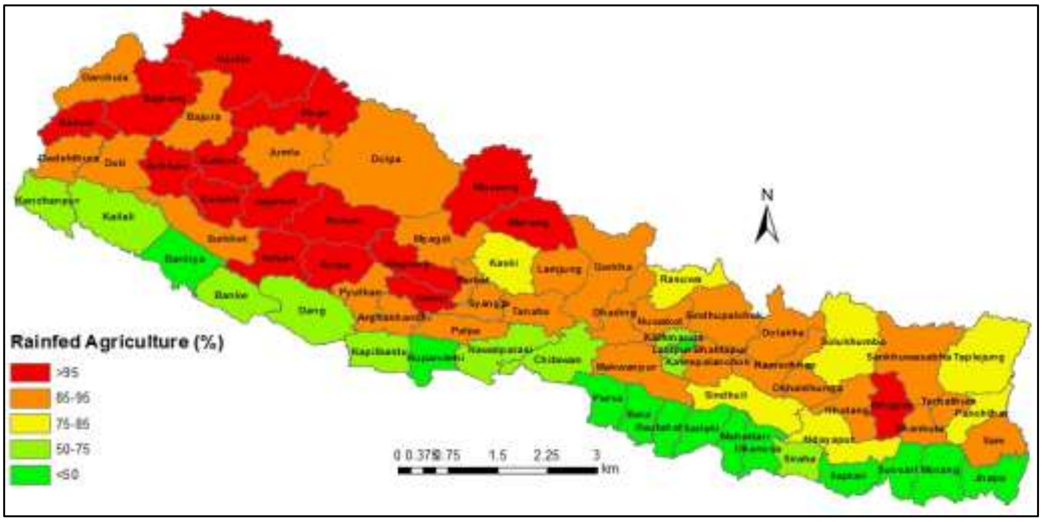

Figure 1: Percentage of rainfed agriculture by district in Nepal

Several other risks such as increased infestation of disease and pests, increased soil erosion, and soil nutrition deficiency are also directly or indirectly associated with climatic variability of both inter-annual and intra-seasonal rainfall and temperature. In the rainfed areas, soil moisture availability during pre-monsoon determines the planning date of maize. Long dry spells during and late monsoon period can significantly affect the establishment of millet and buckwheat. The priorities for maize and millet based cropping systems must shift to the maximization of moisture and soil conservation and use of improved seeds for increased production under climate change and variability. These are more evident in the hills and mountains that are warming more rapidly than the plain areas.

The spatial distribution map (Figure 2) shows variability in rainfall over in last three decades (1981-2010). The western Part of Nepal receives low total annual rainfall compared to the eastern part. Highest annual rainfall occurrs in the middle part of the country. In the last 50 years, the Coefficient of Variation (CV) in annual rainfall was high (20-30) in the Terai region of Nepal, particularly in eastern and mid-western Terai districts and lower high regions (Figure 3). In mountain areas, such as in Manang and Mustang districts, the CV in annual rainfall is very high (>30). The CV of rainfall is low in the eastern and far western districts. The CV of length of dry spell days was very high in the upper central and western part of Nepal (Figure 4).

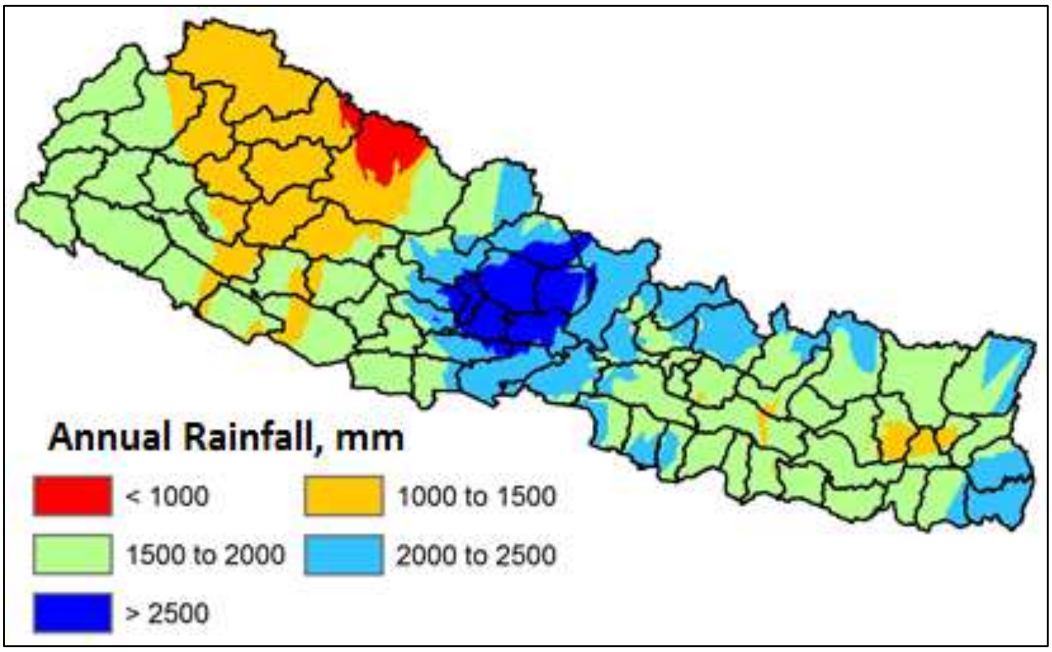

Figure 2: Distribution of Annual Rainfall in Nepal

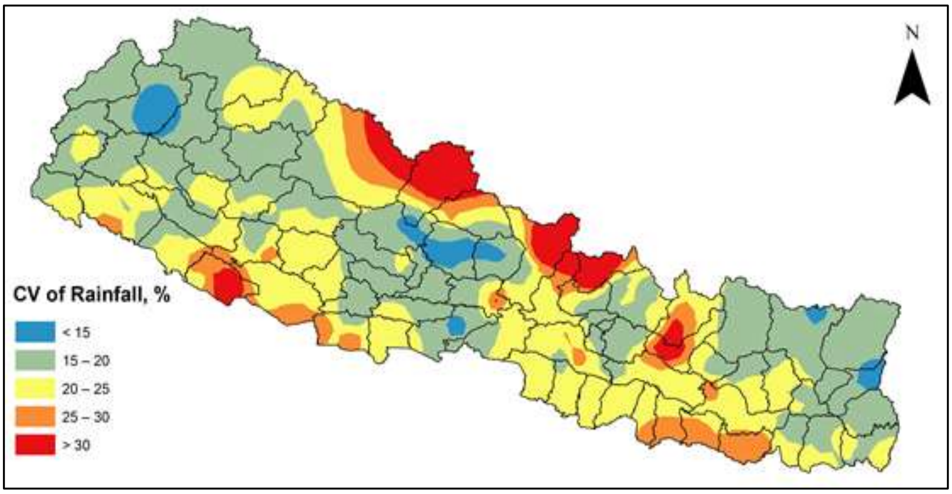

Figure 3: Coefficient of Variation (CV) in annual rainfall

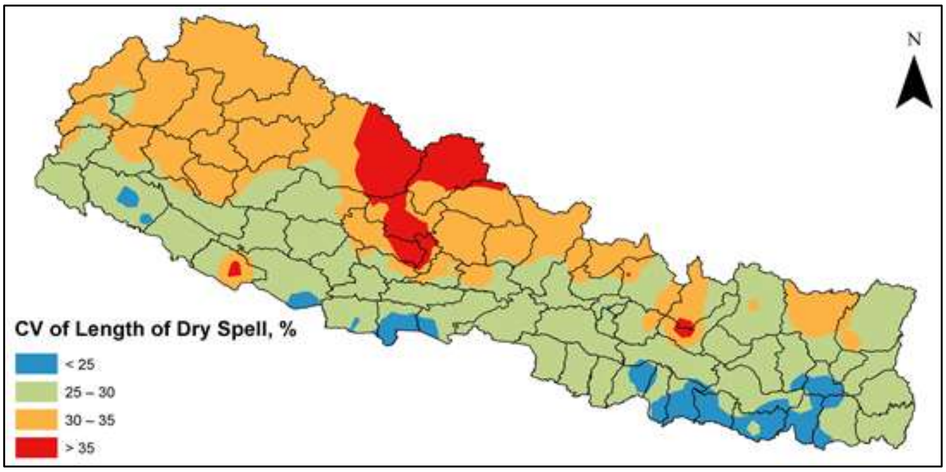

Figure 4: Coefficient of Variation (CV) in length of day spell (%)

Incidence of frequent drought is one of the most important climatic risks in Nepal. This report presents spatial analysis of probability of drought (pre-monsoon, during monsoon, and post-monsoon) using historical data provided by Department of Hydrology and Meteorology for last 50 years (1961-2010). The probability of drought during pre-monsoon is high in the eastern and western hills and mountain regions (Figure 5) where rainfed agriculture is predominant. This pre-monsoon drought can severely affect sowing of main crops in the region. The probability of drought during monsoon season is high particular in central part of Nepal (Figure 6). Monsoon period droughts mainly affect crop growth and development in the rainfed and partially irrigated areas. The severe drought may lead to complete crop failure in many locations where supplementary irrigation would not be possible. The probability of post-monsoon droughts is high in central and eastern Nepal (Figure 7). Severe post-monsoon drought causes yield loss in monsoon crops and reduction in residual moisture for winter crops in the rainfed/partially-irrigated areas.

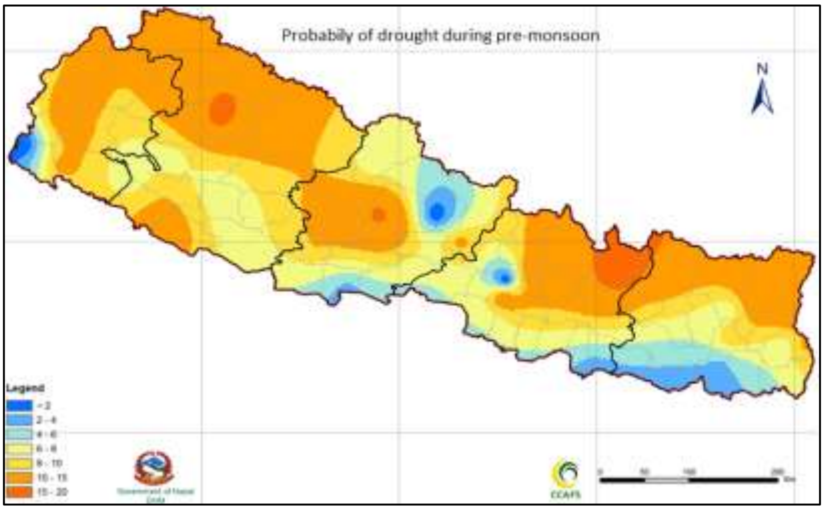

Figure 5: Probability of drought during pre-monsoon in Nepal

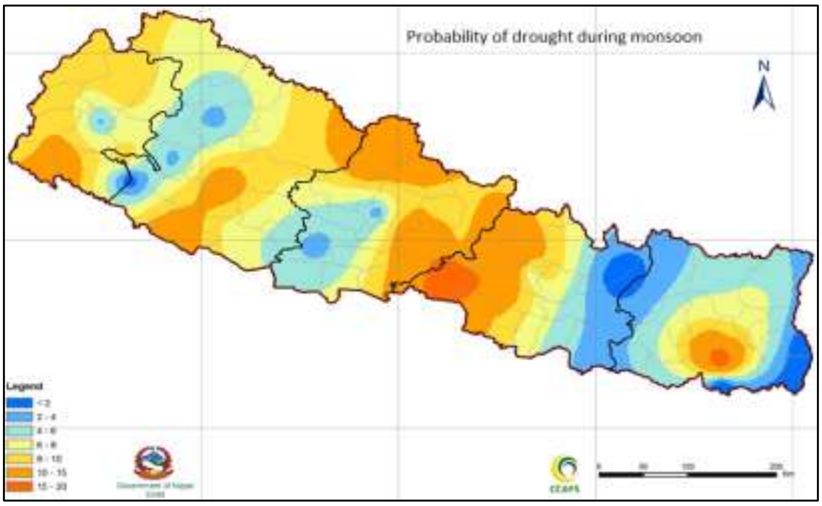

Figure 6: Probability of drought during monsoon in Nepal

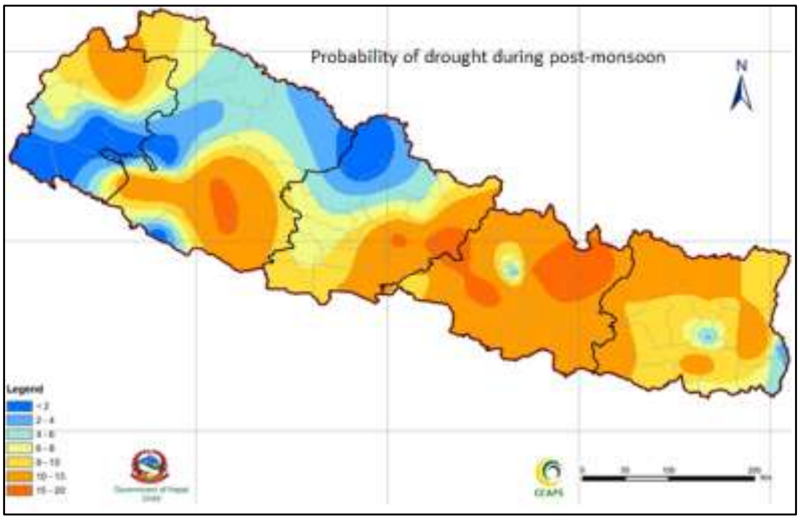

Figure 7: Probability of drought during post-monsoon in Nepal

1.2. Climate-Smart Agriculture (CSA)

Climate-Smart Agriculture (CSA) could be very much context specific. For Nepal where farming systems and farm typology are very diverse and involvement of women in agriculture is very high; location specific climate smart interventions including gender and social inclusion are essential. Figure 8 presents a conceptual framework of climate-smart agriculture which integrates policies around adaptation, mitigation and food security including six desirable outputs: increase productivity, income and resilience, improve input use efficiency, reduce emissions and increase gender and social inclusions. Since majority of the women in the Nepal involves in agriculture and allied sectors, any negative impacts from climate change impose more burden to them than others. There is a clear linkage between agriculture and women, and CSA should play a key role in improving agricultural productivity and food security in the farming communities including women and disadvantaged group.

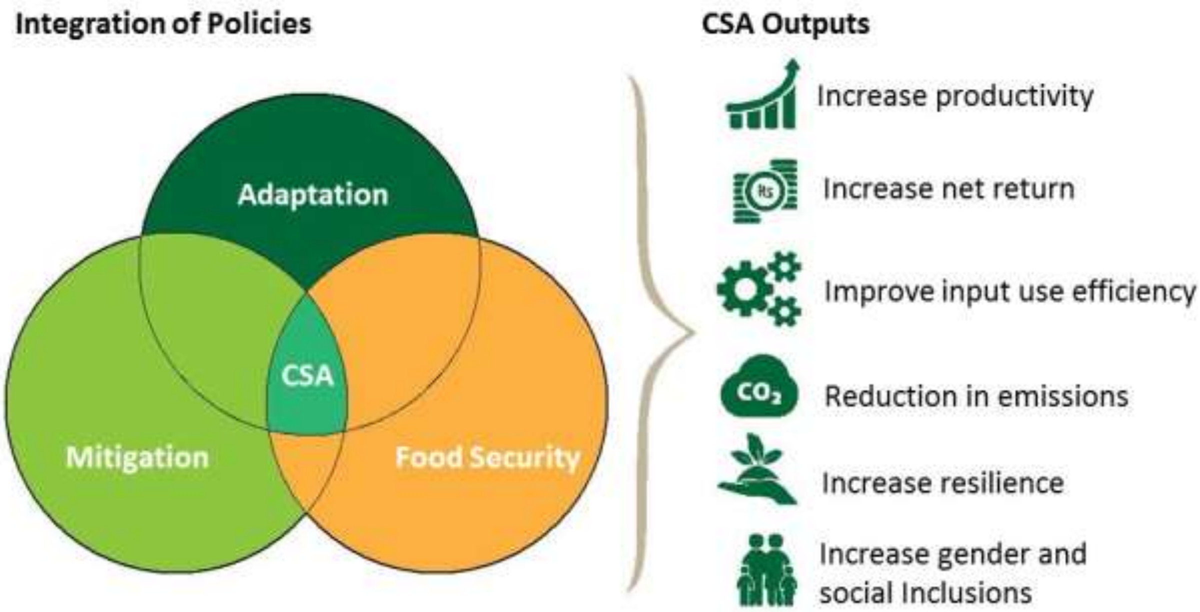

Figure 8: Conceptual Framework for Climate-Smart Agriculture and Expected Outputs

CSA is being promoted for the adaptation and mitigation of climate change and variability in many places. In terms of outputs, the concept of CSA has been well articulated. CSA should help to improve farm productivity, increase resilience to weather extremes and decrease greenhouse gas emissions wherever possible (FAO, 2010; Steenwerth et al., 2014). However, the relationship between these three pillars of CSA is not well-defined and further scientific investigations are essential. Broadly, the CSA focuses on developing resilient food production systems that lead to food and income security under progressive climate change and variability (Vermeulen et al., 2012a; FAO, 2013a; Lipper et al., 2014). Thus, it is obvious that the scale and scope of CSA is gradually expanding beyond agricultural production to value chains, food systems, safety nets and other linkages for enabling the CSA.

There is a debate about what practices and technologies should be considered in CSA. Some argue that any agricultural practice that improves productivity or resource use efficiency can be considered as climate smart (Neufeldt et al., 2013). Others look at CSA as complementary for sustainable intensification of agricultural production systems (Campbell et al., 2014). The relationship between conservation agriculture (CA) and CSA is also poorly understood, such that any practice under conservation agriculture can be considered as CSA. Many conservation agricultural practices such as minimum tillage, different methods of crop establishment, nutrient and irrigation management and residue incorporation can improve crop yields, water and nutrient use efficiency and reduce GHG emission from the agricultural fields (Branca et al., 2011b; Jat et al., 2014; Sapkota et al., 2015). Similarly, researchers also consider rain water harvesting technologies, use of improved seeds and agriculture insurances as climate smart because they help to cope with extreme climatic events (Altieri and Nicholls, 2013; Vermeulen et al., 2012b). There are a wide range of agricultural practices and approaches that are currently available at the field level that can contribute to increased production while still focusing on environmental sustainability (FAO, 2013a). The role of these technologies and practices in reducing current as well as future climate change impacts on agriculture, reducing gender disparities and decreasing GHG emission intensity are crucial.

A wide variety of CSA options has been proposed to reduce the negative impacts of climate change, build climate resilient agricultural production systems, and harness the benefits of global warming. These options range from a simple adjustment in crop management practices (e.g. changes in sowing time, application of water and fertilizers, tillage practices and inter-cultural operations) to the transformation of agricultural production systems (e.g. change in cropping systems and land uses) to adjust to new climatic conditions in a particular location (Vermeulen et al., 2012b; Howden et al., 2007). These options can 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 in raising the production, income and building resilience of farming communities in many locations in South Asia (Khatri-Chhetri et al., 2016; Aryal et al., 2015; Jat et al., 2014; Sapkota et al., 2015). These interventions have, however, varying costs and economic impacts, and their implementation requires appropriate investment decisions in both on-farm capital and for wider agricultural outreach programmes. Therefore, prioritization, evaluation and development of location specific portfolios of CSA interventions linking with climatic risks are pre-requisite for developing scaling up/out pathway and CSA implementation plan.

1.3 CSA related Policy and Programs in Nepal

Realising the need for planned efforts to address the challenges of climate change and variability, Government of Nepal has mobilized its National Adaptation Programme of Action (NAPA), initiated a Pilot Program on Climate Resilience (PPCR), enacted a national Climate Change Policy 2011 (CCP), and has started a valuable testing ground for emerging Local Adaptation Plans of Action (LAPA). Promoting Climate Friendly Practices in Agriculture is one of the strategies in the Intended Nationally Determined Contribution to reduce greenhouse gas emissions. Climate change adaptation, agriculture development and food security related policies in Nepal primarily focus on the implementation of better agricultural practices and technologies, livelihood diversification and capacity building (MoE, 2010; MoE, 2011; MoAD, 2015). GHG emission reduction from agriculture is not a priority but new Agricultural Development Strategy 2015 (ADS) of Nepal aims to promote green technologies and reduce carbon emissions. Table 1 presents key CSA related policies, institutions and financial mechanisms in Nepal.

The climate adaptation policies have been paralleled with a similarly growing portfolio of agricultural investment and research plans through a new ADS of Nepal. The ADS targets strengthening the capacity of agricultural extension staff and farmers on CSA practices and technologies for improved resilience to climate change and variability. The ADS also aims to promote CSA across the country but elaboration is needed around: i) where investment should be targeted; ii) what crops and technologies should receive investment; iii) when and how investment should be made; and iv) the implications of investments on food production, incomes, environment and food security (MoAD, 2015). Thus, it is very important to identify and prioritize CSA technologies and practices for different agro-ecological regions and integrate them into the climate change adaptation plans and policies to develop a climate-resilient agricultural system in Nepal.

Table 1: Key policies, institutions and financial mechanisms in Nepal

Domain	Policies	Institutions	Financial mechanisms
Agriculture Development and food security	Agriculture Development Strategy (2015); Agriculture development policy 2004; Agriculture Extension Strategy (2007); National Biodiversity Strategy and action plan (2014); Agro-biodiversity policy 2014; Irrigation policy, 2003; NARC Vision 2011-2030; Three-year plan (69-71) of NPC: DDC periodic plans, Sectoral Ministry's Annual Plans (of past 5 years); VDC grant guideline (from working districts); DADO's annual reports (of past 5 years from working districts);	National Planning Commission; Ministry of Agriculture Development, Ministry of Livestock, NARC, Department of agriculture and Focal persons for Environment, Climate Change and CSA in these institutions District Agriculture Development Offices (DADOs); DDCs; VDCs of working districts FAO, SNV, ICIMOD, DFID, CCAF, UNDP, CDKN, ADB/WB, IDE/CEAPRED, USAID (feed the future) and Practical Action Agriculture and Forestry University research and extension division	Min of Finance, National Planning Commission; MoAD/DoA; DDC, VDCs, Insurance companies; Banks and FNCCI UNFCC fund, Green Climate Fund Seed Companies
Climate Change	Nepal second national communication to UNFCC 2014; Climate change and risk management framework (2011-2022 FAO); Climate change policy 2011; District disaster management Directives, 2069; Local Adaptation Programme of Action (LAPA of 3 districts); National Adaptation Program of Action (NAPA), 2011; Low Carbon Economy Development Strategy (2015); Disaster Risk Management Strategy, 2009; Environment Friendly Local Governance Framework, 2014; COP Paris Declaration	Ministry of Environment, Science and Technology, department of meteorology; DDCs; VDCs of working districts FAO, SNV, ICIMOD, DFID, CCAFS, UNDP, Practical Action, NCCSP and PPCR Agriculture and Forestry University research and extension division	Min of Finance, National Planning Commission; MoAD/DoA; DDC, VDCs, Insurance companies; Banks and FNCCI, UNFCC fund, Green Climate Fund CFUGs

The "Scaling-Up of Climate Smart Agriculture in Nepal" project assessed potential of scaling up/out of different CSA technologies across the country. This project has identified CSA technologies, practices and services suitable for different agro-ecological zones of Nepal, assessed the climatic risks across the country, tested and evaluated portfolio of CSA options at farmers' fields and extrapolation of CSA assessment results at the country level. On the basis of these analyses, the project has developed CSA portfolios for different agro-ecological zones of Nepal. This report presents assessment of climate-smart agricultural options for different agro-ecological zones of Nepal.

2. Overview of Agricultural System in Nepal

2.1. Crop and cropping system

The direct impact of climatic risks on agriculture depends on the type of crop and cropping system, soil characteristics, and availability of water resources in a particular location, among others. It was revealed that three types of farming systems are dominant in Nepal: rainfed/dryland, partially irrigated (irrigation during monsoon only), and fully irrigated (perennial water supply from surface or underground sources). Figures 9-11 depict spatial distributions of crop and cropping systems in the country. Rice-wheat systems are dominant in the Terai region and some parts of eastern and central hills (Figure 9), mostly in irrigated and partially irrigated areas. The system is characterised by a monsoon/wet season rice crop and a winter dry season wheat crop, followed by a short spring vegetable crops in some locations.

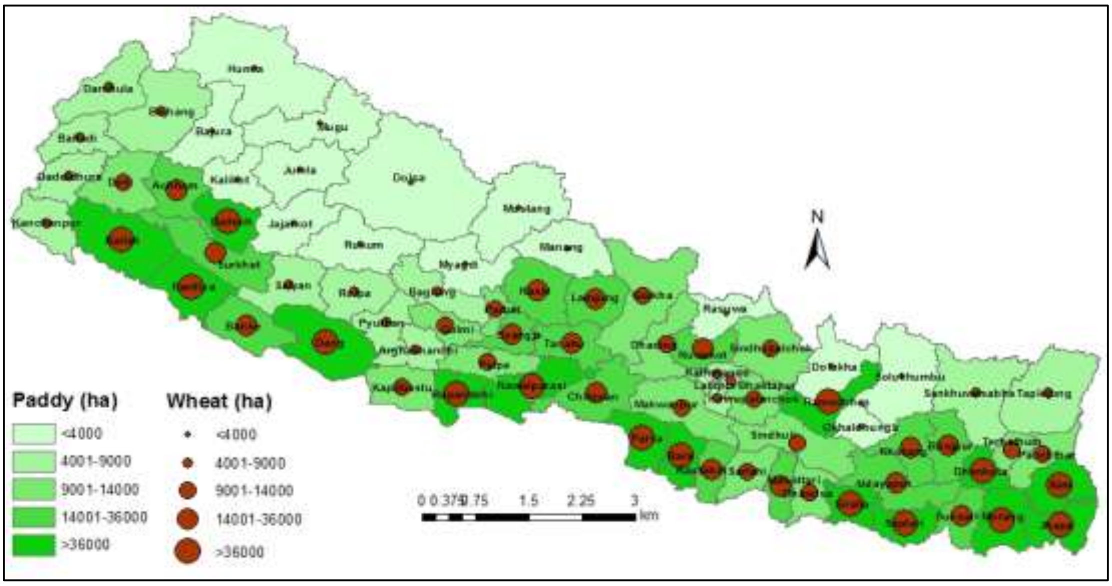

Figure 9: Area under paddy and wheat crops in Nepal

Maize and millet based agricultural production systems are dominant in major parts of hills and mountain regions of Nepal (Figure 10). In hills and mountain, maize is grown under rainfed conditions during the summer (April-August) as a sole crop or relayed with millet. In the terai, inner-terai, and low-lying river basin areas with irrigation source, maize is also grown in the winter and spring. Buckwheat cultivation is common in mountain and some parts of mid-hills (Figure 11). Pulses are grown mainly as rainfed crops in lowland rice-based system in terai/inner terai and upland maize-based system in hills. Winter pulses (lentil, chickpea, pigeon-pea, grass-pea, etc.) are mostly grown in the terai/inner terai region after harvesting summer crops (rice and maize) and account for about 60 percent of total area and production of total pulses in Nepal. Summer pulses (soybean, black-gram, horse-gram, etc.) are commonly grown in mid and high hills of Nepal and play a vital role in crop diversification, restoration of soil fertility, and cropping system intensification under rice- and maize-fallow systems.

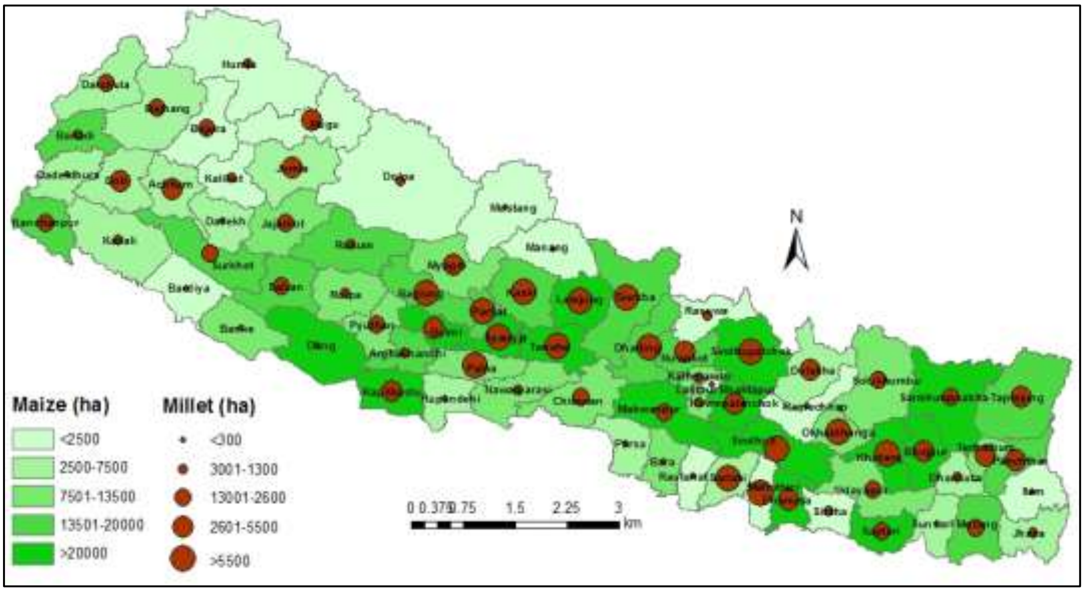

Figure 10: Area under maize and millet crops in Nepal

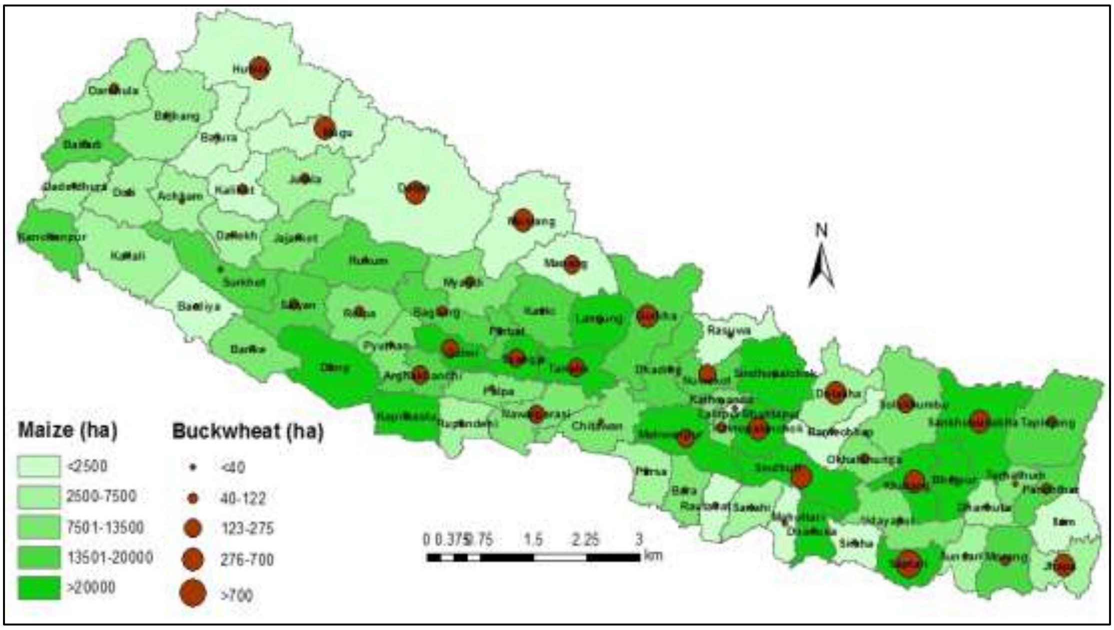

Figure 11: Area under Maize and Buckwheat crops in Nepal

2.2 Crop yield gaps

The yield gaps in major crop were measured based on existing yield and maximum yield observed for the crop by the Nepal Agriculture Research Council and Department of Agricultural Development of Nepal. The crop yield is a difference between maximum yield and existing yield for each crop. Large yield gaps exist in all major crops (paddy, wheat, maize and millet) in Nepal. The yield gap in paddy exist up to 60% (Figure 12). Large yield gaps are prevalent in the major rice growing districts in eastern Nepal (Rautahat, Sarlahi, Mohattari, Dhunasha, Siraha, Saptari, Sunsari and Morang). In the western districts of Nepal, the yield gap ranges from 21-32%. Very low yield of paddy is found in the eastern and far western hill and high hill districts. Similarly, very high yield gap in wheat crop is found in the mid and far-western regions (Figure 13). The yield gap is also high in the hill district of the western region (Kaski, Parbat, Syangja, Palpa and Gulmi). Yields of maize and millet are very poor in the majority of the districts (Figure 14 and 15). In both crops, high yield gaps persist across the country. This analysis yield gap in major crops indicates very high potential in crop yield improvement in Nepal.

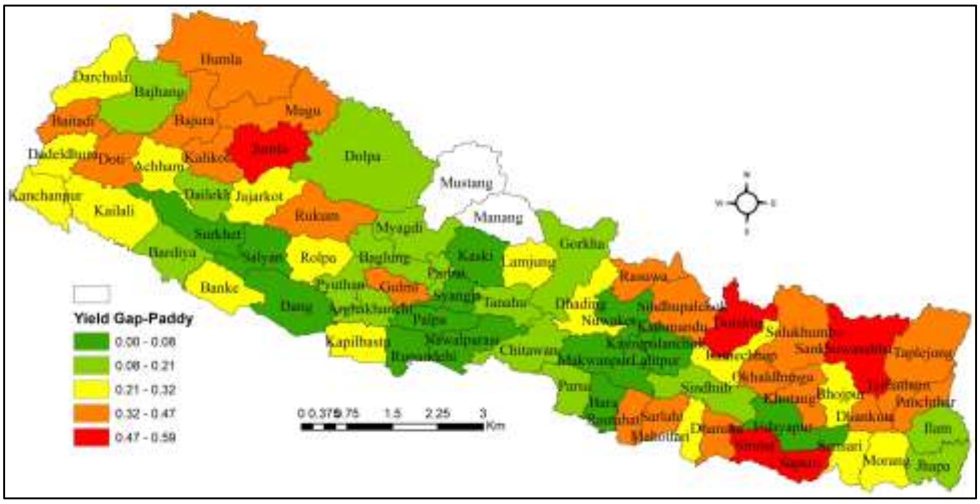

Figure 12: District wise crop yield gap in paddy

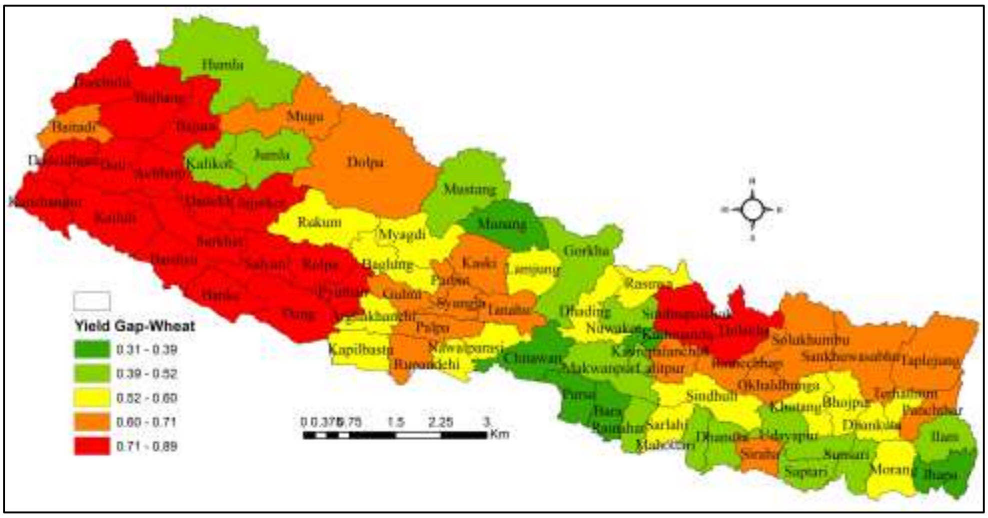

Figure 13: District wise crop yield gap in wheat

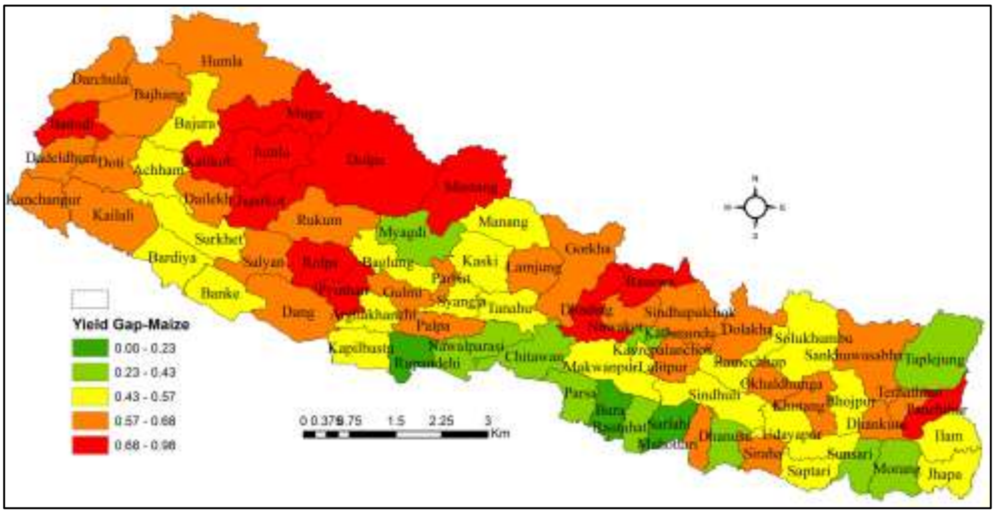

Figure 14: District wise crop yield gap in maize

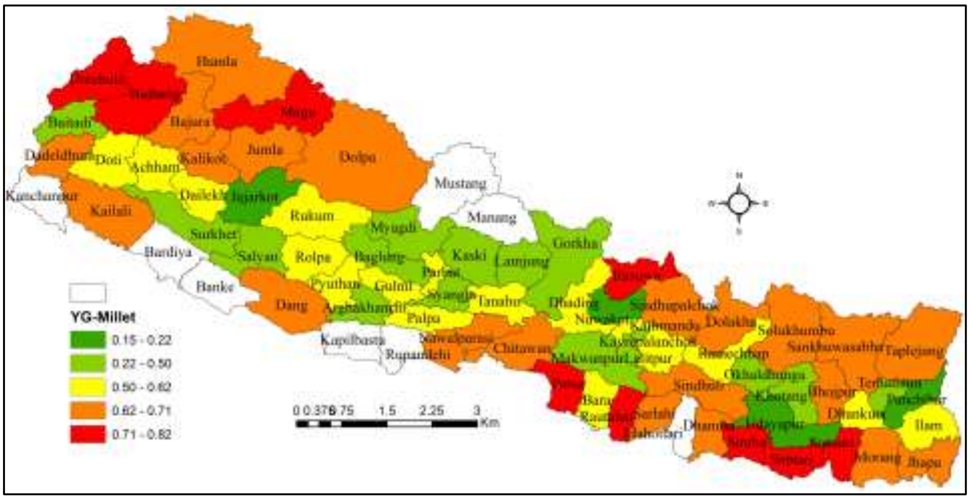

Figure 15: District wise crop yield gap in millet

2.3 Resilience in crop production

This study used historical observed data (1981-2014) for climate (rainfall) obtained from Department of Hydrology and Meteorology and crop yield data available from Agriculture Statistics Division of Ministry of Agricultural Development to measure the coefficient of variation in yields and rainfall over the time. Less variation in crop yield over the time measures stability in yield and vice versa. Similarly, variation in rainfall over the time is capture from the coefficient of variation in rainfall. It measures amount and distribution of rainfall during the cropping season. High coefficient of variation in rainfall represents high risk in agricultural activities and may have large yield impacts. Stability in crop yield during high variability in climatic condition is one of the indicators of resilience in the agricultural production system. The ratio of coefficient of variation in crop yield and coefficient of variation in rainfall during the cropping season provides a strong indicator of resilience in crop production.

Co-efficient of variance in yield: The CV of yield was calculated for seasonal crop yield from 1981-2014 and mapped over the 75 districts.

$$CV = \frac{\text{Standard Deviation Crop Yield}}{\text{Mean Crop Yield}} * 100$$

Co-efficient of variance in rainfall: The CV of rainfall was calculated for daily rainfall from 1981-2014 and mapped over the 75 districts.

$$CV = \frac{\text{Standard Deviation Seasonal Rainfall}}{\text{Mean Seasonal Rainfall}} * 100$$

$$Resilience\ in\ crop\ production = \frac{CV\ of\ Crop\ Yield}{CV\ of\ rainfall\ during\ the\ cropping\ season}$$

The low index value indicates high resilience to variation in rainfall. Figure 16-19 presents resilience in the main paddy, wheat, maize and millet production in all districts of Nepal. Eastern region is less resilient for paddy production and mid-hill region is less resilient for wheat production (Figure 16 and 17). Maize crops are relatively hardy in terms of rainfall variation (Figure 18). The mid and far western region is less resilient for millet production (Figure 19). The coefficient of variation in maize yield is not fluctuating very much. Similarly, wheat production in the western terai region is more resilient compared to paddy production. High rainfall unpredictability and rainfall variation during paddy transplanting and early growth period in the western region of Nepal are the main climatic risks for paddy cultivation.

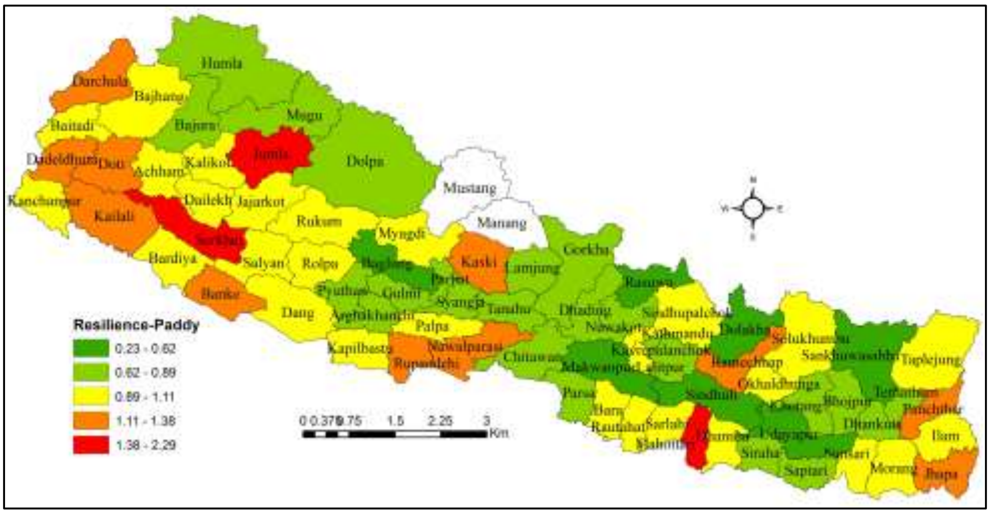

Figure 16: District wise crop resilience in paddy

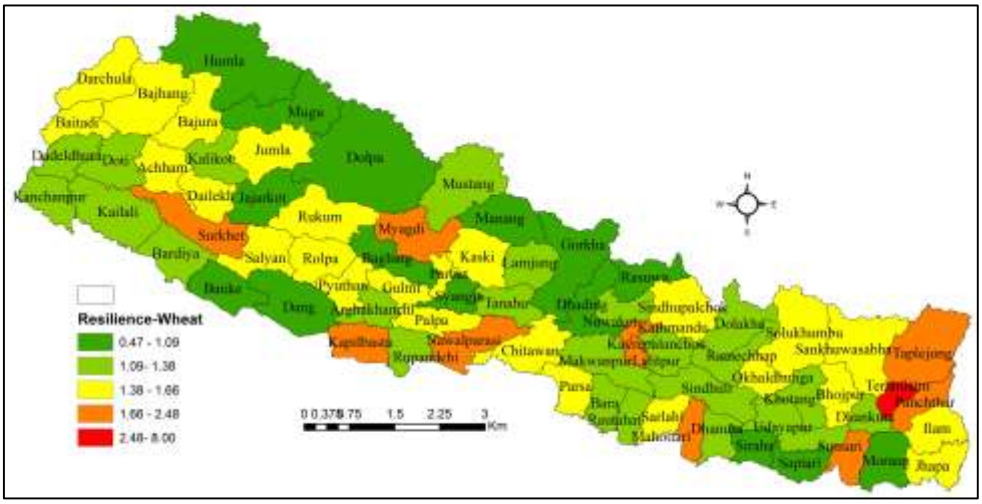

Figure 17: District wise crop resilience in wheat

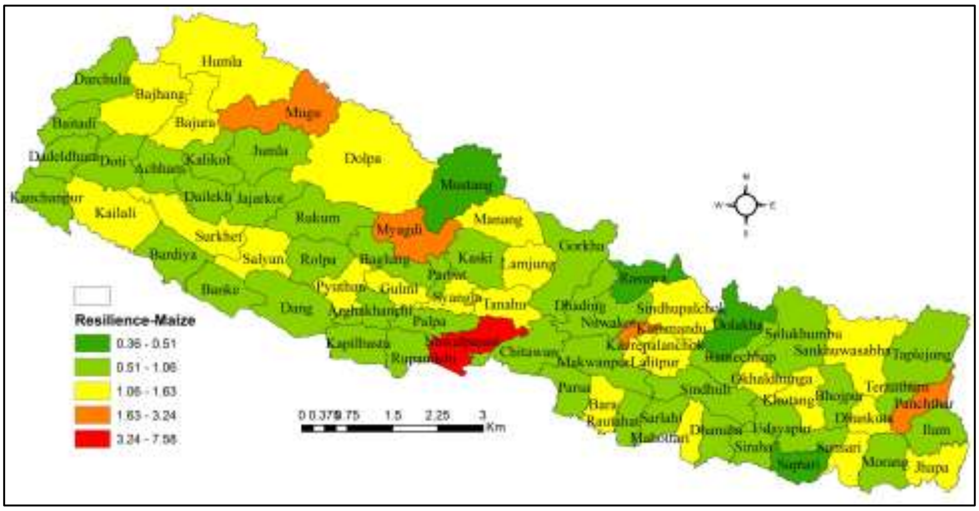

Figure 18: District wise crop resilience in maize

Figure 19: District wise crop resilience in millet

2.4. Status of climate smartness at district level

All districts in Nepal are clustered into different groups based on current level of productivity, and resilience. The emissions from the crop production are very low due to low use of chemical fertilizers and availability of irrigation. Major emission from agriculture comes from livestock stock sector due to poor management of feed, fodder and less productive breeds. Therefore, emission intensity for hectare of land is very low for Nepal and ignore in the analysis.

Based on the productivity and resilience indicators all districts in Nepal are plotted in four quadrants based on high and low resilience and crop yield; Q1: Low Resilience-Low Yield, Q2: Low Resilience-High Yield, Q3: High Resilience-Low Yield, and Q4: High Resilience-High Yield. Districts in Q1 represent climatically highly risk and Q4 represents high adaptation of climatic risks. All climate smart interventions should help to move all districts from Q1, Q2 and Q3 to Q4 to make districts more resilient and increase crop yield. Districts in Q1 require to adopt climate smart technologies and practices that can increase resilient and yield. Districts in Q2 require climate smart technologies that can minimize climatic risks. Districts in Q3 are more resilient but high yield gaps persist. This quadrant requires yield improving technologies and practices. Appendix 1 presents resilient and yield gap values for all districts in Nepal.

Figure 20-23 present mapping of districts based on resilience and yield gap in paddy, maize, wheat and millet production across the country (see value of individual districts in Appendix). For paddy production, many districts have high yield gap and low resilience (Q2). Some districts have very low yield gap and high resilience (Q3) and high yield gap but high resilience (Q4). The majority of the districts for maize and millet production fall under quadrant 4; high yield gap but high resilience. Cultivation of low yield variety of the millet crop can be a major reason of high yield gap. These crops are very resilient crops in terms of climate change adaption. However, closing the yield gap through the implementation of climate smart practice is an important issue for both crops. The yield gap is also high in wheat crop but the majority of the districts fall under 'high resilience'

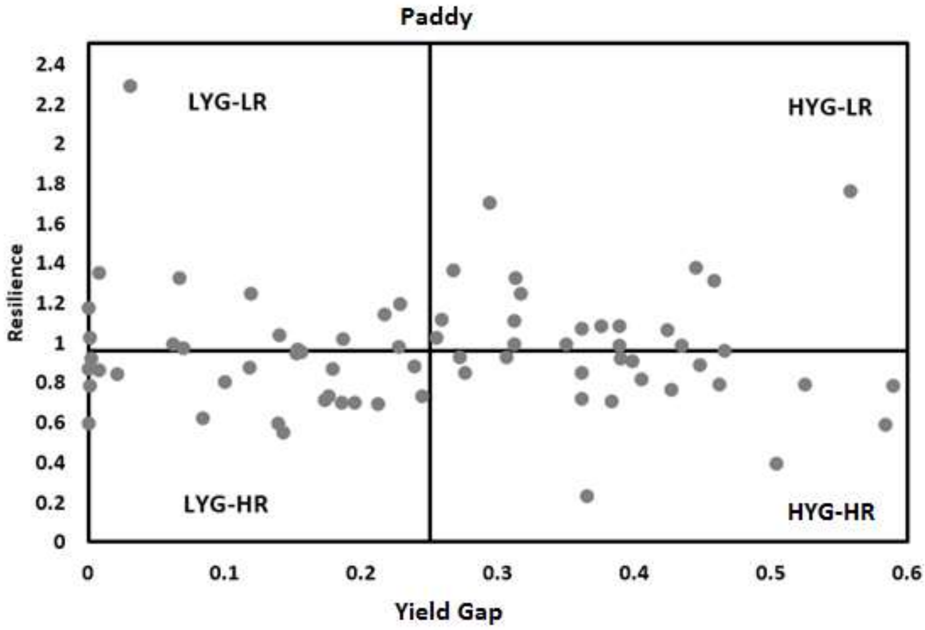

Figure 20: Mapping of districts based on resilience and yield gap in paddy production

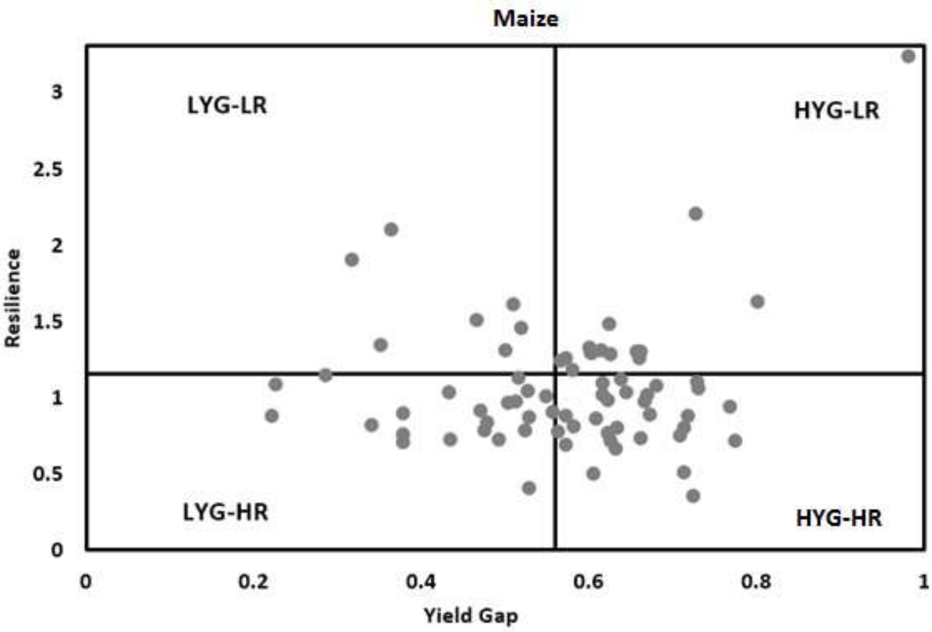

Figure 21: Mapping of districts based on resilience and yield gap in maize production

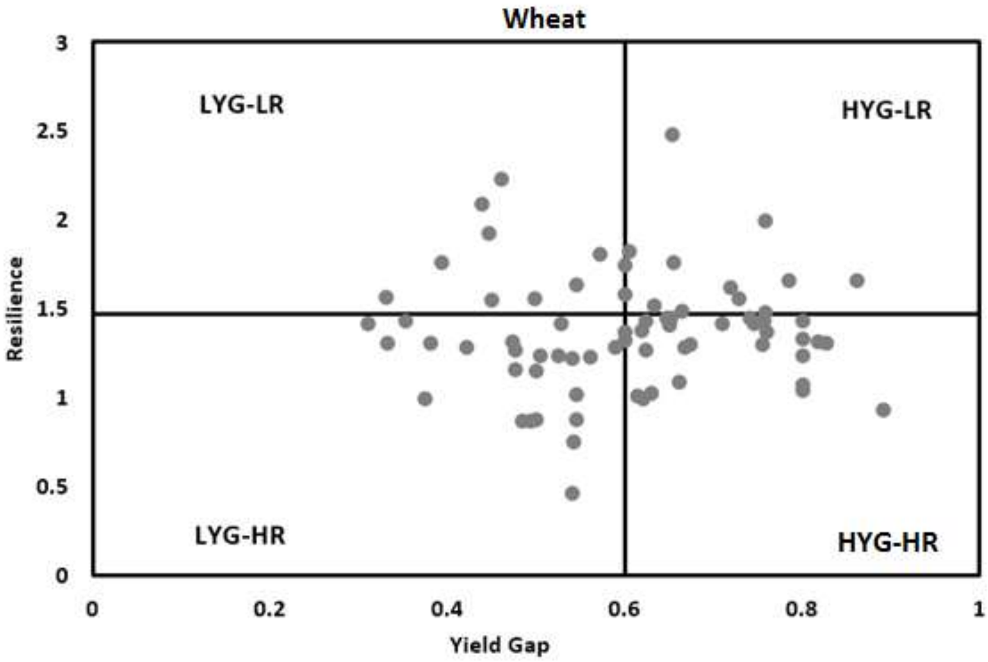

Figure 22: Mapping of districts based on resilience and yield gap in wheat production

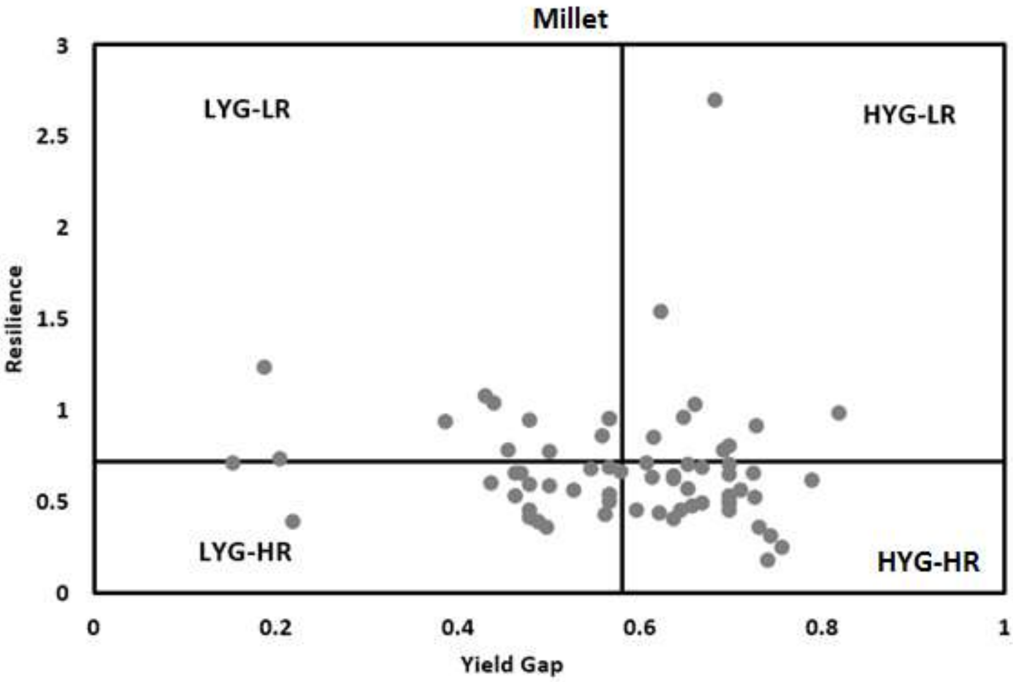

Figure 23: Mapping of districts based on resilience and yield gap in millet production

3. Assessment of Climate Analogue Sites

The climate analogue tool allows researchers to identify, connect and map sites with statistically similar climates across space and time in order to find a future (or present) climate which is comparable to the present (or future) climate of the location of interest (further details on: http://analogues.ciat.cgiar.org/climate/). Climate analogue is a novel way of supporting policy recommendations with on-the-ground testing. It connects sites with statistically similar ('analogous') climates across space and/or time.

This research has used two kinds of climate analogues: i) Spatial analogues that identify areas whose current climate appears as a likely analogue to a similar climate for another location. Thus it presents promising areas for comparative research for adaptation planning in addition to facilitate sharing of knowledge and genetic resources among communities to enhance their adaptive capacity. ii) Temporal analogues that make use of current climates in order to create a representative time series for future climate and identify current technology/practices that can be applicable in the future climatic conditions of similar locations. Once analogue sites are identified, information gathered from local field studies/databases are used to propose high-potential CSA technologies and practices. Hence it can be useful for local adaptation planning by: facilitating farmer-to-farmer exchange of knowledge, validating computational models and testing new technologies and practices and or techniques. This report presents analogue sites of the pilot villages in two temporal directions:

- Sites at present that are similar to the CSA pilot villages in terms of climate (current to current): this facilitates sharing and exchange of knowledge technologies and practices, and genetic resources in both ways at current climate;
- Sites at present that would be climatically similar to the future climate of the CSA pilot villages (future to present): this facilitates sharing of CSA knowledge, technologies and practices from other sites to the CSA pilot villages.

Data provided for the online tool includes monthly precipitation and mean temperature data, as well as 19 bioclimatic variables that describe in detail the seasonality, extremes and climate averages at sites. The online tool provides data for current conditions as well as the 2030s (2020-2049) time period for 24 Global Climate Models (GCMs) and an ensemble (average value of all the GCMs) under emissions scenarios A1B, A2 and B1. This time period was selected as it allows sufficient time for significant climatic changes to be realized while also remaining a relevant timescale for current planning and adaptation measures. An ensemble option is available that utilizes the average value of all GCMs. Both baseline and future climate information on the online tool has been statistically downscaled to provide high resolution (approx. 1 km) climate surfaces that capture fine-scale variations, such as affected by altitude, that are not represented at the coarse (100-300 km) scale of GCMs.

Table 2 presents areas under different levels of similarity based on rainfall (amount and distribution) temperature (average, max and min over time) with current climate for Nawalparasi, Kaski and Lamjung district. These districts were selected for testing and evaluation of various climate smart technologies in participation with farmers and local stakeholders. More than 65% of the area falls under 25-50% climate similarity in all three districts. Similar or different varieties of crop should be considered in the 25-50% similar areas. CSA practices and technologies tested and evaluated in the pilot sites may not be suitable for that areas. More than 50% similarity areas range only from 13% to 21%. In these areas CSA technologies and practices that were tested and evaluated in the pilot site can be scaled out.

Table 2: Area under different level of similarity with current climate for project districts

Climate similarity	Nawalparasi		Kaski		Lamjung	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
< 0.25	1,855	0.01	0	0.0	6773	0.04
0.25 to 0.5	10,083,749	68.8	11,575,726	79.0	12,578,119	85.9
0.5 to 0.75	3,175,774	21.7	2,932,351	20.0	1,959,309	13.4
> 0.75	1,385,546	9.5	138,844	0.9	102,723	0.7

Note: Data for agricultural area for each districts are collected from the CBS Nepal (CBS 2014).

Table 3 presents areas under different levels of similarity with future climate for Nawalparasi, Kaski and Lamjung district. The area under 25-50% in all districts ranges from 62 to 84%. Similar or different varieties of crop can be cultivated in these areas in the future. More than 50% similarity areas ranges from 15% to 35% of total agricultural land. In these areas same crop variety can be grown in the future.

Table 3: Area under different level of similarity with future climate for project districts

Climate similarity	Nawalparasi		Kaski		Lamjung	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
< 0.25	0	0.0	0	0.0	0	0.0
0.25 to 0.5	9,276,961	62.3	11,888,490	79.8	12,546,742	84.2
0.5 to 0.75	5,313,587	35.7	2,834,813	19.0	2,298,534	15.4
> 0.75	305,565	2.1	172,809	1.2	50,837	0.3

Note: Data for agricultural area for each districts are collected from the CBS Nepal (CBS 2014).

Figure 24 shows current climate analogies for Nawalparasi, Kaski and Lamjung districts across the country. Similarly, Figure 25 presents future climate analogous for the Nawalparasi, Kaski and Lamjung districts in the country. Analogue tool predicts future climate of a particular location using historical dataset. All historical datasets for Nepal are in-built in the analogue tool. Appendix 2 presents the area and percentage of agriculture land under major crop in current and future climate analogue for each districts. The climate analogue analysis indicates that Nawalparasi district is well representative for all terai districts. More than 80% paddy, wheat, maize and millet cultivated areas is similar current climatic condition of Nawalparasi. Hill and high hills areas climate is representative for Kaski and Lamjung districts. This indicates that any CSA technology and practice tested and evaluated in these pilot sites can be scaled out in the similar climatic conditions for adaptation to changing climate.

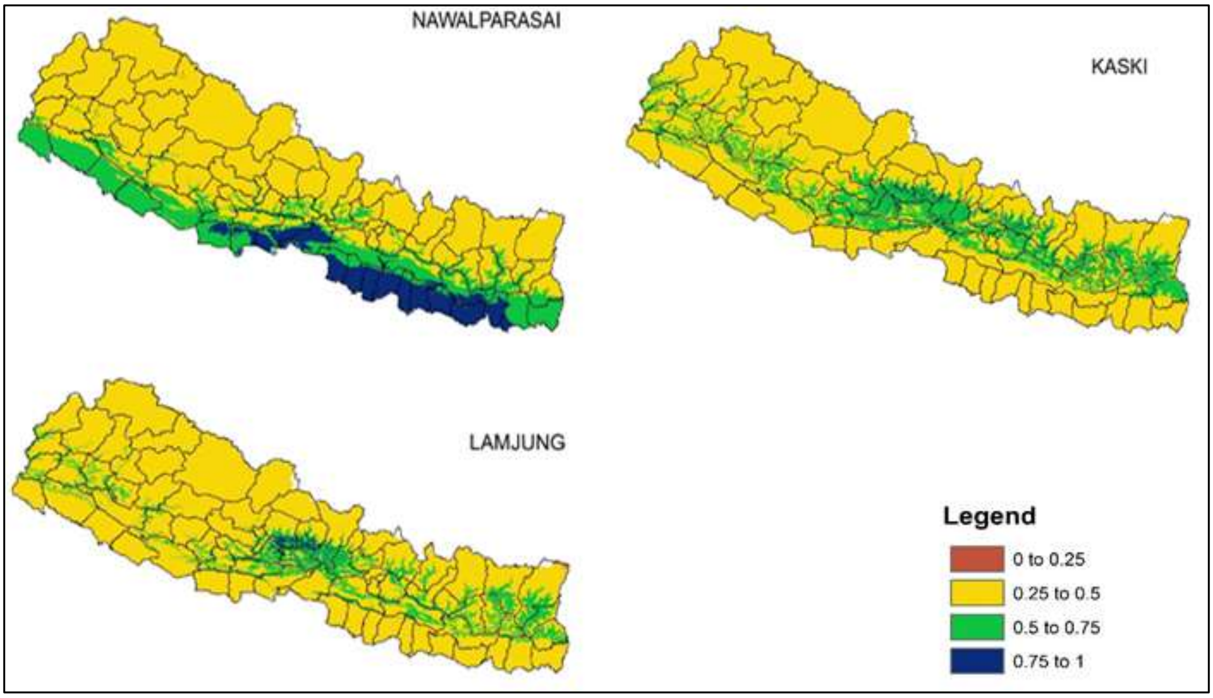

Figure 24: Current climate analogue for Nawalparasi, Kaski and Lamjung districts of Nepal

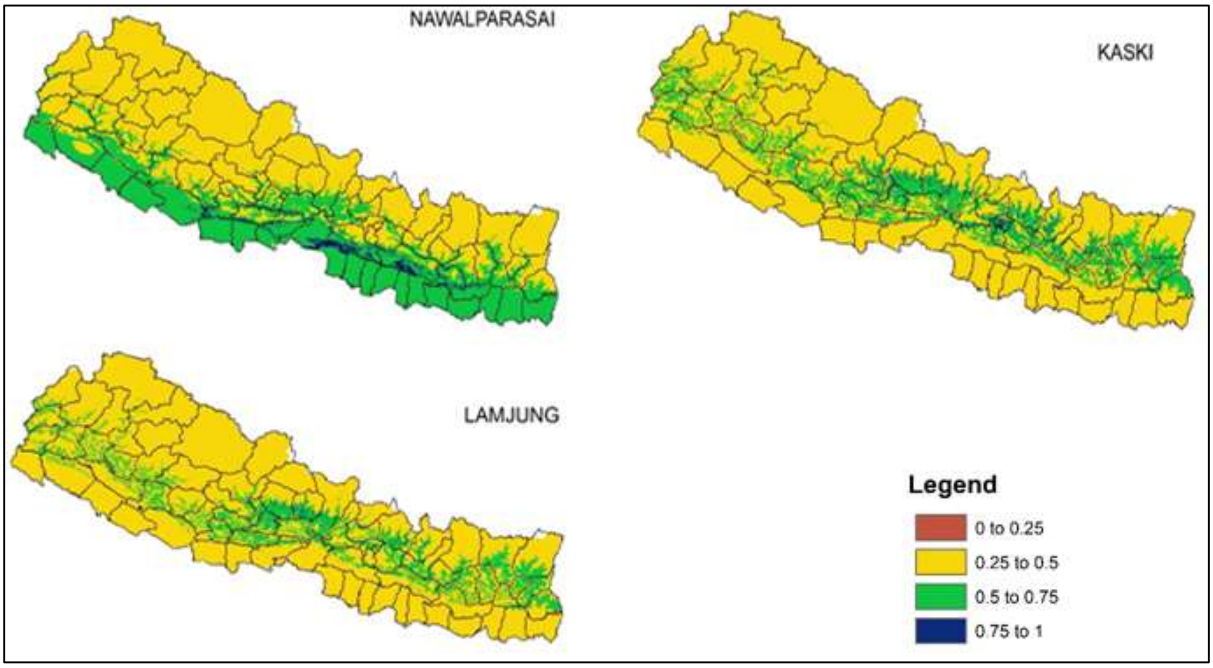

Figure 25: Future climate analogue for Nawalparasi, Kaski and Lamjung districts of Nepal

3. Extrapolation of CSA options

Extrapolation of CSA options based on field evidence can help CSA policy makers and implementers at national and sub-national level to make informed decisions and invest in the strategic CSA portfolio under the existing and future uncertainties. This is important because CSA includes a package of interventions best suited to a local context to improve the local production against the backdrop of climate change. For extrapolation purpose, this project focus more on the analogue sites identified through current and future climatic conditions similar to the project districts (Nawalparasi, Kaski and Lamjung).

3.1 Selection of CSA options

With evidence from field data considering several factors, the champion CSA technologies and practices were selected for further exploring possibility of scaling-up. A process of selection of most suitable CSA options is presented in Figure 26. Selection of champion CSA options was basically done with the help of four criteria: technical appropriateness, farmers' acceptance, climate sensitiveness, and scalability.

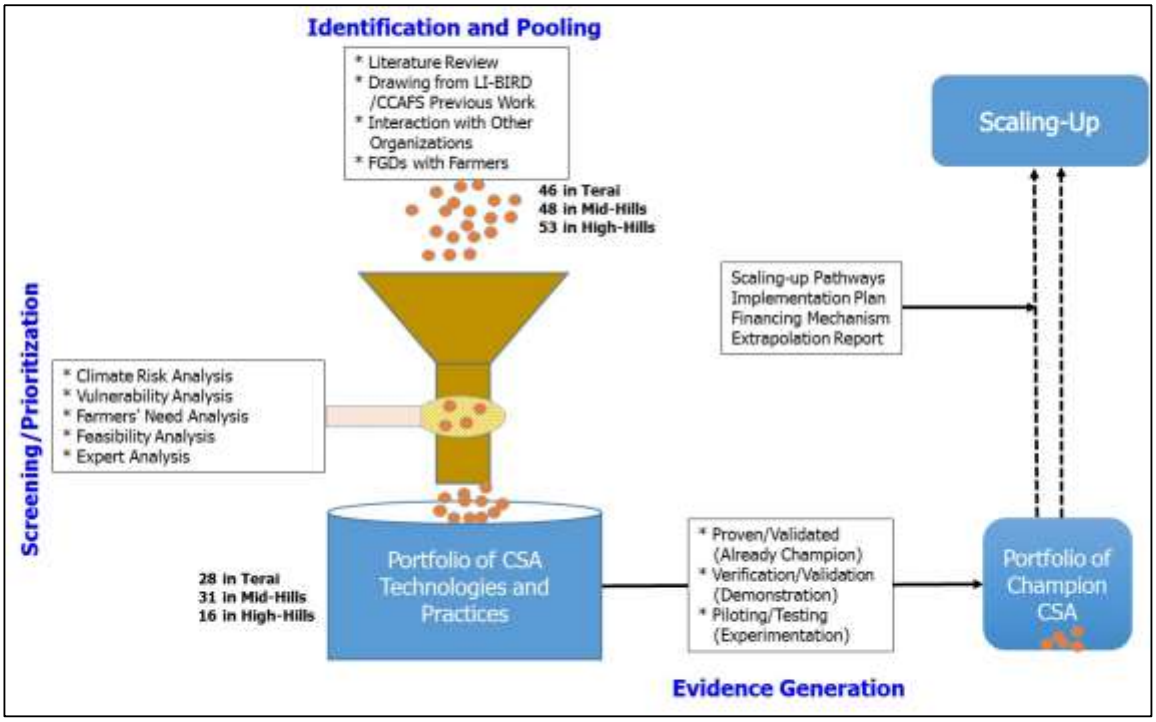

Figure 26: Project Activities in a Nutshell

3.2 Identification of CSA Options

This project has used a systematic approach of assessing potential CSA options for Nepalese agriculture using a combination of different methodologies developed by FAO and CCAFS (FAO, 2013a; Dunnett and Shirsath, 2013; CIAT 2014; Mwongera et al., 2015). The FAO documents helped in the methodological conceptualization of CSA and defining the major pillars: food security, adaptation, and mitigation. The CCAFS literature has used several smart criteria for categorization of the potential CSA technologies and practices. Building on the CCAFS work, the potential technologies and practices were collected based on following smart features of CSA technologies, practices and services: Water smart; Weather smart; Nitrogen (Nutrient) smart; Knowledge smart; Energy smart; and Carbon smart (Aggarwal et al., 2013).

According to the nature of interventions, all the potential CSA technologies and practices are grouped into four categories: (i) a change in agronomic practices such as improving water, nutrient and energy use efficiencies, use of improved seeds or modern varieties, following crop rotations or other means of sustainable intensification; (ii) use of modern technologies and equipment to increase water, nutrient or other input use efficiency (e.g. Green Seeker and leaf colour chart to optimize nitrogen use, tensiometer based irrigation scheduling etc.); (iii) various information related interventions such as use of ICT for dissemination of climate information based agro-advisories and weather forecast services; and (iv) practices that reduce or transfer farming associated risks, such as weather index based agriculture insurance. Table 4 presents a list of major CSA technologies identified for different crop and cropping system in Nepal.

Table 4: Inventory of Climate Smart Technology, Practices and Services

Water-Smart	***Interventions that improve Water-Use Efficiency***
Rainwater Harvesting- Farm Ponds	Collection of rainwater not allowing to run-off and use for agriculture in rainfed/dry areas and other purposes on site.
Drip Irrigation	Application of water directly to the root zone of crops and minimize water loss
Sprinkler Irrigation	Method of applying irrigation water which is similar to rainfall, high irrigation efficiency due to uniform distribution of water
Direct Seeded Rice	Requires less water compared to traditional transplanting
Alternate Wetting and Drying (Rice)	Need based application of water in the rice filed, minimize overuse of water
Systems of Rice Intensification (SRI)	Change in management of plants, soil, water and nutrients in rice cultivation
Conservation Furrow	Conserve water and allows better drainage and run-off
Raised Bed Planting	Conserve water and allows better drainage and run-off
Drainage Management	Removal of excess water (flood) through water control structure
Cover Crops Method	Reduces evaporation loss of soil water (also adds nutrients into the soil)
Energy-Smart	***Interventions that improve Energy-Use Efficiency***
Minimum Tillage	Reduces amount of energy use in land preparation. In long-run, it also improves water infiltration and organic matter retention into the soil
Solar Pumps	Increased access to power through renewable energy; adaptation and mitigation
Nutrient-Smart	***Interventions that improve Nutrient-Use Efficiency***
Site Specific Integrated Nutrient Management	Optimum supply of soil nutrients over time and space matching to the requirements of crops with right product, rate, time and place
Green Manuring	Growing and incorporating legume biomass into soil. This practice improves nitrogen supply and soil quality.
Leaf Color Chart/GreenSeeker	Quantify the required amount of nitrogen use based on greenness of crops.
Intercropping with Legumes	Cultivation of legumes with other main crops in alternate rows or different ratios. This practice improves nitrogen supply and soil quality
Carbon-Smart	***Interventions that reduce GHG emissions***
Agro Forestry/Horticulture	Promote carbon sequestration including sustainable land use management
Concentrate Feeding for Livestock	Reduces nutrient losses and livestock requires low amount of feed
Fodder Management	Promote carbon sequestration including sustainable land use management
Integrated Pest Management	Reduces use of chemicals
Bio-gas	Reduced methane emissions and fossil fuel use
Weather-Smart	***Interventions that provide services related to income security and weather advisories to farmers***
Climate Smart Housing for Livestock	Protection of livestock from extreme climatic events (e.g. heat/cold stresses)
Climate Information (seasonal and in season)	Advance climate information help reduce climate risk or take advantage of better seasons
Weather Based Crop Agro-Advisory	Climate information based value added agro advisories to the farmers
Crop Insurance	Crop-specific insurance to compensate income loss due to vagaries of weather
Knowledge-Smart	***Use of combination of science and local knowledge***
Contingent Crop Planning	Climatic risk management plan to cope with major weather related contingencies like drought, flood, heat/cold stresses during the crop season
Improved/Short Duration Crop Varieties	Crop varieties that are tolerant to drought, flood and heat/cold stresses
Fodder Banks	Conservation of fodders to manage climatic risks
Seed Systems/Banks	Ensuring farmers access to climate ready cultivars
Stress Tolerant High-Yielding Breeds of Livestock	Livestock breed that perform better under climatic stress/drought
Livestock & Fishery as Diversification Strategy	Reduce risk of income loss due to climate variability
Prophylaxis & Area Specific Mineral Mixture for Livestock	Livestock better withstand abiotic stresses
Rotational Grazing	Sustainable fodder production from pastures/commons

3.3 Prioritization of CSA options

The three pillars of CSA, namely food security, adaptation, and mitigation including GESI as a cross-cutting theme were used for prioritization of CSA options. A weighing exercise with CSA experts was conducted. Each participant was provided with 100 points that they could distribute to the three pillars and GESI depending on the characteristics of the CSA option. Table 5 presents individual and mean value for key indicators of CSA. The average weightages for food security, adaptation, mitigation, and GESI were 40, 30, 10, and 20, respectively. Food security received the highest weightage since it is the key priority area of the country due to prevalence of high food insecurity. Whereas, mitigation received the lowest weightage because it is considered as a co-benefit and falls under lesser priority for the country due to its low carbon footprint as a nation. Climate change adaptation is important, as smallholder farmers are highly vulnerable to climate change. GESI is important due to prevalence of high discrimination and social exclusion based on gender, caste, and ethnicity.

Table 5: Weighing exercise for providing weightage (%) to CSA pillars

Scorer (Person) ID	Food Security	Adaptation	Mitigation	GESI
1	40	25	20	15
2	20	30	20	30
3	25	30	15	30
4	40	30	5	25
5	40	25	10	25
6	35	35	10	20
7	40	30	20	10
8	40	40	10	10
Average	35	31	14	21
Final Weightage	**40**	**30**	**10**	**20**

After defining the criteria, a scoring exercise was done for the CSA technologies, practices and services. In this process, the specific site team along with key informant farmers scored the potential CSA technologies and practices based on their relevance for their village. All indicators of CSA in the Table 1 were evaluated with each technology based on 1 to 5 scale, where 1 means lowest positive impact and 5 means highest positive impact. The respective scores for each pillar were then multiplied by respective weightage derived in Table 1. The following decision was made (threshold or cut-off scores): scores up to 6 to be considered low promising CSA; from 6 to 9 moderately promising CSA; from 9 to 12 highly promising CSA; and above 12 are considered extremely promising CSA. For this project, any technologies and practices scoring above 9 are considered as potential CSA technologies and practices, which are eligible for further review, study, testing, and piloting.

3.4 Selection of CSA options for scaling out in large areas

A portfolio of climate smart options with top five most preferred technologies, practices and services for four major crops (paddy, wheat, maize and millet) were selected based on field evidences, preferences from the farmers and agriculture experts in the project districts and national consultation meeting with key stakeholders. Table 6 presents crop specific selected technologies, practices and services for extrapolation in the climate analogue sites across the country. Seed, water and nutrient management technologies and practices are most preferred for all crops. These options can 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 in raising production, income and building resilience of farming communities in many locations in South Asia (Khatri-Chhetri et al., 2016; Aryal et al., 2015; Jat et al., 2014; Sapkota et al., 2015).

Table 6: Selected CSA options for mapping in climate analogue sites

Technology/Practice/Service	Productivity	Adaptation (Resilience)	Mitigation
Paddy			
1. Improved seed (stress tolerant, short duration varieties)	5	5	2
2. Irrigation management (Solar or other sources)	4	4	3
3. Nursery management	3	5	2
4. Site specific nutrient management (LLC, GreenSeeker, Nutrient Expert tool)	4	2	5
5. ICT-based agro-advisory	4	4	2
Wheat			
1. Zero/minimum tillage	3	3	4
2. Improved seed (stress tolerant, short duration varieties)	5	5	2
3. Irrigation management (Solar or other sources)	4	4	3
4. Site specific nutrient management (LLC, GreenSeeker, Nutrient Expert tool)	4	2	5
5. ICT-based agro-advisory	4	4	2
Maize/Millet			
1. Zero/minimum tillage	3	3	4
2. Improved seed (stress tolerant, short duration varieties)	5	5	2
3. Intercropping with legumes	4	3	3
4. Site specific nutrient management (LLC, GreenSeeker, Nutrient Expert tool)	4	2	5
5. ICT-based agro-advisory	4	4	2

Note: 5 = very high, 4 = high, 3 = medium, 2 = low, and 1 = very low

4. Potential Benefits of Selected CSA Options

4.1 Existing literature on CSA

A meta-analysis of adoption benefits of climate smart technologies and practices was conducted on experimental and on-farm research. Interventions, related to nutrient, water, and energy were examined across South Asia. Adoption of a single technology or a combination of them for rice and wheat crops has a significant impact on yield. Table 7 presents change in rice yield from the adoption of different technologies. Average increase in rice yield from the use of nutrient and water management technologies was 83% (2.42 ton/ha) and 23% (0.19 ton/ha), respectively. Use of zero-tillage in rice can reduce its yield but combination of minimum tillage with other technologies such as nutrient and water management can help to improve rice yield by 6.89%. Similarly, use of leaf colour chart (it shows the greenness of the crop leaf, which indicates nitrogen requirement for the crop) and GreenSeeker (it is used to measure vegetative index to determine nutrient requirement for the crop) to manage nutrient application through split dose in rice crop can improve average yield by 39% or 1.73 ton/ha. Also, laser based land levelling improves water and fertilizer distribution in rice field resulting in yield improvement by about 13% (0.55 ton/ha).

Table 7: Change in rice yield after climate smart interventions in different locations of South Asia

Technology Intervention	No. of Observation	Average yield, ton. ha^{-1} (with intervention)	Average yield, ton. ha^{-1} (without intervention)	Mean difference in yield, ton. ha^{-1}
1. Precision nutrient management method	70	5.21 (0.13)	3.93 (0.15)	+1.28***
2. Precision nutrient + water management method	25	7.08 (0.26)	4.64 (0.15)	+2.44***
3. Use of leaf colour chart and GreenSeeker	43	6.02 (0.29)	4.37 (0.21)	+1.65***
4. Use of laser land levelling	8	4.83 (0.16)	4.28 (0.07)	+0.55***

*Value in parenthesis indicates standard error of mean, *** indicates mean difference is significant at 1% between with and without interventions. Published papers used for meta-analysis are listed in Appendix 1.*

Similarly, Table 8 presents change in wheat yield from the adoption of different climate smart technologies. Average improvement in wheat yield from the use of nutrient and water management technologies were 85% and 24%, respectively. In wheat crop, both minimum tillage and combination of tillage, nutrient and water management technologies have positive impacts. Minimum tillage alone can improve wheat yield by 5.8% (0.25 ton/ha) and combination with other technologies by 8.8% (0.35 ton/ha). In both rice and wheat crops, water and nutrient management have a large impact on yields.

Table 8: Change in wheat yield after climate smart interventions in different locations of SA

Technology	No. of Observation	Average yield, ton. ha^{-1} (with intervention)	Average yield, ton. ha^{-1} (without intervention)	Mean difference in yield, ton. ha^{-1}
1. Precision nutrient management method	116	4.21 (0.09)	2.66 (0.09)	+1.55***
2. Precision nutrient + water management method	33	4.99 (0.25)	3.98 (0.23)	+1.01***
3. Minimum tillage/zero-tillage	23	4.70 (0.13)	4.43 (0.14)	+0.26***
4. Zero-tillage/nutrient management/irrigation	22	3.98 (0.25)	3.77 (0.24)	+0.21
5. Use of leaf colour chart and GreenSeeker	46	4.77 (0.11)	1.97 (0.14)	+2.8***

*Value in parenthesis indicates standard error of mean, *** indicates mean difference is significant at 1% between with and without interventions. Published papers used for meta-analysis are listed in Appendix 1.*

4.2 Evaluation at farmers' fields

Portfolios of adaptation options were tested and evaluated in different project sites in partnership with different stakeholders such as farmers and their groups, District Agriculture Development Offices (DADOs) and Nepal Agricultural Research Council (NARC). Project team has evaluated a range of CSA technologies and practices with respect to different bio-physical, socio-economic, and gender dimensions. Table 9 presents estimated benefits of different CSA options in three major crops. Provision in supplementary irrigation and integration of legumes and ginger crops can significantly improve in maize yield. Nutrient management has large positive impacts in all three crops. Zero and minimum tillage have negative impact on wheat yield, but this method of crop sowing has substantially reduced the cost of cultivation. The profit from wheat cultivation under zero or minimum tillage is higher than conventional tillage method.

Table 9: Benefits of CSA options tested in maize, paddy and wheat in the pilot sites

CSA options	Yield change (ton/ha)	Yield change (%)
Maize		
Nutrient management (RD)	0.44	14.18
Nutrient management (RD+FYM)	0.32	10.81
Irrigation management (irrigation in rainfed areas)	1.38	44.64
Legume integration	0.78	31.21
Ginger intercropping	1.32	43.55
Paddy		
System of Rice Intensification	0.33	5.40
Nutrient management (RD)	0.82	12.0
Nutrient management (RD+LLC, GreenSeeker, Nutrient Expert)	0.38	11.12
Wheat	Change in Profit (%)	Change in Yield (%)
Minimum tillage + RD	12.26	-8.15
ZT-RD	43.83	-4.40
ZT-RD+GS	42.50	-6.10
ZT-RD+GS+Legume	72.00	-5.07
ZT-RD+Ginger	-08.7	-17.82

Note: RD = Recommended Dose of fertilizer, FYM = Farm Yard Manure, LCC = Leaf Colour Chart, GS = GreenSeeker, ZT = Zero Tillage

4.3 Estimated area for scaling out CSA options

Crop wise cultivation areas for paddy, wheat, maize and millet in each district was used to estimate the area for scaling out the selected CSA options. More than 50% climate similarity was assumed to be a favourable condition for technology transfer from one location to another location. This study did not consider socio-economic analogue of pilot sites. Socio-economic variables may have impact on the technology adoption rate, which is an additional subject of research. Table 10 presents estimated areas for scaling out CSA options under the current climate analogue sites. CSA options for paddy and wheat which are tested and evaluated in the Nawalparasi site will be suitable for 1123 and 299 thousand hectares of land in Nepal. All paddy and wheat cultivated areas in the terai region are climatically similar to the Nawalparasi site. More areas under maize under current climate analogue site for Kaski and Lamjung districts. CSA options such as improved seeds, intercropping with maize, minimum tillage etc. can be scaled out about more than 300-thousand-hectare maize crops across the analogue sites.

Table 10: Estimated area for scaling out CSA options under current Climate Analogue (CA)

CSA option	CA with Nawalparasi			CA with Kaski			CS with Lamjung		
	Paddy ('000 ha)	Wheat ('000 ha)	Maize ('000 ha)	Paddy ('000 ha)	Wheat ('000 ha)	Maize ('000 ha)	Paddy ('000 ha)	Wheat ('000 ha)	Maize ('000 ha)
Improved seed (stress tolerant, short duration varieties)	1123	299	304	234	125	332	176	79	209
Irrigation management (Solar or other sources)	1123	299	304	234	125	332	176	79	209
Nursery management	1123	-	-	234	-	-	176	-	-
Site specific nutrient management (LLC, GreenSeeker, Nutrient Expert tool)	1123	299	304	234	125	332	176	79	209
Zero/minimum tillage	-	299	304	-	125	332	-	79	209
Intercropping with legumes	-	-	304	-		332			209
ICT-based agro-advisory	1123	299	304	234	125	332	176	79	209

Note: Estimated area is based on more than 50% similarity in climate (temperature and rainfall characteristics)

Table 11 presents estimated area for scaling out CSA options under the future climate analogue (2030) sites. CSA options for paddy and wheat which are tested and evaluated in the Nawalparasi site will be suitable for 1197 and 550 thousand hectare of land across the country. Area under future climate analogue for Nawalparasi district is substantially increased. More area in hill areas will be suitable for rice cultivation in future. Suitability of maize cultivation is also increased with the climate analogue site of Nawalparasi. Climate analogue area for paddy, wheat and maize with Kaski and Lamjung district is slightly decreased under future climate.

Table 11: Estimated area for scaling out CSA options under Future Climate Analogue (2030)

CSA option	CA with Nawalparasi			CA with Kaski			CS with Lamjung		
	Paddy (‘000 ha)	Wheat (‘000 ha)	Maize (‘000 ha)	Paddy (‘000 ha)	Wheat (‘000 ha)	Maize (‘000 ha)	Paddy (‘000 ha)	Wheat (‘000 ha)	Maize (‘000 ha)
Improved seed (stress tolerant, short duration varieties)	1197	520	403	205	118	294	171	92	231
Irrigation management (Solar or other sources)	1197	520	403	205	118	294	171	92	231
Nursery management	1197	-	-	205	-				
Site specific nutrient management (LLC, GreenSeeker, Nutrient Expert tool)	1197	520	403	205	118	294	171	92	231
Zero/minimum tillage	-	520	403	-	118	294		92	231
Intercropping with legumes	-	-	404	-	-	294	-	-	231
ICT-based agro-advisory	1197	520	403	205	118	294	171	92	231

Note: Estimated area is based on more than 50% similarity in climate (temperature and rainfall characteristics)

5. Scaling-out Climate Smart Agriculture in Nepal

5.1 Enabling Environments

The CSA Technologies which have potential to improve agriculture productivity, increase resilience and reduces emissions do not achieve an impact without successfully scaled-out through various mechanisms supported by strong enabling conditions. Financial system, incentive mechanisms and information provided through extension services can empower farmers and farming communities to invest in CSA technologies, practices and services. Similarly, policies and institutional structures at different levels and plan/schemes that include various incentive mechanisms can help to promote CSA technologies in the vulnerable areas. Table 12 provides an overview of the enabling environment needed to pave the way for scaling-out CSA technologies, practices and services in Nepal.

Table 12: Summarizes the enabling environment for scaling-out 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 capacity development, M&E and link to the market	• For adoption and scaling up of CSA practices and technologies, provision of proper seed supply system, nutrient supply system, marketing of value chain support is 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 support	• Provision for fixation of minimum price to the agricultural products • Buy back guarantee system • Partnership with non-government stakeholders
Agriculture 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
Local institutions	• Promotion of Farmers Producer Organizations (FPOs), Forest and Water Users groups, women's groups, saving and credit groups etc. • Development and promotion of farmers' custom hiring centres • Local agriculture business hubs

5.2 Scaling-up Pathway for CSA

Scaling-up of promising CSA technologies, practices and services is required to effectively increase the socio-economic, environmental and food security impacts from a small to a large scale. Achieving these multiple goals of CSA need widespread adoption across different agro-ecological zones and cropping systems. Scaling up is a long-term process that includes context specific approaches integrating scientific and local knowledge and use of existing institutions or development of new institutions. The scaling up CSA in Nepal can follow one or combination of following approaches.

5.2.1 Knowledge-transfer approach

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.

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.

5.2.2 Market-based approach

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.

5.2.3 Public-Private Partnership Approach

A strong cooperation between the public and private sectors can play a significant role in developing and promoting CSA technologies and services. In order to address challenges of climate change in agriculture and allied sector Public-Private Partnership (PPP) is needed. In this partnership, the public sector uses the experience of the private sector and private sector provides its services to the public sector. The PPP approach can mainly focus on two areas: i) technology innovation, and ii) technology transfer. Table 13 presents key areas of public-private partnership for scaling out CSA technologies, practices and services.

Table 13: Key areas of PPP for scaling-out CSA

Technology Innovation	Technology Transfer
➢ Information and communication technology for dissemination of climate information and agro-advisories to large number of farmers (e.g. mobile based applications) ➢ Water and energy use efficient technologies (e.g. micro-irrigation, tensionmeter based irrigation, laser land leveler and solar technologies) ➢ Nutrient efficient technologies (e.g. crop nutrient sensor such as GreenSeeker and nutrient expert tool) ➢ Minimum tillage (e.g. zero-till machine and combine harvester ➢ Improve seeds (e.g. climatic stress tolerant crop variety and livestock breeds)	➢ Integration of government's technology subsidy and credit incentive in CSA technology business model ➢ Provision of the desired products or service with the target volume and quality ➢ Testing and evaluation of technologies and business models ➢ Capacity building

5.2.3 Community-based Climate-Smart Villages (CSVs) approach

Climate-Smart Village (CSVs) is an innovative multi-stakeholder approach that can converge adaptation and mitigation schemes/programs at the local level to promote climate-smart agriculture. This approach incorporates climate smart technologies, practices, services and processes relevant for local climatic risks management and aligned with current adaptation policies/plans and village development programs (Figure 27). In a CSV, researchers, farmers' groups, private sector representatives, and policy makers collaborate to select and trial a portfolio of technologies and institutional interventions that promote CSA which aims to enhance productivity, increase incomes, build climate resilience and lower greenhouse gas emissions wherever possible.

The focus is generally on a basket of synergistic options, rather than on single technologies. Major initiatives include: i) strategic design of land use options including prioritizing crops, technologies and practices based on agro-ecological analysis and farmer typologies, ii) promoting climate-smart technologies and maximizing synergies among interventions; iii) providing value-added weather information services including weather insurance to farmers; iv) facilitating community partnership for knowledge sharing; and implementation of CSA practices, v) scaling-out through outreach activities like farmers' fairs and videos, and vi) scaling-up through linkages with on-going government schemes, policies, and programs, and the private sector.

Figure 27: Key components that are considered in a Climate-Smart Village approach

This approach has demonstrated the value of this participatory approach in different contexts, and this has already started delivering concrete policy impacts in several countries. The government of Nepal has already recognized this approach of climate change adaptation and started to implement as a part of efforts to adapt to climate change in Nepal. Figure 28 presents types of climate smart options promoted through the climate smart villages approach. Interventions selected differ based on the region, its agro-ecological characteristics, level of development, capacity, and interest of farmers and the local government.

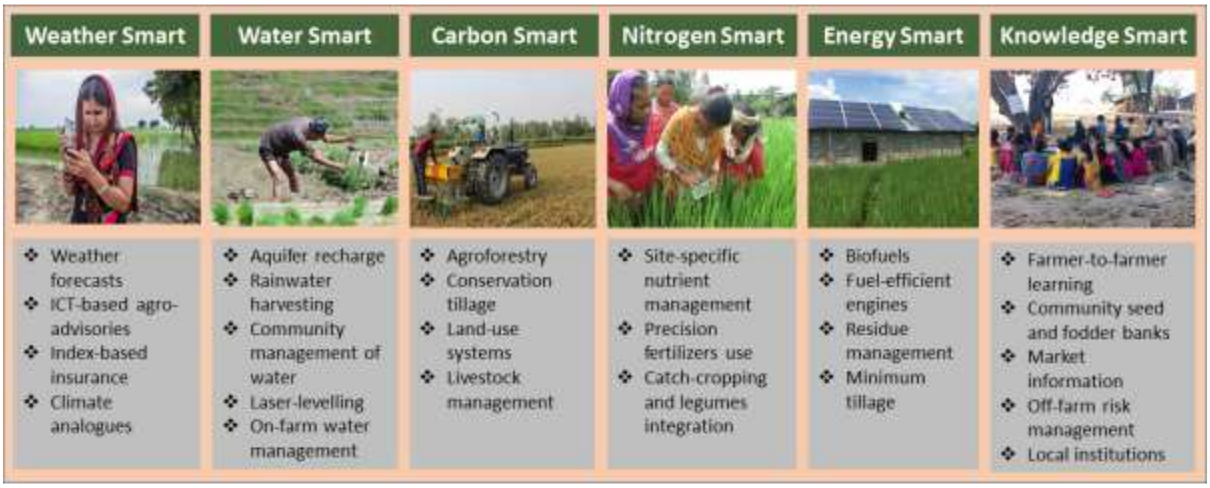

Figure 28: Type of climate smart interventions promoted through CSV approach

6. Lessons Learnt

Although research in climate-smart agriculture has now been done for some time and has shown tremendous promise at the local scale, it has still not reached the desired scale in most countries. Development and promotion of climate smart agriculture is highly crucial in Nepal where agriculture is highly incentive to changing climate and food security. This "Scaling up Climate Smart Agriculture in Nepal" project which was implemented in 2015-2016 has following lessons:

Lesson 1: A wide range of climate smart agricultural technologies, practices and services that are suitable for different agro-ecological zones are available in Nepal: A CSA pool of 147 potential technologies was developed based on literature review, consultation with other organizations working similar field, drawing previous experiences of LI-BIRD and CCAFS, and based on farmer's need and demand. These technologies are grouped into four categories: (i) a change in agronomic practices such as improving water, nutrient and energy use efficiencies, use of improved seeds or modern varieties, following crop rotations or other means of sustainable intensification; (ii) use of modern technologies and equipment to increase water, nutrient or other input use efficiency (e.g. Green Seeker and leaf colour chart to optimize nitrogen use, tensiometer based irrigation scheduling etc.); (iii) various information related interventions such as use of ICT for dissemination of climate information based agro-advisories and weather forecast services; and (iv) practices that reduce or transfer farming associated risks, such as weather index based agriculture insurance.

Lesson 2: There is no fixed package of CSA interventions; they are location specific based on climatic risks, agriculture production system and other bio-physical/socio-economic conditions: Assessment of location specific climatic risks, agriculture systems and current climate smartness has been done to identify CSA options for a particular location. This project has also tested and evaluated single or portfolios of CSA options at different agro-ecological zones of Nepal. Results show that CSA interventions may differ based crop and cropping system and location.

Lesson 3: For scaling out CSA one approach may not fit for all options: CSA options differ according to their characteristics, method of application and ability to mitigate climatic risk agriculture and allied sector. Single or combination of approaches can be used to scaling out CSA options to a large scale. Scaling out through the existing agricultural extension systems, pure market based approach, private public partnership and community based approaches can be used in differ CSA options.

Lesson 4: Enabling environment play a key role in scaling out CSA: There should be a proper incentive mechanism through policy and program to promote CSA. Policies and institutional structures at different levels and plan/schemes with various incentive to the farmers can help to promote CSA options. Many current policies and plan in agriculture sector are not explicitly focusing on CSA scaling out for climate change adaptation in agriculture. In order to capitalise the global and national policy processes for climate smart agriculture and translate these policy intentions into the reality, Nepalese agriculture needs to adopt the following early actions.

- Taking stock of existing good practices and develop complete models
- Integration of policy into plans and budget

- Intersectoral coordination and building synergy
- Investment on CSA specific human and social capital
- Targeted packages for different categories of farmers
- Facilitating local institutions and non-government actors and learning
- Strengthen Extension Coverage and Capacity–
- Partnerships with Private Sectors and cooperatives
- Simplify Financial Support and Incentive Mechanism
- Investment on Research and Extension
- Gender mainstreaming and women's empowerment

7. Future Work

This project has focused on identification of promising CSA technologies and evaluated in a limited time. But, scaling-up CSA is a long-term and non-linear process that often requires combination of activities. Future work should focus on:

- ➢ Creating evidences of single or combination of CSA options in different agricultural production systems and socio-economic conditions;
- ➢ Improved understanding of farmer and stakeholder perceptions along the value chain of CSA options;
- ➢ Assessments of the conditions for success and failure of interventions,
- ➢ Enhanced understanding of the policy/institutional options that would enable scaling of CSA; and
- ➢ Gathering information about adoption and spread of CSA technologies in different bio-physical and socio-economic conditions and assess the drivers of CSA adoption.

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