CLIMATE-SMART AGRICULTURE

FOR ADAPTATION TO CLIMATE CHANGE

A SOURCE BOOK

NETHERLANDS DEVELOPMENT ORGANIZATION AND
DEPARTMENT OF AGRICULTURE

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ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
Tashichhodzong
Thimphu:Bhutan

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FOREWORD

The RNR sector is indeed the most vulnerable sector that will be adversely affected by Climate change and climate induced disasters. Climate change stands out as an overwhelming challenge that is severely affecting agriculture value chains. One of the priorities of the Ministry of Agriculture in the current 11th Five Year Plan is to make the RNR sector resilient to Climate change. In doing so, the MoAF has recognized the importance of Climate-smart Agriculture as the most sustainable mechanism for adaptation to Climate change.

I am indeed pleased to note that SNV, the Netherlands Development Organization with the Department of Agriculture (DOA) has come up with the Source Book on Climate-smart Agriculture at a time when the concept of Climate-smart Agriculture is evolving in the country. The various initiatives and experiences of SNV on Climate-smart Agriculture since 2013 which were undertaken in collaboration with the MoAF are comprehensively captured in this Source Book which is expected to serve as an immediate reference for our filed staff. The Source Book has been designed in such a manner that it is simple yet comprehensive covering all aspects of Climate-smart Agriculture. This Source Book is an outcome of extensive process including desktop reviews, consultations with farming communities and national stakeholders engaged in Climate change adaptation programs. To support our smallholder farmers to respond to the evils of Climate change, we must be mindful in making the efficient and sustainable use of our local resources and to tune our farming practices to make it more resilient to Climate change. I would like to urge all my colleagues and the readers of this Source Book to maximize its use. I would like to congratulate Mr. BN Bhattarai, Project Manager of Climate-smart Agriculture project for his initiatives and leadership on Climate–smart Agriculture and the development of this Source Book.

Finally I take this opportunity to thank the SNV who has always been our long development partner for over 27 years. The Royal Government of Bhutan has always cherished to live in harmony with nature and remains committed in mainstreaming Climate-smart Agriculture into the five year developmental plans as a sustainable adaptation strategy to Climate change.

Yeshey Dorji
Minister

ACKNOWLEDGEMENT

Bhutan Media and Communications Institute (BMCI), Thimphu, would like to sincerely thank the Climate-smart Agriculture (CSA) Project, SNV the Netherlands Development Organization for awarding us the work for the development of Climate-smart Agriculture Source Book. This source book is expected to serve as practical hands on reference for adaptation to Climate change.

We are extremely happy that we could develop this source book in a participatory manner and in close consultations with relevant stakeholders including the Climate-smart Farmers Associations (CsFA), and all agencies involved in the facilitation and implementation of Climate-smart Agriculture approach on a pilot basis under six districts in Bhutan. To this effect, the BMCI would like to express sincere thanks to the Department of Agriculture, the researchers, extension colleagues, and the farmers of CSA pilot sites for the support and cooperation extended at various stages of drafting this source book. The BMIC is honored by the trust bestowed upon by SNV management to develop this CSA collaborative initiative into a comprehensive and informative source book which we confidently believe this source book as first of its kind in Bhutan.

Finally, we would like to acknowledge and share extensively that this CSA Source book would not have been possible without the technical, materials and advisory support of Mr. BN Bhattarai, Project Manager, Climate-smart Agriculture Project and Mr. Tirtha Bdr. Katwal, Specialist, RDC Yusipang.

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EXECUTIVE SUMMARY

Food production and food security is facing enormous challenges from Climate change. Science has established that Climate change is real and it will spare no countries and communities. The impact of Climate change on agriculture and food security is going to be overwhelming from the increasing frequency of extreme climate events. According Food and Agriculture Organization (FAO), Climate change will affect all the four dimensions of food security which are food availability, food accessibility, food utilization and food systems stability. The impacts of Climate change on agriculture and food security will mainly emanate from impacts of increasing frequency and more intense extreme weather events and from the changing temperatures and precipitation patterns. Rural poor and the farming communities that mainly subsist on agriculture are likely to be affected the most by Climate change.

In Bhutan, the National Adaptation Plan of Action (NAPA) has identified the Renewable Natural Resources (RNR) sector and the farming communities as the most vulnerable to the ensuing impacts of Climate change. Recognizing the potential threats and impacts of Climate change to the RNR sector, the Ministry of Agriculture and Forest (MoAF) in the current 11th Five Year Plan (FYP) has identified Climate-smart Agriculture (CSA) as one of the underlying strategies for adaptation to Climate change. The Food and Agriculture Organization (FAO) has presented a very convincing case for CSA as a new sustainable approach for smallholder farmers for adaptation to Climate change. CSA is an integrative approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under Climate change. CSA is increasingly being advocated as the answer to Climate change for its salient features that have the potential to sustainably increase agricultural productivity and income, adapt and build resilience to Climate change and reduce or remove Green House Gases (GHG) where possible.

In keeping with the 11th FYP priority to promote CSA for adaptation to Climate change, the CSA project was started in 2013 by SNV in partnership with the Department of Agriculture (DOA). The CSA project initiated work on the promotion and demonstration of CSA intervention in 12 sites spread across six different Dzongkhags. The project has tested and validated different CSA approaches and interventions and, has identified those that are feasible for adoption under the Bhutanese context for adaptation to Climate change.

One of the notable outputs of the project is the development of this Source Book on CSA. This source book on CSA has been developed with the following four key objectives which are:

- To create awareness to the stakeholders on the impact of and vulnerability of agriculture and food security to Climate change.
- To provide a simple and a quick field reference on Climate change and its potential impact on agriculture, food security and gender under Bhutanese farming environment.
- To introduce the concept of CSA to the national stakeholders associated with Climate change adaptation programs and to promote CSA as one of the options for adaptation to Climate change as reflected in the 11^{th} FYP.
- To provide simple and applied Climate change vulnerability assessment methods and tools for the stakeholders.
- To introduce, promote and popularize CSA approaches and interventions validated and adapted by the CSA project.

This source book is an outcome of the CSA process developed and implemented by the CSA project for two years. During the project period, different CSA approaches and interventions were validated and assessed from the perspective of adaptation of Bhutanese agriculture to Climate change. For the development of this source book resource material from different international and national publications on all aspects of CSA have been used. The CSA approaches and tools discussed in this source book were introduced and validated by the CSA project. The CSA interventions developed and demonstrated by the Research and Development Centers (RDCs) which were further validated by the CSA project in the project sites for their suitability as adaptation options to Climate change have also been included.

This source book is divided into nine chapters covering different dimensions of the impact of and vulnerability to Climate change. Each chapter dwells upon a specific topic that is relevant to the Bhutanese agriculture under the Climate change context. The theme and focus of each chapter are highlighted below:

i. Chapter one briefly introduces Climate change and the CSA project. The potential reasons why Bhutanese farmers are highly vulnerable to Climate change are highlighted.

ii. Chapter two discusses the impact of Climate change on agriculture and food security; the underlying causes of global climate change; GHG emission from different sectors in Bhutan; Climate change in Bhutan and its potential impact on Bhutanese agriculture and how Climate change is likely to affect the Bhutanese subsistence farmers.

iii. In chapter three the CSA approaches is defined. The salient features of CSA and its relevancy to Bhutanese agriculture are deliberated.

iv. Chapter four summarizes the participatory Climate change vulnerability assessment framework and tools adapted by CSA project that could be used for analysis and vulnerability assessment are presented. This chapter also covers challenges associated with the assessment of impact and vulnerability of agriculture to Climate change. For analysis and assessment of vulnerability ten different tools have been suggested.

v. Chapter five describes the stepwise CSA process and strategies adopted by the CSA project for implementing CSA activities and the approaches used for the adaptation and identification of potential CSA interventions. This chapter also outlines some of the potential CSA interventions for Bhutanese farmers for adaptation to Climate Change.

vi. Chapter six attempts to provide insights into how Bhutanese women who play a very significant role in agriculture could be severely impacted by Climate change. Currently the role of women in agriculture and the potential impact of Climate change on women are not adequately studied and understood.

vii. Chapter Seven briefly dwells on the different policies and the policy environment for the transition of Bhutanese agriculture to CSA. The existing policy instruments pertaining to agriculture and Climate change are analyzed and the immediate strategies for effective mainstreaming of CSA into agriculture research and development programs are suggested.

viii. The source book is completed with a short conclusion in chapter eight and definitions of key Climate change and CSA terms in chapter nine.

CSA approach is new and the overall awareness and understanding of the CSA among the Bhutanese stakeholders is relatively poor. This source book is expected to provide a simple and a quick reference on the principles and approaches of CSA for different stakeholders at all levels.

ACRONYMS

°C	Degree Celsius
CAFCO	Chhuzagang Agriculture Farmers' Cooperative
CSA	Climate-smart Agriculture
CsFA	Climate-smart Farmers Association
DoA	Department of Agriculture
ECHAM	European Center Hamburg Model
FAO	Food and Agriculture Organization
GCM	Global Climate Model
GDP	Gross Domestic Product
GHG	Green House Gases
GNHC	Gross National Happiness Commission
GLOF	Glacial Lake Outburst Floods
HadCM	Hadley Center Coupled Model
IATF	Integrated Agriculture Technology Farm
IFAD	International Fund for Agricultural Development
IPPC	Intergovernmental Panel on Climate change
mm	millimetres
MoAF	Ministry of Agriculture and Forest
NAPA	National Adaptation Program of Action
NEC	National Environment Commission
NOP	National Organic Program
NSSC	National Soil Service Center National Post
NPHC	National Post Harvest Center
NWFPs	Non Wood Forest Products
RNR	Renewable Natural Resources
RDCs	Research and Development Centers
SAPA	Sector Adaptation Plan of Action
SNV	Netherlands Development Organization
ToT	Training of Trainers
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United National Framework Convention on Climate change
WMO	World Meteorological Organization
WUAC	Water Users' Association of Chhuzagang

CHAPTER ONE
GENERAL INTRODUCTION

1.0 Background

Bhutan is primarily an agrarian society with 69 % of the population still continue to live in rural areas. Agriculture and forestry provide direct employment to about 56 % of the population [1]. From the three Renewable Natural Resources (RNR) sectors that comprise agriculture, livestock and forestry, agriculture alone contributes 8.8% to the GDP [2]. Agriculture is an integral part of the Bhutanese economy as it provides food and livelihood for the majority of the population. Bhutanese agriculture is still overwhelmingly subsistence and farmers predominantly practice traditional and self-sustaining farming practices to meet their domestic needs. The farming environment is highly challenging due to the rugged mountainous terrain, steep slopes contributing to increasing soil erosion and limiting the scope for farm mechanization, low productivity, declining soil fertility, lack of access to markets, credit, suitable technologies, increasing insurgence of pests and severe crop predation by wildlife. The arable area available for farming is only 2.93% of the total geographical area [3]. Agriculture is largely dominated rainfed dryland farming which depends on the southwesterly monsoon rain that accounts to 60 to 90 % of annual precipitation. The domestic food production is currently able to meet only 64% of the total cereals requirement making the country still dependent on imported food grains [2]. The rural communities who dwell in far flung remote areas often remain disconnected from the main settlements during the heavy monsoon rains in summer and snowfalls in winter. The geologically fragile and yet self-sustaining Bhutanese agro-ecosystem is now further threatened by the unprecedented menace of Climate change. Bhutan as a least developed country is the least contributor to the global Climate change but it will not be spared by its impacts. The country is already witnessing the impacts of Climate change that is manifested in the form of local symptoms like glacial lake outburst, flash foods, windstorms, cyclones, outbreak of new pest and disease in crops and livestock, increasing incidences of forest fire and many others.

Agricultural resources which constitute the economic lifeline of Bhutanese are highly vulnerable to the impacts of Climate change. The most severe impacts of Climate change on agriculture and food security is expected to be in the form of loss of limited arable land from flash floods and landslides, accelerated soil degradation and loss of soil fertility, outbreak of new pest and disease, shortage of

water for crop production and uncertainty of precipitation that will directly affect the rainfed dominant agriculture [4]. There is a growing certainty that the extreme weather events are going to increase in frequency and intensity that will negatively impact the Bhutanese agriculture and the vulnerable farming communities **(Box 1)**.

Recognizing the imminent threats from Climate change to the sustainable livelihood, the Ministry of Agriculture and Forest (MoAF) in the current 11th Five Year Plan (FYP) has identified climate smart sustainable management and utilization of natural resources as one its priority goals [5]. In order to enhance and ensure the long term sustainability of rural livelihood and to make it more resilient to Climate change the promotion of Climate- smart Agriculture (CSA) has been identified as one of the key sector strategies.

1.2 Climate-smart Agriculture Project

In line with the 11th FYP priority of the MoAF to promote CSA, the Department of Agriculture (DoA) and the SNV Bhutan formulated the CSA. The CSA project is supported by the Government of Netherlands and is implemented by SNV in partnership with the Department of Agriculture. It is a collaborative project that is implemented in partnership with different central programs of the DoA, the Dzongkhag extension services and Research and Development Centers (RDCs).

The project aims to identify and promote CSA interventions as one of the option for adaptation to Climate change, mainstream CSA into the research and development programs of the DoA and develop information and communication materials for up scaling CSA. The CSA project is working in 12 specific sites spread across nine Geogs and six Dzongkhags namely Chhukha, Thimphu, Wangdiphodrang, Tsirang, Samtse and Sarpang (Table 1). In these six Dzongkhags, CSA sites that are highly vulnerable to Climate change were selected in consultation with the stakeholders and local communities by using the CSA vulnerability assessment tools. The baseline information on the CSA sites were collected and potential CSA interventions were introduced and evaluated. The different CSA interventions introduced by the project were then assessed for its acceptability and adoption by the communities was reviewed by an independent local consultant. Those interventions suitable and accepted by the communities are being further up scaled by the project stakeholders. These popular Climate-smart interventions have been finally compiled in this source book for further dissemination at the new sites vulnerable to Climate change.

Table 1. Details of CSA sites

No	Dzongkhag	Geog	CSA Sites	Agro-ecology
1	Chhukha	Samphelling	Burkay	Humid Sub-tropical
2	Sarpang	Chhuzagang,	Chaskar, Dawathang,	Humid Sub-tropical
			Barthang (CAFCO),	Humid Sub-tropical
		Shershong	Tashiphu	
		Umling	Dangling & Dungmin	Humid Sub-tropical
3	Samtse	Ugyentse	Ngashang, Gathia	Humid Sub-tropical
4	Tsirang	Goseling	Pemathang	Dry Subtropical
5	Thimphu	Mewang	Gida Wom & Gom,	Warm temperate
			IATF	
6	Wangdiphodrang	Phangyul	Nabesa	Warm temperate

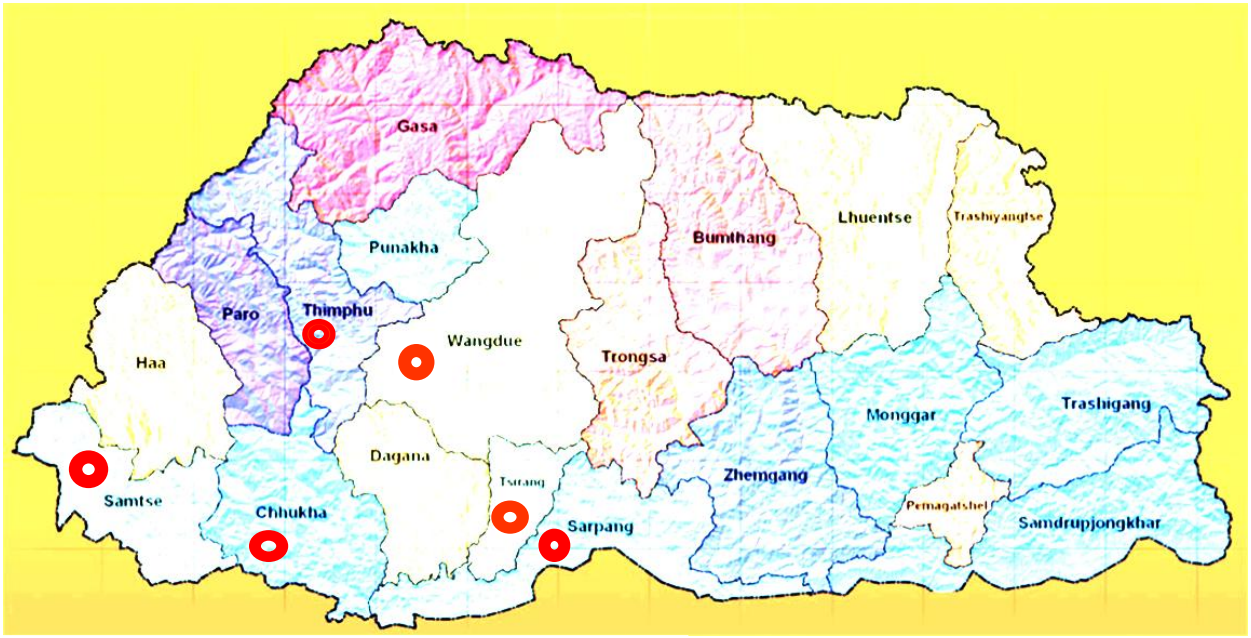


Plate 1. CSA sites

1.3 Purpose of this Source Book

Climate change and CSA are both evolving and knowledge intensive subjects that are closely interlinked. At present the understanding of both these topics amongst all the national stakeholders in the country is relatively weak. Climate-smart interventions are highly location-specific and knowledge-intensive and being a new approach it currently lacks tools and experience [6]. Before

embarking upon the up scaling of CSA, it is necessary to ensure the comprehensive understanding of this approach and hence there is a need to develop this source book. The broad objective of this source book is to provide simple and comprehensive information on all the aspects of CSA to the different stakeholders engaged in Climate change adaptation programs in agriculture. This source book also aims to meet the following specific objectives:

i. To create awareness to the stakeholders on the impact of and vulnerability of agriculture and food security to Climate change.
ii. To provide a simple and a quick field reference on Climate change and its potential impact on agriculture, food security and gender under Bhutanese farming environment.
iii. To introduce the concept of CSA to the national stakeholders associated with Climate change adaptation programs and to promote CSA as one of the options for adaptation to Climate change as reflected in the 11th FYP.
iv. To provide simple and applied Climate change vulnerability assessment methods and tools for the stakeholders.
v. To introduce, promote and popularize CSA approaches and interventions validated and adapted by the CSA project.

1.4 Methodology used for the development of Source Book

This source book is an outcome of the CSA process developed and implemented by the CSA project for two years. During the project period, different CSA approaches and interventions were validated and assessed from the perspective of adaptation of Bhutanese agriculture to Climate change. This source book draws heavily on different international publications, national reports and open resources available in the public domain on all aspects of CSA. Many local resources and experts were consulted by the CSA project on different specific topics covered in this source book. During the project period three rounds of national stakeholders workshop was organized for brainstorming on the approaches and the strategies required for mainstreaming CSA into the national agriculture policies and programs. The CSA approaches and tools discussed were sourced from different CSA materials and validated by the CSA project. The CSA interventions suggested in this source book are mainly those developed and demonstrated by the Research and Development Centers (RDCs). They were further validated by the CSA project in the project sites for their suitability as adaptation options to Climate change. The final compilation, editing, layout and

design were outsourced to a local consulting firm. The development of this source book was fully supported by the CSA project and its national stakeholders

BOX 1. Why Bhutanese farmers are highly vulnerable to Climate change?

i. An overwhelming majority of the Bhutanese (69%) depend on agriculture and natural resources for their livelihood on which Climate change has a direct impact.
ii. Majority of the Bhutanese are subsistence farmers who farm on an average land holding size of three acres or less.
iii. The farming environment is highly challenging and labour intensive due to the rugged mountainous terrain.
iv. Agriculture is largely dominated by rainfed farming with only less than 18% of the arable land under irrigation.
v. The overall awareness and understanding of the farming communities on the potential threats of Climate change is poor.
vi. Farming communities do not have any assured safety nets and alternative livelihood source to fall back in the event of crop failures. Crop insurance schemes are yet to be initiated.
vii. Over 98% of the farmers depend on their farm saved seed for planting in the next season.
viii. Access to and availability of Climate-smart technologies for adaptation is limited.
ix. Access to climate forecasting and advisory service for farmers is nonexistent or very poor.
x. The overall preparedness and adaptive capacity for climate related risks and disasters are poor.

Plate 2: A Climate-smart village, Burkay, Samphelling.

CHAPTER TWO
IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY

1.0 Introduction

Science has firmly established that Climate change is a reality and a global phenomenon. Across the scientific community there is an overall consensus that global climate is changing and that human activity significantly contributes to Climate change [7]. Climate change is the major, overriding environmental issue of our time, and the single greatest challenge facing environmental regulators. Climate change is a growing crisis with economic, health and safety, **food production, security**, and other dimensions [8].

Climate change is likely to have a significant impact on the global environment. Climate change will spare no one and no place and will have a much heightened impact on world's farmlands and rural communities where a large majority of the world's poorest dwell. Climate is the primary determinant of agricultural productivity and given the fundamental role of agriculture in the overall human welfare Climate change is a cause for concern [9]. The detrimental effects of Climate change on agriculture will be through higher temperatures, greater crop water demand, more variable rainfall and extreme climate events such as heat waves, floods and droughts. The currently vulnerable areas where low yields and poverty are prevalent, may become further marginalized as a result of land degradation through deforestation, wind and water erosion, repetitive tillage and overgrazing[10]. According to the United Nations Food and Agriculture Organization [11] Climate change will affect the four dimension of food security which are food availability, food accessibility, food utilization and food systems stability. Climate change will impact livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. The impacts of Climate change on agriculture and food security will mainly emanate from impacts of increasing frequency and more intense extreme weather events and from the changing temperatures and precipitation patterns. In agriculture the entire value and supply chain will be affected by Climate change at large.

1.2 What are the Causes of Climate change?

According to the World Metrological Organization (WMO) Climate change is caused by 'natural' and 'anthropogenic' (human induced factors). There are three main causes of Climate change which are:

i. **Green House Gases (GHG)** – Are those gases that trap heat in the atmosphere. The main GHGs are water vapour, carbon dioxide, methane, nitrous oxide and other fluorinated gases. By increasing the heat in the atmosphere, greenhouse gases are responsible for the greenhouse effect, which ultimately leads to global warming.

ii. **Aerosols** - are fine, airborne particles consisting at least in part of solid material. The ocean is a major source of natural aerosols. Aerosols play an important role in the global climate balance, and therefore they could be important in Climate change. Aerosols affect the climate directly and indirectly by scattering solar radiation and absorption of terrestrial radiation that affect the climate.

iii. **Land use Changes**- Land-use changes such as deforestation for farming have led to changes in the amount of sunlight reflected from the ground back into space. The scale of these changes is estimated to be very high and is rapidly increasing causing the emissions of greenhouse gases. Other significant changes in the land surface resulting from human activities include tropical deforestation which changes evapotranspiration rates (the amount of water vapour put into the atmosphere through evaporation and transpiration from trees) and desertification. Analyses show that forest clearing for agriculture and irrigated farming in arid and semi-arid lands is two major sources of climatically important land cover changes. The two effects tend, however, to cancel out, because irrigated agriculture increases solar energy absorption and the amount of moisture evaporated into the atmosphere, whereas forest clearing decreases these two processes.

1.3 What are the Green House Gases?

The earth's atmosphere contains naturally occurring GHG. The earth has a natural green house effect where some of the GHG allow the sunlight to enter the earth's atmosphere and absorb the heat radiation. Since these gases absorb the heat, they keep the average surface temperature on Earth around 14°C. If these natural greenhouse effect was absent then the Earth's average surface temperature would be around -19°C and too cold for living things to survive [12].

Water vapour- It is the most abundant GHG, however because it spends just a short time in the atmosphere it is not considered the most important GHG.

Carbon dioxide (CO2)- It is only a small part of the atmosphere, but one of the most important GHGs. CO2 is released naturally into the atmosphere through volcanic eruptions and animal respiration but it is also released through human activities such as deforestation and the burning of fossil fuels for energy. CO2 also spends a long time in the atmosphere increasing its impact. Since the industrial revolution, humans have increased atmospheric CO2 concentration by 30%.

Methane (CH_4)- It is the second most important GHG which is produced both naturally and through human activities. The most significant sources of Methane come from the decomposition of organic matter (eg. rice fields). Another large source of methane is from the digestion of ruminants (cows, goats) known as enteric fermentation. Methane is a stronger GHG than CO2 because it can absorb more heat; however it is much less abundant in the atmosphere.

Nitrous oxide (N_2O) - It is a very powerful greenhouse gas which is heavily produced in the agriculture sector, from the use of inorganic and organic fertilizers. It is also produced when burning fossil fuels.

Chlorofluorocarbons (CFCs) - These are man-made compounds produced for industrial use, mainly in refrigerants and air conditioners. They cause adverse affect on the Ozone Layer and are now regulated.

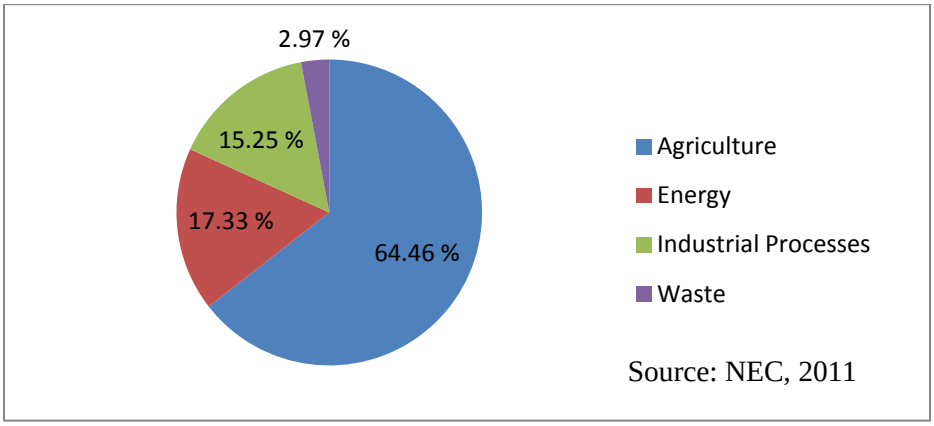
Different human activities are increasing the concentration of these GHGs and contributing to Climate change. The human activities that increase the emission of GHGs are:

i. Burning fossil fuel like coal, oil and gas that produces carbon dioxide and nitrous oxide.
ii. Deforestation and slash and burn system of farming (*Tsheri*).
iii. Excessive use of chemical fertilizers containing nitrogen produces nitrous oxide emissions.
iv. Livestock farming produces GHGs like carbon dioxide, nitrous oxide and methane.
v. Irrigated rice farming that produces methane.
vi. Use of fluorinated gases in industries that produce a very strong warming effect.

The total GHG emission for Bhutan excluding Land Use Change and Forestry (LUCF) for the year 2000 is estimated at 1559.564 Gg Co_2 – equivalent, however, the total GHG including LUCF is estimated at -4750.04 Gg Co_2 – equivalent, indicating that Bhutan is a net sink for GHG emissions

[13]. In Bhutan the main sources of GHG emissions are Energy, Industrial processes, Agriculture and Waste (Figure 1). The Land Use Change and Forestry (LUCF) actually sequestered a total of 6,309.63 Gg Co_2 – equivalent in 2000 which is four times the level of Bhutan's GHG emission excluding LUCF [13].

Figure. 1. GHG emission from different sources in Bhutan for 2000 excluding Land Use Change and Forestry

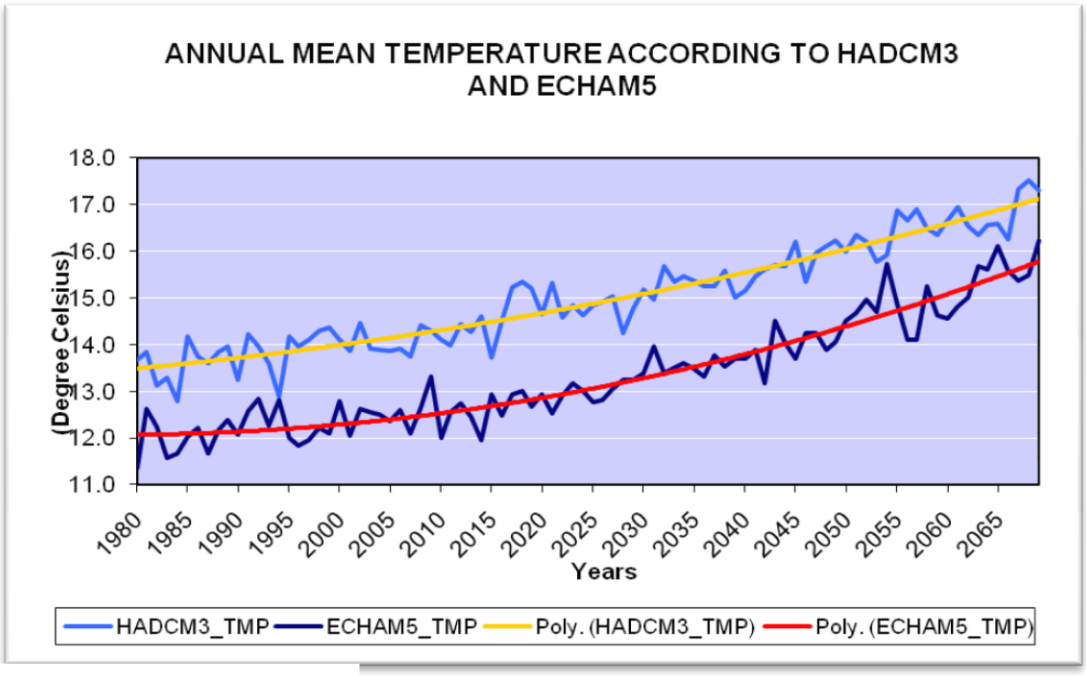


1.4 Climate change in Bhutan

Availability of reliable time series climate data is one of the key limitations for a long term analysis and baseline assessment of climate in Bhutan [13]. In order to generate future Climate change scenarios, the National Environment Commission (NEC) has used two different Global Climate change Models (GCM) namely ECHAM5 and HadCM3Q0 A1B in PRECIS to generate the Climate change trend for the period 1980 to 2069.

The annual trend in the annual mean temperature is shown in Figure 2. Both the ECHAM5 and HadCM3Q0 climate model output of air temperature show a progressive and steady increase in air temperature from 1980 to 2069 (Figure 2.0). The HadCM3Q0 simulation shows an increase of 3.5°C by 2069 from 13.5 °C in 1980 to 17°C in 2069 while the ECHAM5 simulation shows a similar temperature increase of 3.5°C from 12.0°Cin 1980 to 15.5 °C in 2069 [13].

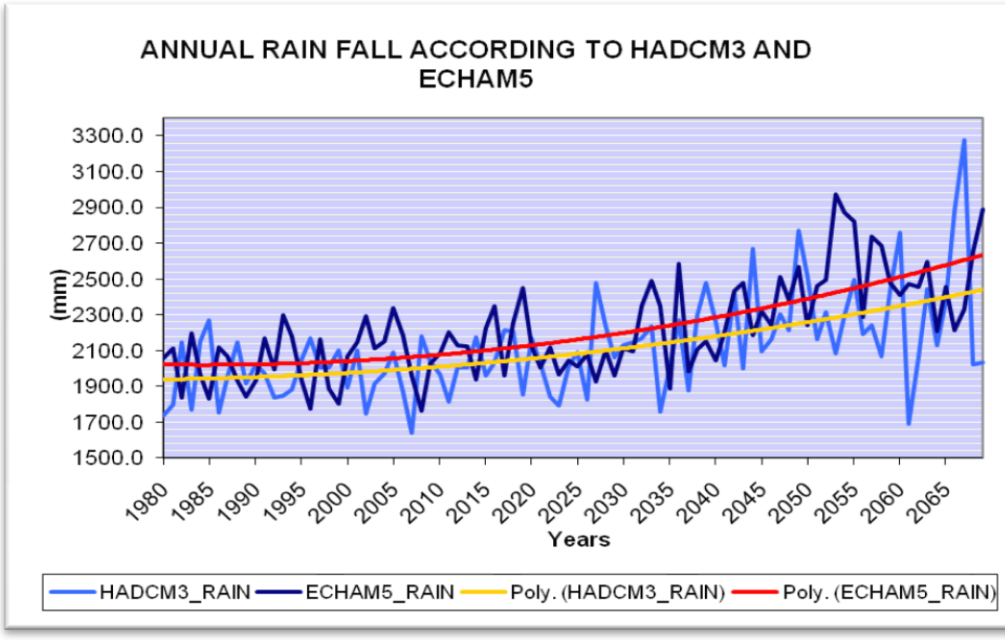
Figure 2. Annual trends of mean air temperature (°C) from 1980 to 2069 for Bhutan according to the PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios



Source: NEC, 2011

With regard to the annual trend in the annual mean precipitation for the period of 1980 to 2069, the same GCM models for air temperature were used and the trend is shown in Figure 3. In case of the precipitation both the models show a progressive and steady increase in precipitation from 1980 to 2069 (Figure 3).The ECHAM5 shows a steady increase of 600 mm per year in the annual precipitation from 2000 mm per year in 1980 to 2600 mm per year in 2069 while the HadCM3Q0 shows an increase of 500 mm per year in the annual precipitation from 1900 mm per year in 1980 to 2400 mm per year in 2069 [13].

Figure 3. Annual trends of mean total annual precipitation (mm) from 1980 to 2069 for Bhutan according to the PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios



Source: NEC, 2011

The above climate scenarios obviously indicate that Climate change will occur in the form of increase in annual mean air temperature and mean total precipitation for Bhutan. The temperature increase by 2069 is projected at 3.5°C from the mean temperature of 1980 while the mean total annual precipitation will increase by 500-600 mm by 2069 as compared to that of 1980. However, it has to be noted that this is a general trend and there will certainly be very large seasonal variation and variation within the different agro- ecological zones. Another very obvious indication of Climate change is the observation of increasing frequency of extreme weather events such as the Glacial Lake Outburst Floods (GLOF) of 1994, flash floods of 2004 in eastern Bhutan, cyclone Aila of 2009, and outbreak of new pest and diseases in crops.

1.5 Potential Impact Change on Bhutanese Agriculture

Agriculture is the primary source of livelihood for an overwhelming majority of the Bhutanese people and is important for food security and livelihood. Bhutanese agriculture is extremely sensitive to Climate change because of its dependence on the seasonal rains brought mainly by the

South-West monsoon. Further, Bhutan represents a fragile mountain and a predominantly rainfed agricultural ecosystem where farming is mostly done in steep slopes that are extremely prone to land instability and erosion. Due to the steep terrain, the bio-physical sensitivity of the cultivated land is prone to the climate related hazards. Bhutanese agriculture is highly vulnerable to the impacts of Climate change that manifest in the form of untimely monsoon, droughts, cold temperature in higher elevations, frost, hailstorms, windstorms, drought, flash floods, landslides, outbreak of new pest and diseases, and increasing scarcity of water for crop production [14].

Bhutanese agriculture is dominated by smallholder subsistence farmers who are highly vulnerable to food insecurity. The notable challenges of the smallholder Bhutanese farmers are low productivity stemming from poor agriculture practices, difficult topography with steep terrain, limited scope for mechanization, unproductive farm land, lack of access to markets, credit and appropriate technology which is further compounded by insurgence of new pests and diseases, crop predation by wildlife and loss of land and livelihoods to extreme natural calamities exacerbated by Climate change [15]. The different direct and indirect ways how the Bhutanese farmers will be affected by Climate change are listed in **Box 2**.

In the back drop of the increasing extreme weather events Bhutanese agriculture has to be more resilient. Since agriculture is critically dependent on local temperatures and precipitation, Bhutanese farmers have to be more innovative and adjust their current farming practices through CSA approaches for long term sustainability. Bhutanese agriculture has to be made "climate smart" in order to meet the household food security, adapt to increasing frequency of extreme weather events and to mitigate the potential long term threats from Climate change.

Plate 3: Consultation with policymaker – a part of CSA process

BOX 2. How will Climate change affect subsistence Bhutanese farmers?

The smallholder subsistence farmers are highly vulnerable to Climate change. Their household food security hinges on domestic production and any major alteration in the local climate has a direct bearing on food production. In general Climate change will make farming difficult mainly due to the disruption of the existing ecosystem. The subsistence farmers could be affected by climate change both directly and indirectly in many different ways.

A. Direct effect of Climate change

i. Complete crop failure from delayed monsoon or very limited precipitation.
ii. Reduction of crop yield from high temperature.
iii. Erratic precipitation significantly decreasing the availability of water for crop production and drinking, drying of water sources or untimely monsoon.
iv. Increasing frequency of droughts leading to crop failures, threaten pastures and feed supplies.
v. Occurrence of early frost and abrupt cold temperatures that will affect crop at different stages.
vi. Loss of property and sources of livelihood from extreme weather events such as flash food, windstorm, hail storms and landslides (Example: Cyclone Aila of 2009).
vii. Insurgences of new pest and diseases in crops such as the Rice Blast Disease (*Pyricularia grisea)* of 1995, Gray Leaf Spot (*Cercospora zea maydis)* of Maize 2007 and Army Worm (*Spodoptera frugiperda*) outbreak of 2013 and prevalence livestock diseases and parasites
viii. Loss of seeds and planting materials for next season planting.
ix. Land degradation and loss of soil fertility due to erosion of top soil and runoff sparked by incessant rainfall.
x. Damages to key infrastructures like and bridges disconnect people from far flung remote areas making them highly vulnerable to food insecurity.
xi. Overall degradation of natural resources resulting in poor access.
xii. Loss of agro-biodiversity and disruption of traditional seed system.

B. Indirect effects of Climate change

i. Increased crop failures will lead to decreased domestic food production resulting in the increased imports of food.
ii. Increase in prices of essential commodities will drive poor farmers to further poverty.
iii. Increased incidence of pest and diseases on humans and animals affecting their health.
iv. Increased drudgery and work load on rural women due to declining accesses and degradation of natural resources.
v. Climate change can disrupt the local seed system and put pressure on women who take the lead role in seed saving, seed selection and conservation of crop and varieties.
vi. Increased rural- urban migration and fallowing of agricultural land.
vii. Crop failures causes increased work load on women who are the carers and responsible for feeding the family.

CHAPTER THREE
CLIMATE-SMART AGRICULTURE

1.0 What is Climate-smart Agriculture?

Climate-smart Agriculture (CSA) was first defined and presented by the Food and Agriculture Organization (FAO), in 2010 at the International Conference on Agriculture, Food Security and Climate change at Hague in the Netherlands [6].

The Food and Agriculture Organization (FAO) defines CSA as **"Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals."** CSA is composed of three key pillars which are:

i. Sustainably increasing agricultural productivity and incomes
ii. Adapting and building resilience to Climate change
iii. Reducing and/or removing greenhouse gases emissions, where possible

CSA is an integrative approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under Climate change. CSA approach is designed to identify and operationalize sustainable agricultural development to adapt to the impacts of Climate change. The CSA approaches aim to strengthen livelihoods and food security of smallholders by adopting appropriate methods and technologies for the production, processing and marketing of agricultural goods. The CSA approach has recently emerged as a framework to capture the concept that agricultural production systems can be developed and implemented to simultaneously improve food security and rural livelihoods, facilitate Climate change adaptation and also provide mitigation benefits. Although CSA has been framed and put forth as the concept for sustainable agricultural development for food security under Climate change, in essence CSA comprises sustainable farm based agricultural land management practices such as conservation agriculture, efficient water management, crop diversification, crop residue management, agro-forestry, promotion of alternative livelihood, and many others [16]. Some salient features of CSA is presented in **Box 3**.

Climate-smart Agriculture is not a new agricultural system, nor a set of practices. It is a new approach, a way to guide the needed changes of agricultural systems, given the necessity to jointly address food security and climate change [6].

CSA is an approach that supports the more efficient use of resources; with less food losses and promotes shifts towards more resilient smallholder farming systems [17].

2.0 Why is CSA needed?

According to the FAO there are several reasons that call for the rapid transition of the present agriculture production system to a more Climate-smart and resilient production system in the back drop of increasing risks from Climate change and climate associated disasters. The following are the six important reasons to make the Bhutanese agriculture production system Climate-smart.

i. The demand for food is increasing and more food has to be produced with the same amount of resources such as the land, water and capital.
ii. There is an overall depletion and degradation of the natural resource which sustain agriculture production.
iii. Subsistence farmers are highly vulnerable to the impacts of Climate change and there is urgency for a more sustainable approach for adaptation to Climate change.
iv. There is a need for enhancing food security while contributing to mitigate Climate change and preserving the natural resource base.
v. In the face of Climate change the agricultural production systems have to be more productive, use inputs more efficiently, have less variability and greater stability in their outputs, and are more resilient to risks, shocks and long-term climate variability.
vi. The awareness and understanding of the farming communities on the potential impacts of Climate change on agriculture is limited which calls for the urgent need to create awareness and build their capacity for adaptation.

In the Bhutanese context CSA is highly relevant approach for adaptation to Climate change because:

i. Small holder Bhutanese farmers are increasingly affected by extreme weather events such as seasonal droughts, windstorms, insurgence of new pest and disease and many more climate sparked disasters.
ii. The coping and adaptation capacity of the Bhutanese farmers to Climate change is limited.
iii. The three key pillars of CSA which hinges on sustainably increasing agricultural productivity, adapting and building resilience to Climate change and reduction of green house gases are highly coherent with the MoAFs' 11th FYP objective to enhance food security through sustainable utilization of arable agriculture and pasture resources.

iv. CSA is a holistic approach that considers the agro-ecosystem through a landscape approach and is suitable for Bhutanese farmers who practice an integrated farming.

v. CSA is gender responsive and addresses the impact of Climate change on women which constitute about 65% of the work force in agriculture and forestry and youth.

BOX 3. Some Salient Features of CSA

i. CSA is not a new agricultural system, nor a set of practices. CSA is a new approach.

ii. CSA is a way to guide the needed changes of agricultural systems to jointly address food security and Climate change.

iii. CSA is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development.

iv. CSA approach is designed to identify and operationalize sustainable agricultural development within the explicit parameters of Climate change.

v. CSA is sustainable agriculture, based upon integrated management of water, land and ecosystems at landscape scale.

vi. CSA is a necessary approach for smallholder farmers to cope and adapt to Climate change.

vii. CSA is location-specific and knowledge-intensive.

viii. CSA helps to identify barriers to adoption and provides appropriate solutions.

ix. CSA strives to achieve multiple objectives while prioritizing benefits and trade-offs.

x. CSA strengthens livelihoods by improving access to services, resources and markets.

xi. CSA addresses adaptation and builds resilience to shocks.

xii. CSA considers Climate change mitigation as a potential co-benefit.

xiii. CSA integrates climate financing with traditional sources of agricultural investments.

xiv. CSA brings together practices, policies and institutions that are not necessarily new but are used in the context of Climate change.

3.0 Conclusion

CSA is a sustainable approach for adaptation of small holder farmers to the potential risks imposed by Climate change. It aims to enhance food security through sustainable and efficient use of scare and depleting natural resources. CSA is a participatory approach which also builds on local

livelihoods, traditional knowledge and practices of the farmers which are location specific and proven. CSA aims to develop and enhance the knowledge and skills of the farmers that will enable them to appropriately adjust their farming practices to make it more resilient to Climate change. CSA is also highly consistent and in line with the agriculture development approaches of the MoAF for the 11th FYP and beyond.

Plate 4 : Consultation with communities as a part of CSA planning

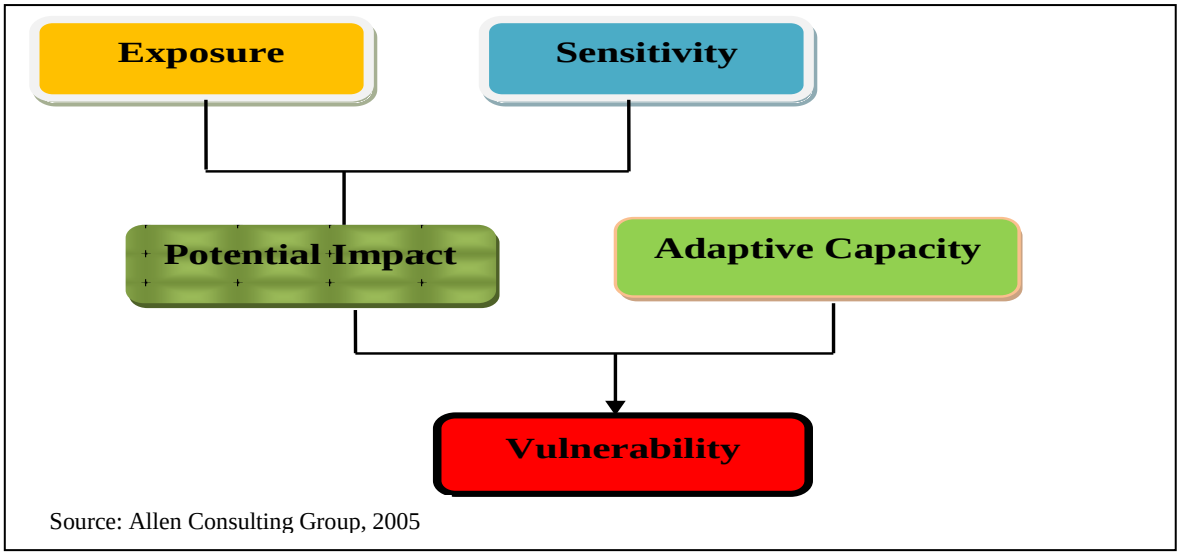
CHAPTER FOUR
PARTICIPATORY CLIMATE CHANGE VULNERABILITY ASSESSMENT FRAMEWORK AND TOOLS ADAPTED BY CSA PROJECT

1.0 Introduction

The Intergovernmental Panel on Climate change (IPPC) defines Vulnerability as "The degree to which a system is susceptible to, or unable to cope with, adverse effects of Climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity".

This IPPC definition of vulnerability highlights the three main components of vulnerability which are exposure, sensitivity and adaptive capacity (Figure 4). A system is considered vulnerable if it is exposed and sensitive to the effects of Climate change and at the same time has only limited capacity to adapt [18].

Figure 4. Linkage between the three components of vulnerability



Source: Allen Consulting Group, 2005

In assessing the vulnerability of agriculture sector to Climate change it is important to understand the three components of vulnerability which are exposure, sensitive and adaptive capacity.

Exposure – relates to "the nature and degree to which a system is exposed to significant climatic variations" [19].

Sensitivity- relates to the "degree to which a system is affected, either adversely or beneficially, by climate variability or change". The effects may be direct or indirect [19].

Exposure + Sensitivity = *Potential impact that* Climate change can have on a system.

Adaptive capacity - represents the potential of a system to adapt rather than the actual adaptation.

2.0 What is the Vulnerability of Agriculture to Climate change?

The vulnerability of agriculture to Climate change directly stems from its dependency to and high degree of exposure to different climatic factors. The exposure and sensitivity of the agriculture sector to Climate change is very high and uncertain. Agriculture especially in the least developed countries is associated with poor and subsistence communities whose adaptive capacities are very low for different socio-economic reasons. The potential impact of Climate change in agriculture is considered very high making agriculture and food security highly vulnerable to Climate induced impacts. Further, Climate change related extreme events are highly uncertain, context specific, specific to place and system and they can vary over time.

The main direct effects of Climate change to agriculture will be caused by climatic factors such as temperature, precipitation, length of growing season, and timing of extreme or critical events relative to crop development, as well as through changes in atmospheric CO2 concentration which may have a beneficial effect on the growth of many crop types. The other main effects expected are the increased variability of production, decrease of production in certain areas and changes in the geography of production. The indirect effects include incidence of potentially detrimental diseases, pests, weeds, the effects of which have not yet been quantified in most available studies [20, 18]. Climate change will also expose agriculture to different types of shocks and stresses the consequences of which are highly complex in nature.

3.0 Introduction of Methods for Assessing Vulnerability of Agriculture to Climate change

Assessing the impacts and vulnerability of agriculture to Climate change is a vast and a complex subject. There are several challenges associated with the assessment of impact and vulnerability of agriculture to Climate change as climate is a primary determinant of agriculture **(Box 4).** Over time several approaches have evolved and frameworks have been developed and proposed by different institutions. A comprehensive review of different conceptual frameworks for assessing the Climate

change related vulnerability in agriculture sector has categorized the different vulnerability assessment methods into two broad groups [18].

I. **Top down** - This approach typically proceeds from global climate projections which can be downscaled and applied to assess regional impacts of Climate change.
II. **Bottom up** - This approach involves the population and stakeholders of the system in identifying Climate change stresses, impacts and adaptive strategies. This approach is more participatory.

Any vulnerability assessment methods for agriculture should be able to identify the vulnerability of a community area in respect of their livelihood sources, production systems, crops and natural resources base. The methods and tools have to be simple and participatory. They have to be comprehensive covering both biophysical and socio-economic components of vulnerability. It should map different stakeholders affected by Climate change and those that will be engaged in the adaptation process. It has to be gender responsive and inclusive.

BOX 4. Challenges associated with the assessment of the impact and vulnerability of agriculture to Climate change:

i. The concept of vulnerability is diverse and its interpretation varies with outcome and context.
ii. Vulnerability is purpose and context specific as well as specific to place and time.
iii. The method for assessing vulnerability is to a great extent influenced by the type of vulnerability (Example: Socio economic vulnerability such as income; Biophysical vulnerability such as land degradation).
iv. Vulnerability assessment entails scientific analysis of information, data, detail investigation of cause and effect of the problem and is highly knowledge intensive.
v. The impact of climate change is highly uncertain and vulnerability is difficult to assess.
vi. For assessing the impacts and vulnerability to Climate change there is a need for good quality information.
vii. Information required for assessing vulnerability includes climate data, such as temperature, precipitation pattern, frequency of extreme events, and non-climatic data like livelihood sources, water etc.
viii. Assessing Climate change impacts and vulnerabilities in agriculture requires the integration of socio-economic data.
ix. Socio-economic factors are important for the adaptive capacity of agriculture system.
x. It involves many stakeholders at Community, Geog, Dzongkhag and national level.

4.0 Participatory Framework and Tools Adapted by CSA Project for Analysis of Vulnerability of Agriculture to Climate change

Before adopting a particular vulnerability assessment tool, the project had to understand and assess the level of awareness and understanding of the stakeholders on the ***impact of*** and ***vulnerability to*** Climate change in agriculture sector. There was a need for a simple and a pragmatic approach to rapidly assess the vulnerability of production system, sources of rural livelihoods and crops on which the communities subsist including any existing local coping and adaptations strategies in place. The CSA project in partnership with the DoA initiated the vulnerability assessment of agriculture to Climate change in its pilot sites. The underlying objectives of the assessment were to understand the impact and vulnerability of agriculture, rural livelihood, and communities to Climate change in the pilot sites. For undertaking the vulnerability assessment of the sites the CSA project

partners were provided hands on training on the use of the vulnerability assessment tool through the Training of Trainers (ToT). During the TOT the CSA stakeholders tested the different vulnerability assessment tools. The CSA project adopted a participatory framework emphasizing and engaging the local communities in the vulnerability assessment process. It evaluated different methods and tools for the vulnerability assessment exercise. The local community were in the forefront of the exercise providing information on socio-economic status, identifying climate related causes and impacts, designing adaptation interventions and for the monitoring and evaluation of the adaptation options.

The vulnerability assessment exercise helped in identifying and better understating of extreme climate events and local symptoms of impacts on agriculture, level of awareness and understanding of impacts of Climate change, extent of exposure to Climate change impacts, socio-economic situation of the households, their access to resources, impact on gender, available coping strategies to Climate change, and available technological options for adaptations.

It is indeed extremely challenging to develop and recommend a single comprehensive methodology for assessing the vulnerability of agriculture. With the experiences gained from the assessment of impact and vulnerability to Climate change from different sites in the country a simple framework is suggested for **Participatory Vulnerability Assessment of Agriculture to Climate change (Table 2).** It may be noted that the tools and framework suggested is by no way complete and exhaustive and should be treated as a guiding framework. The information to be gathered and captured will largely depend on guiding question and participatory interactions with the local communities. For assessing the impact on gender a separate matrix is proposed in the section under impact of Climate change on gender.

5.0 Conclusion

Assessing the impacts and vulnerability of agriculture to Climate change is challenging due to its diverse and complex nature. Vulnerability is wide-ranging and its interpretation varies with outcome and context. The assessment of vulnerability entails scientific analysis of information, data and detail investigation of cause and effect of the problem which is highly knowledge intensive. Vulnerability is also purpose and context specific and specific to place and time. There is no single best methodology or tool to correctly assess the vulnerability of agriculture to Climate change. The CSA project found that it is extremely challenging to develop and recommend a single comprehensive methodology for assessing the vulnerability in agriculture. Based on the experiences

in CSA sites and review of CSA literature a participatory framework has been suggested which should be used as a guiding framework (Table 2).

Table 2 Suggested Framework for Participatory Vulnerability Assessment of Agriculture to Climate change

No	Tools	Purpose	Process	Information to be captured
1	Stakeholders Mapping	Know the actors in the site/community Know the level of awareness and understanding of Stakeholders the impact of Climate change	Venn- diagram Group discussion on Climate related impacts, indicators of Climate change	Map out the actors, roles and relationship. Ranking of stakeholders based on the level of awareness and understanding of impacts of Climate change
2	Profiling of Livelihood Sources and Strategies	Know the different livelihood sources and strategies of the target community	Group discussion, resource mapping	Identify main sources and livelihood strategies, socio economic status(land holding, income source etc)
3	Well being (Process to assess what local people understand as the factor that are relevant to them for a good quality life)	Analysis of the characteristics different groups in a community from well being perspective To understand local perception of "being well"	Participatory listing and ranking of wellbeing indicators (Example:. income, land, work force etc.)	Well being categories based on identified well being indicators (Example: rich, poor, very poor etc)
4	Timeline and trends of Climate change/Local symptoms of Climate change	To understand and identify changes and trends with relation to extreme climate events and variability, local symptoms of Climate change	Group discussions, brainstorming, recall of events by communities, secondary data	Record trends, impacts of extreme events, trend of important production data
5	Mapping biophysical sensitivity of the site in relation to Climate change	Understand the vulnerability of an agro-ecosystem which is site specific in terms of its environment & socio-economic needs To understand and capture how vulnerable is the site to Climate change	Physical observation on land stability, agro-ecosystem, photographs, water source, irrigation, status of natural resources,	Rank the sensitivity and vulnerability of the site, extend of exposure to extreme events, record status of natural resources (example: water)
7	Crop Vulnerability Mapping	Identify the vulnerability of the producers and crops to climatic factors and map out their intensity	Spider web	Map crops and producers Rank producers and crops based on the intensity of extreme events
8	Crop Phenology (How life cycle of crop is influenced by climatic variation)	Find out the critical stages of the crop growth, harvesting and post-harvest handling and impacts of Climate	Brainstorming based on year calendar.	Record extend of damage on crops, crop failures from extreme events, production losses influenced by Climate
9	Mapping the occurrence of new pest and disease	Note the occurrence of new pest and disease influences by Climate change	Recall of pest outbreaks , Tabulate using symbols of pest and crops	List pest outbreaks by types and crops List coping strategies
10	Document existing Coping strategies	Understand local adaptation and coping strategies s	Group discussion to capture local coping strategies	List of local coping strategies Rank strategies by its popularity

CHAPTER FIVE
CLIMATE-SMART AGRICULTURE PROCESS AND POTENTIAL CLIMATE-SMART INTERVENTIONS FOR BHUTANESE FARMERS

1.0 Introduction

It has been highlighted at the outset that CSA is an approach for sustainable development of agriculture in the back drop of Climate change. The sustainable development of agriculture in the Bhutanese context should emphasize Climate-smart innovations that helps meet present needs of the small holder subsistence communities without compromising the ability of the agriculture sector to meet the needs of the future generation. The CSA approaches for Bhutanese agriculture obviously does not support new readymade techno fix and climate ready technologies that are often promoted under the caption of CSA. The CSA innovations intended for Bhutanese agriculture are expected to be production efficient and Climate-smart enough to enhance food security and augment the adaptation of agriculture to Climate change **(Box. 5).**

BOX 5. : CSA Innovations and Interventions for Bhutanese agriculture should;

i. Be able to address farmer's adaption needs to Climate change.
ii. Enhance food security of the small holders in the backdrop of Climate change.
iii. Have wider adaptability for replication across different agro-ecological zones with minimum modifications.
iv. Be cost efficient and simple.
v. Promote water conservation and water use efficiency.
vi. Enhance sustainable management of land and soil nutrient.
vii. Be sensitive to the needs of women and youth.
viii. Be gender responsive.
ix. Be scientifically assessed and proven under local situation.
x. Promote and build on indigenous knowledge in agriculture.

CSA is location specific and it is very knowledge intensive which needs partnership building and collaboration among all the stakeholders who are directly or indirectly associated with agriculture development. Through a more holistic approach it aims towards developing a sustainable agriculture production system as well as an efficient and inclusive food value chain. The role of local and public institutions in supporting the small holder farmers for transition to CSA is seen very critical from the perspective of developing the capacity of the small holder farmers and

supporting them [6]. In keeping with the salient features of CSA, the project took a partnership approach with the national agencies of the DoA engaged in agriculture and with local government institutions and communities at the site level to pilot and adapt potential CSA interventions. To initiate the adaptation of CSA interventions the project designed a process that started with the reviewing of NAPA, SAPA, the 11th FYP priorities of the MoAF, crop production issues induced by Climate change, farmers awareness on Climate change and finally by demonstrating potential CSA interventions in selected sites.

2.0 Climate-smart Agriculture Process

The CSA process basically describes the strategies adopted by the CSA project in implementing the CSA activities and the approaches used for the adaptation and identification of potential CSA interventions. CSA has been recognized as one of the key strategy for adaptation to Climate change in the 11th FYP. The recognition of CSA served as the stepping stone to further popularize and scale up CSA. Immediately after the inception of the CSA project, mainstreaming of CSA was started by mapping the 11th FYP priorities of MoAF with Climate change related issues (Figure 5). This was followed by the mapping of the relevant stakeholders, defining their roles and responsibilities (Table 3), identification of CSA sites based on secondary information and experiences of stakeholders and, CSA activity planning and implementation. The stepwise CSA process is presented in Figure 6.

Figure 5: Linkages between MoAF 11th FYP Priorities, Issues and CSA

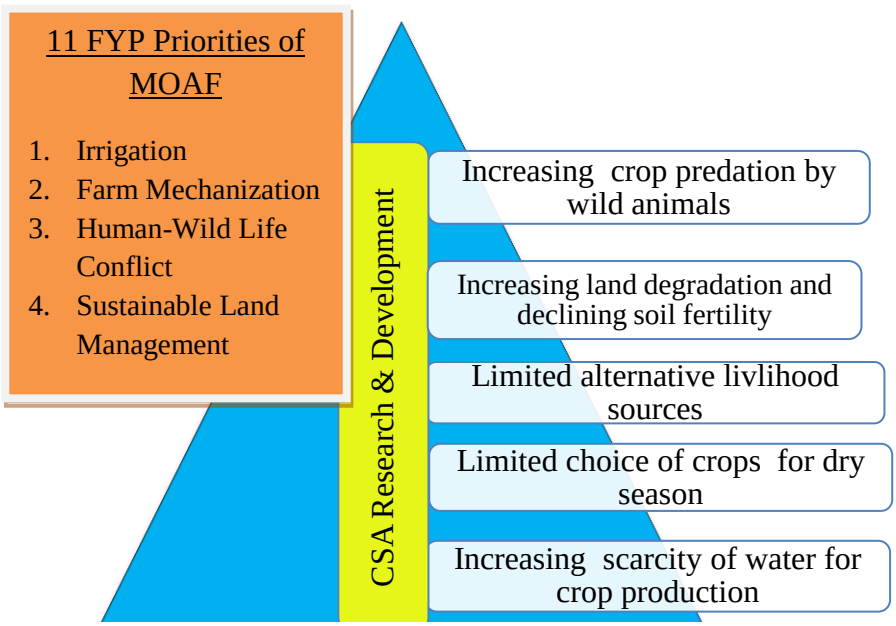


Figure 6. Stepwise CSA process followed by the project

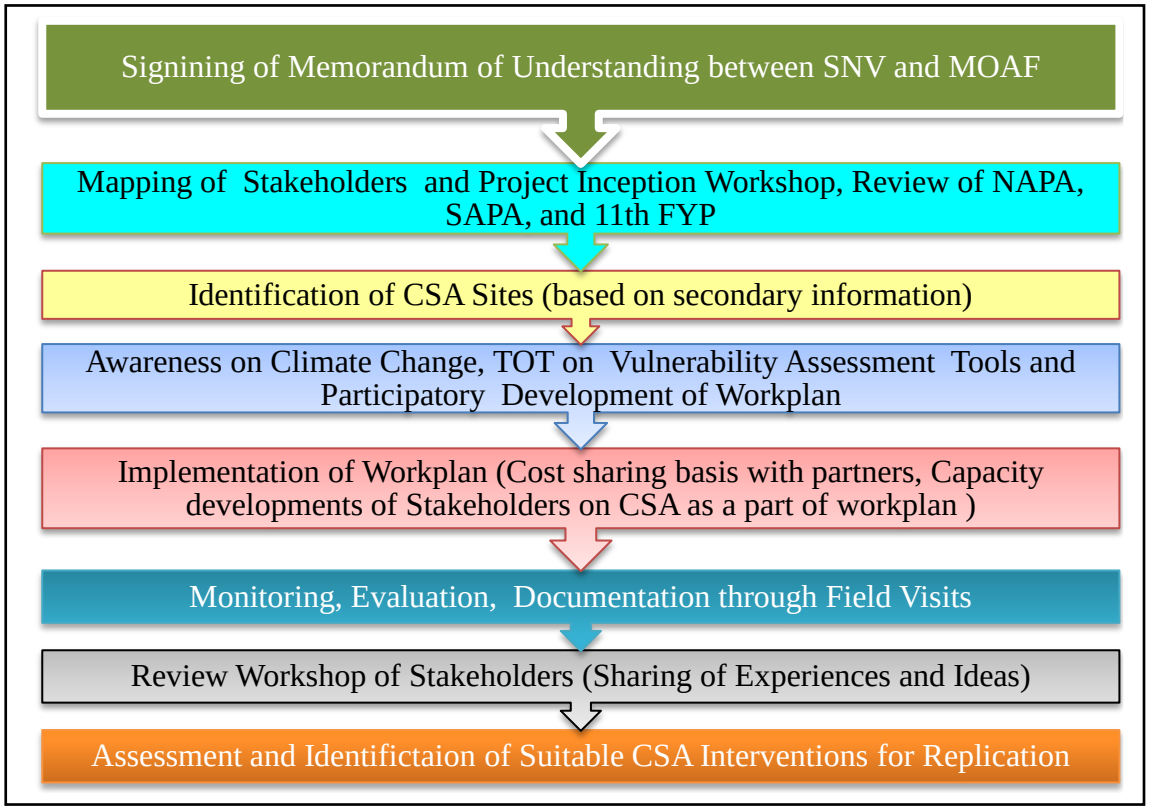


Table 3. CSA stakeholders and their roles and responsibilities

CSA Stakeholders	Roles and Responsibilities
SNV Bhutan (CSA project)	Initiate and lead the CSA project activities in collaboration with the Department of Agriculture. Assess needs using appropriate tools to develop local plans and implementation apparatuses; initiate capacity building process of relevant stakeholders and clients, provide Technical Assistant and funds as appropriate in keeping with cost sharing mechanism to implement the planned activities. Continue to build trust and confidence of the stakeholders and clients by way of exchange visits, workshops and meetings. Conduct regular field visits to monitor pilot activities and documentations.
Department of Agriculture, MoAF (DOA/MoAF)	Guide CSA project in policy, pilot sites identifications and planning; provide implementation and coordination support for the success of the CSA project. Assist to mobilize and share resources for the CSA project activities where appropriate. Provide technical support, guide and project's sustainability. Collaborate to mainstream CSA research in the RDCs' programs
Dzongkhag Administration/Dzongkhags/ Geogs Extension:	Closely work with CSA, SNV to plan and implement all CSA pilot field activities and support in follow up, Monitoring and Evaluation (M&E) and reporting of activities. Assist to guide in the up scaling of potential CSA strategies and approaches
Community/beneficiaries:	Work closely with the Geogs Extension Agents (EA), and involve actively in planning, implementation, monitoring, discussions meetings and reporting of CSA pilot activities in their respective areas. Voluntarily contribute labor and locally available materials for the CSA pilot activities as and when required
Other CSA related technical agencies and stakeholders:	Provide all necessary technical and relevant support to implement the planned CSA activities as per the work plan. The agencies namely the National Organic Program (NOP), National Soil Service Center (NSSC), National Post Harvest Center (NPHC), National Seed center (NSC), Research and Development Center (RDCs) at Bhur, Yusipang, Bajo (Tsirang) as earmarked for technical support & facilitation for relevant inputs and capacity development.

3.0 Potential Climate-smart Agriculture Interventions for Bhutanese Farmers

CSA approaches and practices revolve around sustainable management of natural biological processes. It spreads across all dimensions of agricultural systems including land, water, energy, crop, livestock, fisheries, forestry and other natural resources. Climate-smart interventions help the different production system to respond and adapt to changing climates, particularly to the increased variability. The type of CSA interventions is often specific to a particular component of agricultural

systems. Many CSA interventions are indigenous to the local communities while others are evolving and are being adapted under different ecosystems.

The CSA project focused primarily in the demonstration and evaluation of CSA intervention on agriculture. To start with, the project reviewed the NAPA, SAPA and the 11th FYP priorities to identify Climate change issues affecting the agriculture sector and the national priorities for adaptation to Climate change. Thereafter it identified ready to adopt Climate–smart technologies already evaluated by the RDCs, communities and other relevant agencies for further adaptation and demonstration. The CSA project concentrated on Climate change induced constraints while assessing the performance of these selected interventions. In essence it assessed whether the interventions were Climate–smart enough for adaptation to Climate change for increasing the production for food security. Through the different CSA interventions the project targeted four underlying solutions Figure 7. Based on the agro-ecology, local setting and vulnerability of the CSA sites, the CSA project demonstrated different CSA interventions which are summarized in Table 4.

Figure 7: Four target solutions of CSA

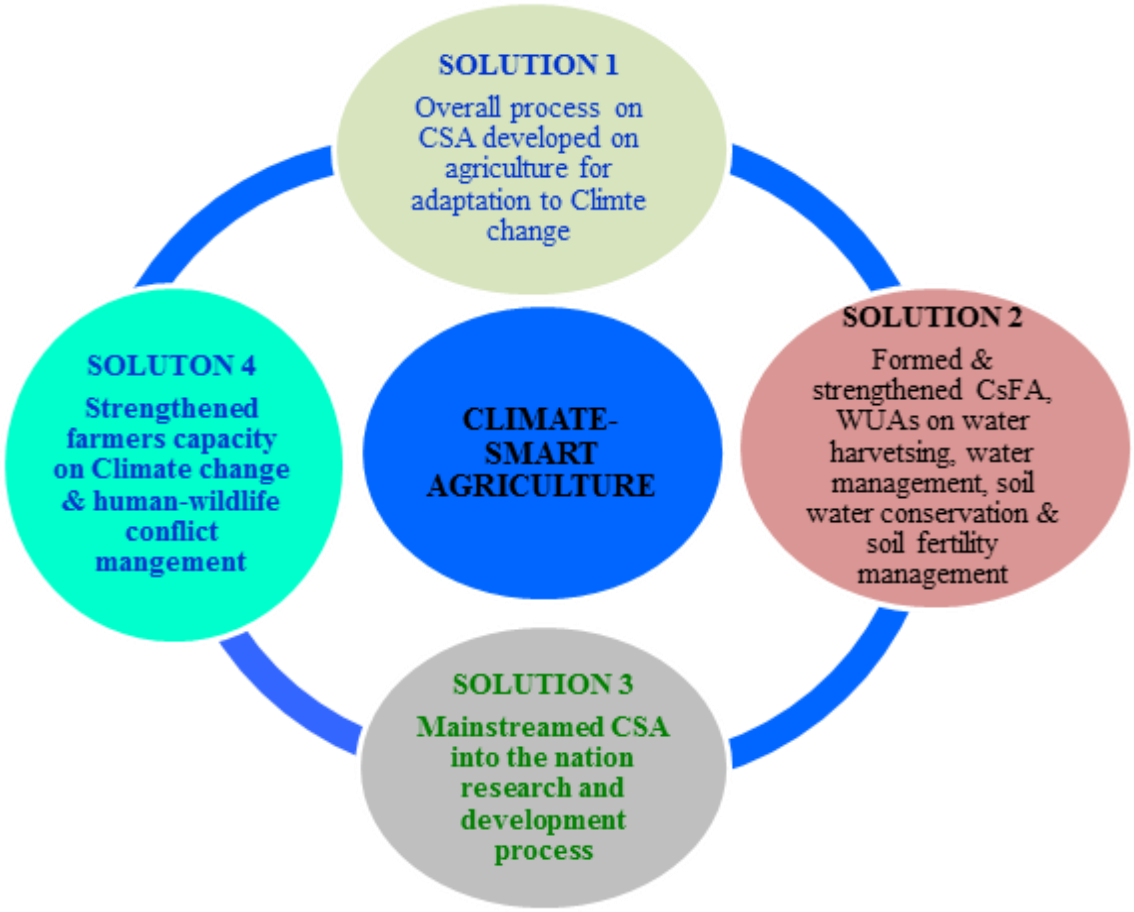


Table 4. Summary of CSA approaches and interventions adapted by CSA project

Dzongkhag	Geog	CSA Approaches	CSA Interventions
Chhukha	Samphelling	Crop diversification,	Promotion of Upland rice and post production and marketing
		Land use management	Promotion of agro-forestry
Samtse	Ugyentse	Livelihood protection	Electric fencing
		Crop diversification	Promotion of Upland rice , Soybeans, Maize
		Water Conservation & Capacity building of local institutions	Irrigation channel rehabilitation & formation of Climate-smart Farmers Association (CsFA)
Sarpang	Chhuzagang Shersong Umling	Livelihood protection & Alternative Livelihood	Electric fencing , eco-friendly fencing with arecanut leaf tops Biodegradable plates making from Arecanut leaves, Value addition of ginger
		Crop diversification	Promotion of upland rice, lentil, ginger
		Water Conservation & Capacity building of local institutions	Strengthening of Taklai irrigation WUA for Chuzagang and Sershong Strengthening of Panchphaley irrigation WUA for Umling
		Conservation Agriculture	Mulching with arecanut leaves
Tsirang	Goseling	Alternative Livelihood & Improving adaptive capacity through income generation	Strengthening Climate-smart Farmers Association (CsFA) for production and marketing of vegetables,
		Water Conservation and efficient use	Water harvesting with construction of a central reservoir tank
Thimphu	Mewang	Alternative Livelihood & Improving adaptive capacity through income generation	Demonstrations of vegetables production for income generation
		Water Conservation & efficient utilization	Water harvesting with construction of a central reservoir tank Demonstration of efficient sprinklers
		Crop diversification	Promotion of upland rice and maize
		Sustainable Land Management & Nutrient management	Land management options Heap composting
		Protected Agriculture	Pit nursery, Plastic house
Wangdipho drang	Phangyul	Livelihood protection	Electric fencing
		Crop diversification	Promotion of upland rice and maize

Besides the above CSA options and interventions initiated in the different CSA sites, the project also focused on the following areas for facilitating the transition of the existing agriculture production system to a more Climate-smart and sustainable system.

i. Water Users Association operational and management manual.
ii. Climate-smart Agriculture Training Manual.
iii. Management plan for Cold storage.
iv. Development of framework for Climate-smart Farmers Association (CsFA) .
v. Rehabilitation mechanism for small canals at land slide prone areas.
vi. Rehabilitation and protection of key water source such as pond.
vii. Development of spring water harvesting and distribution system.
viii. Capacity development of stakeholders on CSA focussing on;
    a. Awareness on Climate change.
    b. ToT on Vulnerability Assessments tools and methodologies.
    c. TOT on Alternative Livelihoods options through value addition.
    d. TOT on Human-wildlife conflicts management.
    e. Practical hands on training on gender inclusive exercise on vulnerability assessment.
    f. Training on pests and diseases prevention through organic methods.
    g. Trainings on Soil-water management, organic farming and sustainable land management.
ix. Provision of inputs for protected agriculture like plastic houses, shade house, net house, and sprinklers.
x. Supported seeds of climate resilient crops for communities.
xi. Supported vegetables production for cash income generation.

Apart from the CSA interventions discussed above there are several other potential CSA options that could be adapted for Bhutanese agriculture. Some the potential CSA interventions are:

i. System Rice Intensification (SRI) for efficient water utilization and increasing rice yield.
ii. Agro-forestry.
iii. Different multiple cropping practices for insurance against crop failures.
iv. Efficient water utilization technologies.

v. Efficient post-harvest technologies to reduce post-harvest losses and value addition.

vi. Crop Insurance schemes.

vii. Promotion of Climate-smart crops in water constrained areas besides such as ;

a. Coffee
b. Groundnuts
c. Soy-beans
d. Maize
e. Millets
f. Vegetables
g. Sorghum
h. Ginger
i. Turmeric

4.0 Conclusion

The CSA project significantly facilitated the demonstration of CSA approaches in the different sites in partnership with the various agencies of the DOA associated with agriculture research and development. Despite several challenges, it is now apparent that CSA is a suitable approach for adaptation to Climate change under the Bhutanese context. A simple yet comprehensive CSA process that has been outlined in this chapter can now be replicated in any new sites. Considering the fact that CSA spreads across all dimensions of agricultural systems it was only able to demonstrate selected approaches in the CSA site. The project also focused on those CSA interventions already in the shelves developed by the RDCs and locally practiced by communities and assessed if these interventions to find out if they are indeed Climate- smart. There are yet many potential CSA interventions that could be adapted and upscaled for adaptation of Bhutanese agriculture production system to Climate change.

Plate 5: Promotion of mulching for soil water conservation

CHAPTER SIX
GENDER, AGRICULTURE AND CLIMATE CHANGE

1.0 Introduction

Gender refers to the differences in socially constructed roles and opportunities associated with being a man or a woman and the interactions and social relations between men and women. Gender determines what is expected, permitted and valued in a woman or a man in a determined context [21]. Gender is fundamentally influenced by the traditions, rules, customs and practices by which biological differences are translated into social difference between men and women. Gender determines and shapes the different ways in which women and men participate in and benefit from rural development interventions. In agriculture, men and women haves specific roles and hence the impact of Climate change on both could be of different magnitude. It is envisaged that Climate change will have a profound effect on women in direct and indirect ways. There is a general consensus that women are more vulnerable to the effects of Climate change than men primarily because women constitute the majority of the world's poor and are more dependent for their livelihood on natural resources that are increasingly threatened by Climate change [22].

1.2 Why women are likely to be impacted more than men by Climate change?

Women are vulnerable to Climate change not because of their sex and physical composition but because of their socially constructed roles. In a predominantly rural based society, the social roles and responsibilities of women makes women more dependent on natural resources. Women are mostly responsible for food production, fetching water, fuel wood, cooking, washing and feeding the family. In such rural communities women are often at a disadvantaged position due to their social roles, poverty and unheard voices. Due to the under recognized role of women they could be further impacted by Climate change in the following ways:

i. Rural women are mostly engaged in household work as food providers and home makers who have to immensely depend on natural resources. Any impact of Climate change on natural resources increases the drudgery on women than on men.
ii. Women will be physically affected much more by extreme events and natural disasters as they have to take care of the home and children.

iii. Women will be impacted more in terms of access to food driving them towards more malnourishment.

iv. Scarcity of water for drinking and crop production directly impacts women more. When water is scarce it is mostly the women who have to spend more time to fetch water for drinking, cooking and washing. Water scarcity leads to decrease in crop production and food availability which again affects women who have lesser opportunity and access to food than men.

v. Women take the lead role in securing seeds for next seasons. Crop failures exacerbated by Climate change puts higher pressure on women to source and secure seeds.

vi. Women in general have poor access to technologies, knowledge agricultural extension services, and new information as they are more engaged in household work compared to men.

vii. Generally women have lesser opportunities for access to and control of productive resources like land, financial capital and decision making compared to men.

1.3 Gender, Agriculture and Climate change in the Bhutanese Context

The participation of Bhutanese women in Agriculture and Forestry activities is 65% as compared to 54% for men [23]. Bhutanese women are directly engaged in food production, seed saving, and collection of fuel wood, fodder and Non Wood Forest Products (NWFP). This indicates that any impact of Climate change on agriculture and forestry will be definitely felt more by women than men mainly due to the gender based division of labour, limited access to resources and the dependence on natural resources for livelihood [24]. Based on the facts on gender and agriculture (BOX 6) Climate change will affect women in different ways compared to men. Any adaptation interventions on Climate change has to be gender responsive in order to address the needs of the women. Currently the role of women in agriculture largely remains embedded considering the assumption that Bhutanese society is gender balanced.

Plate 6: Women leaders of CsFA group

BOX 6. Key facts on women and agriculture in Bhutan. [25]

i. 65% of women work in agriculture and forestry as food producers and food providers.
ii. Women interact closely with the natural resources and environment as users for grazing, collection of fodder, fuel wood, leaf litter and NWFPs for cash income, food and for other domestic uses.
iii. In the Bhutanese society the division of labour by gender is not rigidly fixed, as men and women can take over each other's tasks, with few exceptions, and this may vary by ethnicity.
iv. Bhutanese society has a matrilineal heritage giving women an advantage in ownership of land and it is estimated that 70% of the land is owned by women.
v. Women considerably contribute to household income through farm and non-farm activities.
vi. Women take the lead role in marketing of farm produces.
vii. As managers of seeds and home gardens women are custodians of agro-biodiversity ensuring its perpetuation and adaptation to Climate change through crop diversification.

1.4 Matrix for assessing the impact of Climate change on women

It stands out very clearly that given the social roles and responsibilities of women, Climate change is likely to affect women differently. Women are much more vulnerable compared to men and Climate change will have larger and more severe implication on women. The adaptation needs of women to Climate change will therefore be different to that of men. In order to develop suitable adaptation options and to adequately address women's needs it becomes imperative to do a proper analysis of the cause and effect of Climate change. Furthermore, women play an important role in supporting households and communities to mitigate and adapt to Climate change and hence mainstreaming gender needs in the Climate change adaptation intervention is very essential. To ensure that adaptation interventions are consciously more gender responsive, a simple matrix (Table 5) is suggested for undertaking a rapid analysis to assess the effect of Climate change on women.

Table 5. Matrix to assess the effect of Climate change on Women

No	Local Symptoms of Climate change	Impact of Climate change	How women will be likely affected more than men?	Opportunities for Adaptation Options
i	Example: Seasonal drought	• Crop failure hence less food for the family • Drying of water source leading to water shortage	• Women and children have less access to food • Increased drudgery on women to fetch water from another source	• Provide drought tolerant crops and varieties • Promote water harvesting • Promote simple water conservation interventions

1.5 Conclusion

Bhutanese society is generally presumed to be gender inclusive as the social difference between men and women are not profoundly visible as in other societies. The distribution of work between men and women is not too rigid and responsibilities can be often swapped between genders without any social taboo. However, gender disparities and inequalities continue to remain in different critical areas particularly in the areas of economic opportunities, access to and control of productive resources like land, financial capital, agricultural extension services, and new information with women having less access and control compared to men. Due to the unavailability of an adequately gender disaggregated and synthesized data for agriculture there is a tendency to underestimate the contribution and responsibilities of women. The role of Bhutanese women in agriculture is indispensible. Women have vast knowledge and skills, and contribute significantly to the development of Bhutanese agriculture in many different ways. Notwithstanding the women's role in farming, an in-depth analysis of the roles and contribution of women in agriculture is very fundamental. For the success of any Climate change adaptation and mitigation options, and to address the challenges faced by rural women the participation and focus on women is essential. Through their knowledge and skills women help the household and communities to adapt to Climate change. In light of the critical role of women in agriculture, there is a need to clearly understand, recognize and integrate the threats and impact of Climate change on women before designing and initiating any interventions for adaptation and mitigation to Climate change.

CHAPTER SEVEN
POLICY ENVIRONMENT AND STRATGIES FOR TRANSITION TO CLIMATE-SMART AGRICULTURE

1.0 Introduction

Bhutan remains one of the least contributors to the global Climate change. Despite its small size Bhutan is highly committed to the conservation of environment. The constitution of the Kingdom of Bhutan decrees that the country maintain a minimum of 60% of the geographical area under forest cover for all times to come. Bhutan has also pledged to the international community to remain carbon neutral. It has ratified and is party to several international conventions on Climate change committing itself to the effort of the international community to combat and contain the impact of Climate change. Bhutan has embraced the policy of sustainable development where economic development does not undermine the value and conservation of environment. Overall, the country has a highly enabling policy framework for conservation of environment and sustainable development. The National Adaptation Program of Action (NAPA) is the key policy document that provides the overall policy framework for adaptation to Climate change for all sectors. The NAPA has rightly recognized agriculture sector and the farming communities as the most predisposed sector to the impacts of Climate change. To operationalize the NAPA and make it more focused to agriculture sector, the MoAF has developed the SAPA. The SAPA outlines very clear framework and strategies for adaptation of agriculture sector to Climate change as one of the key conditions for attaining food security in the 11th FYP. The development of SAPA is a very clear evidence of an enabling policy environment and support of the government in translating the national policies and priorities into sector programs. Important and relevant policy instruments and initiatives in place that supports the transition to CSA are summarized in Table 6.

Table 6. Enabling Policy Instruments and initiatives in agriculture sector

No	Enabling Policy Instruments and Initiatives in Agriculture sector
i	The National Adaptation Program of Action (NAPA) has recognized agriculture and rural poor as the most vulnerable sector to Climate change.
ii	NAPA has identified Community based Food Security and Climate Resilience project for adaptation to Climate change.
iii	The National Organic Framework which is coherent with the principles of CSA is operational under the National Organic Program.
iv	The RNR Sector Adaption Plan of Action (SAPA), 2013 of the MOAF that outlines the different adaptation programs to Climate change is operational.
v	The 11th FYP of the MOAF has recognized the promotion of CSA as the most potential option for adaption to Climate change.
vi	Sustainable Land Management (SLM) technologies are widely promoted by the DoA.

2.0 Opportunities for Transition to Climate-smart Agriculture

The predominantly subsistence Bhutanese agriculture is a low external input system where the excessive use of external inputs are naturally regulated by poor access, availability, cost and affordability. Agriculture continues to be largely conventional with a high degree of dependence on natural resources. However, to meet the increasing demand for food and to alleviate rural poverty, there is a strong drive to transform the subsistence agriculture to a semi commercial production system through a technology focused agriculture development, initiative to produce for market and increasing support for farm mechanization. This drive towards commercialization will significantly impact the depleting natural resources base which is already under increasing pressure from the rising threats of Climate change and population pressure. CSA is increasingly being promoted around the world as a suitable approach for developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under Climate change [6].

The transition from the current technology focused agriculture development towards a CSA is knowledge intensive [6]. The nature of the impact of Climate change on agriculture is uncertain and dynamic and hence the prescription of a technology aimed at adaptation or mitigation may not work

as anticipated. The agriculture production system is complex and is also highly location specific. The implementation and integration of CSA approach into the national agriculture research and development programs is highly challenging due to the lack of tools and experiences and hence needs special attention. Although there is an adequate recognition of the impending threats of Climate change on land, water and agro-ecosystem, policies are yet to be effectively translated into actions mainly because:

i. The overall capacity of all the stakeholders on CSA is limited.
ii. The tools and methods for CSA are evolving and needs location specific adaptation.
iii. The development approach in agriculture is still development focus and production driven without direct focus on adaptation to Climate change.
iv. The use of climate science in technology adaptation and evaluation is non-existent.
v. There are no convincing studies initiated to evaluate the impact of Climate change on agriculture.
vi. Limited priority is accorded for promotion of CSA interventions.
vii. Bio-physical sensitivity and vulnerability of Dzongkhags to the impacts of Climate change are not adequately studied.
viii. There is no adequate platform for multi-stakeholder participation on CSA.

In the back drop of the above situation there is a need to put in place some of the immediate and dynamic strategies for the mainstreaming of CSA as an approach for sustainable development of agriculture for food security and poverty alleviation under the changing climate (Table 7).

Table 7. Immediate strategies for effective mainstreaming of CSA

No	Immediate strategies for effective mainstreaming of CSA
i	Support capacity development of stakeholders on CSA.
ii	Review and realign current research programs to integrate CSA as a research and development approach in the back drop of Climate change.
iii	Adapt and promote CSA interventions as a sustainable development approach for agriculture development and adaptation to Climate change among stakeholders.
iv	Identify and adapt CSA methodologies and tools.
v	Integrate the use of agro meteorology science in agriculture research and development.
vi	Adapt and consciously promote location specific CSA interventions.
vii	Identify and promote gender sensitive CSA interventions.
viii	Create a platform for multi-stakeholder participation in CSA.

3.0 Conclusion

CSA is gaining popularity and increasingly being promoted as a sustainable development approach in agriculture for food security and poverty alleviation for adaptation to Climate change. The transition of the current technology focused agriculture development towards a CSA is knowledge intensive. The existing national policy instruments on Climate change are highly enabling for promotion of CSA. As CSA is new and evolving some immediate strategies are necessary for mainstreaming it into agriculture research and development programs.

Plate 7: Promotion of Lentil as a Climate-smart crop.

Plate 8: Promotion of Upland rice as a Climate-smart crop.

CHAPTER EIGHT
CONCLUSION

Climate change is the overriding contemporary environmental challenge faced by the human society. It has been scientifically established that Climate change is real and that it will spare no countries and communities. The impact of Climate change on agriculture and food security is going to be overwhelming from the incidence of extreme climate events. The frequency and magnitude of the extreme events will vary with the geophysical setting of a country and the socio-economic status of its population. Global food production and food security is likely to face formidable challenges from Climate change. Rural poor and farming communities whose livelihood is primarily underpinned to agriculture are likely to be the most vulnerable to Climate change. In the face of impending threats of Climate change it is imperative that agriculture production systems are made more resilient and adaptive so that the food security is ensured. The 69% of subsistence Bhutanese farmers whose livelihood significantly depends on agriculture are highly exposed and vulnerable despite the fact that the country is a net sink for the GHG.

The FAO has presented a very convincing case for CSA as a new sustainable approach for smallholder farmers for adaptation to Climate change. CSA is increasingly being advocated as the answer to Climate change for its salient features that have the potential to sustainably increase agricultural productivity and income, adapt and build resilience to Climate change and reduce or remove GHG where possible. The MoAF in the 11th FYP has emphasized the promotion of CSA as one of the underlying strategies for adaptation to Climate change. To ensure food security in the back drop of profound challenges imposed by Climate change, Bhutanese farming must be made climate resilient by adopting Climate-smart farming approaches and innovations. The Climate-smart innovations under the Bhutanese context should be able to help meet present needs of the smallholder subsistence communities without compromising the ability of the agriculture sector to meet the needs of the future generation. The CSA approaches for Bhutanese agriculture thus do not support the new readymade techno fix and climate ready technologies. The CSA innovations and practices intended for Bhutanese agriculture are expected to be production efficient and Climate-smart enough to enhance food security and expand the adaptation of agriculture to Climate change.

In keeping with the priorities of the 11th FYP and emerging issues in agriculture exacerbated by extreme climate events there is a need to identify suitable adaptation options for agriculture. The

CSA project initiated the work on the promotion and demonstration of CSA in 12 sites spread across six different Dzongkhags. The project tested and validated different CSA approaches and interventions and, has identified those that are feasible for adoption under the Bhutanese context for adaptation to Climate change. The project has also developed a simple CSA process that can facilitate the transition of the Bhutanese agriculture towards a more Climate-smart production system. A simple participatory framework and tools for the rapid assessment of impact and vulnerability of Climate change in agriculture has been developed for use by those engaged in Climate change adaptation programs. The impact of Climate change on gender is discussed and a simple matrix designed for assessing the impact on gender under Bhutanese environment. The existing policy environment and opportunities that support the transition of the Bhutanese agriculture production system to a more Climate-smart production system is reviewed and discussed.

CSA approach is new and the overall awareness and understanding of the CSA among the Bhutanese stakeholders is relatively poor. The CSA project has attempted to compile the experiences on CSA in the form of this source book. The main purpose of this source book is to provide a simple and a quick reference on the principles and approaches of CSA for different stakeholders at all levels. This CSA source book focuses on agriculture and has been developed in consultation with local partners. The preparation of this source book heavily draws on resources developed by FAO and other relevant institutions and have been appropriately acknowledged.

CHAPTER NINE
DEFINITIONS OF IMPORTANT CLIMATE CHANGE AND CSA TERMS (SOURCE: [6, 21]

Agro-ecology: An ecological approach to agriculture that views agricultural areas as ecosystems and is concerned with the ecological impact of agricultural practices.

Agro-ecosystem: The organisms and environment of an agricultural area considered as an ecosystem.

Adaptation to Climate change: Adjustments to current or expected climate variability and changing average climate conditions. This can serve to moderate harm and exploit beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Climate change: Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate-smart agriculture (CSA): Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals.

Crop diversification: Species diversification through varied crop associations and/or rotations (involving annual and/or perennial crops including trees).

Drought: The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.

Drylands: Areas characterized by lack of water, which constrains their two major interlinked services of primary production and nutrient cycling.

Ecosystem: The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond.

Erosion: The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds and underground water.

Gender: Refers to the differences in socially constructed roles and opportunities associated with being a man or a woman and the interactions and social relations between men and women. Gender

determines what is expected, permitted and valued in a woman or a man in a determined context [21].

Greenhouse gases: Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O) methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine-containing substances, dealt with under the Montreal Protocol. Besides CO_2, N_2O, and CH_4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Landscape approach: Landscape approach means the management of production systems and natural resources in an area large enough to produce vital ecosystem services and small enough to be managed by the people using the land and producing those services

Mainstreaming refers to the integration of adaptation objectives, strategies, policies, measures or operations such that they become part of the national and regional development policies, processes and budgets at all levels and stages [21].

Mitigation (in relation to Climate change): Technological change and substitution that reduces resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to Climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks.

Rainfed agriculture: Agricultural practice relying exclusively on rainfall as its source of water.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner.

Smallholder: The definition of smallholders differs between countries and between agro-ecological zones. In favourable areas of smallholder subsistence agriculture with high population densities, smallholders often cultivate less than one hectare of land, whereas they may cultivate ten hectares or more in semi-arid areas, or manage up to ten head of livestock.

Sustainability (Environmental): Meeting the needs of the present without compromising the ability of future generations to meet their needs.

Vulnerability: The propensity or predisposition to be adversely affected; a function of potential impacts (exposure and sensitivity to exposure) and adaptive capacity.

ANNEXURE 1: FRAMEWORK FOR FORMATION OF CLIMATE-SMART FARMERS ASSOCIATION (CsFA)

1.0 Introduction

The formation of Climate-smart Farmer's Association (CsFA) is a sustainable mechanism to upscale CSA. The idea of CsFA was conceived through CSA advocacy, trainings, demonstrations, and by working in partnership with extension networks, researchers, subject matter specialists and the farmers. The awareness, knowledge and skills gained from CSA project implementation encouraged the stakeholders and the beneficiaries to initiate CsFA. The CSA project aims to initiate CsFA in all the project sites for the long term continuity and sustainability of CSA interventions initiated for adaptation to Climate change.

In order to promote CsFA there is a need for a suitable guiding framework. This CsFA framework is intended to guide facilitators, extension service providers, researchers and the farming communities to comprehend the significance of changing production ecology, understand process and initiate adaptive farming in the context of Climate change which is impacting agriculture value chains at different levels. This framework provides key guidelines for the planners and the stakeholders engaged in the institution of CsFA (Figure 8). The main objective of CsFA is to take forward resilient farming through the creation of local platform for farmers to cope up with changing production ecologies. The CsFA is an association of farmers who know their surroundings and needs better and can take ownership of the initiatives to sustain and upscale CSA. It is based on the principle of "common thoughts for better livelihood for all under Climate change". The CsFA framework (Figure 8) is sub-divided into four major CSA committees which in the broader sense are the activities.

Figure 8: Framework for CsFA, processes, analysis and potential activities.

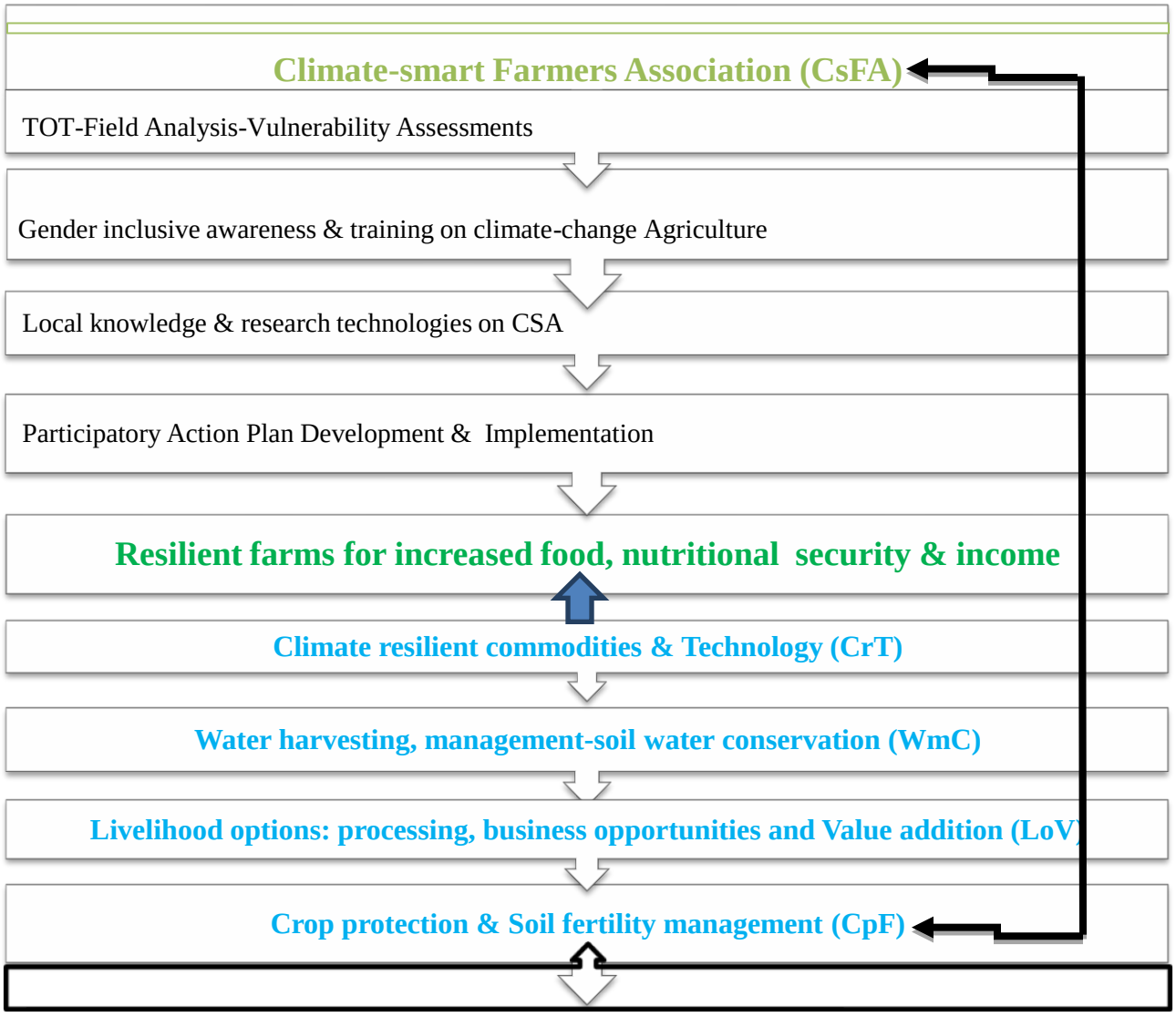


Table 8: The process to initiate CsFA

A	***Agree on convenient time with the village head for a discussion meeting of the community members*** ***Invite community members and organize meeting within the community area***	
B	**Activities**	**Time-frame**
1	i. Introduction & acclimatization with the communities ii. Obtain Feedbacks and views session on: a. Ongoing CSA activities and knowledge on Climate change b. What more they know about Climate change c. Climate change impacts to food production, gender and youths d. Ongoing activities and productions status e. Constraints for productions and marketing f. Local knowledge of adaptations to Climate change g. Discuss constraints and solutions h. Climate change adaptations activities (crop diversities, agro-forestry, alternative livelihoods, value additions)	90 min
2	i. Explain Climate change and its potential threats on the following: a. Water, land scape, farms, food security and income b. Crops production and marketing c. Impacts of climate change to women and youths d. Setting of common goals to adapt climate change	60 min
3	ii. Present back consolidated the findings from community back to them	30 min
4	i. Propose and process the formation of Climate-smart Farmers Association (CsFA) ii. Discuss the Election process, elections & functions of the elected representatives and beneficiaries	60 min
5	i. Facilitate and develop plan of action with the elected office bearers of the CsFA	120 min

The CsFA shall comprise of the following office bearers and the members as furnished in Table 9.

Table 9: CsFA Portfolios

No	Positions	Number of Posts
1	Chairperson	1
2	CSA Motivator	1
3	CSA Finance Manager	1
4	CSA Auditor	1
5	Women & Youths representative	1
6	CSA Executive committee members	2
7	Water Manager	1
8	Electric fencing controller	1
9	CsFA members	Total beneficiaries

2.0 Terms of Reference

2.1 Terms of Reference for different CsFA office bearers

2.1.1 Chairperson

i. Shall be the overall Manager of the association
ii. Shall be the drawing & disbursement authority for the CsFA
iii. Shall guide and support management of CsFA and promote adaptation strategies to climate change towards building resilience for increased production, value addition & marketing
iv. Shall motivate and mobilize farmers members in the CsFA committees and explore up scaling of potential activities for sustainable agriculture farming
v. Shall connect with Extension, research, potential projects and technical agencies for support & advice.
vi. Shall initiate membership and mobilize funds for common savings under the CsFA
vii. Shall open saving account in the nearest Bank and deposit all fees and collections in favour of the CsFA
viii. Shall explore and take members confidence in all decisions and explore fund raising besides invest to enhance revenue
ix. Shall assess and supervise progress reports and book keeping
x. Shall authorize functions of the chairmanship to a relevant office bearer during absence from office.

2.1.2 CSA Motivator

i. Shall assist and support the Chairperson in all the CsFA day to day affairs
ii. Shall maintain and manage office, correspondences and coordination
iii. Shall organize meetings, circulate minutes and follow up actions
iv. Shall assist members in creating awareness and adoption of CSA approach (water saving, promotion of drought resistant crops, human-wildlife conflicts management, use of abandon lands, value additions, agro-forestry, marketing)
v. Shall connect closely with Geog Administration and Extension Supervisor for support and necessary advise

2.1.3 CSA Finance Manager

i. Shall execute & maintain books of accounts (membership contributions, fees, assets, revenue generation etc.) including receipts, deposits, withdrawals, and utilization
ii. Shall be the co-signatory to Bank cheques for all withdrawals
iii. Shall explore prospects for increasing revenues
iv. Shall obtain endorsement of the CsFA general meeting for fund mobilization and utilization
v. Shall maintain transparency in bank of accounts and expenditures

2.1.4 CSA Auditor

i. Shall support functioning of the office and maintain check & balance mechanism in all CsFA affairs
ii. Shall audit book of accounts periodically and make transparent to all the CsFA members and beneficiaries
iii. Shall issue memos on findings and report follow ups and action

2.1.5 Women and Youths Representative

i. Shall oversee all CsFA activities and assess benefits to women and youths against climate change impacts
ii. Shall raise voice on women and youths and suggest appropriate measures
iii. Shall work closely with the CSA Motivator to design activities that benefits women and youths under climate change scenario

2.1.6 Executive Committee members

i. Shall support day to day affairs of the CsFA field operations
ii. Shall initiate new ideas and adaptation strategies to climate change
iii. Shall monitor and support farmers in the communities in planning and implementations
iv. Shall motivate h/holds and farmers to increase membership in the CsFA
v. Shall support upscaling of potential CSA activities in the communities
vi. Explore fund and technical support through CsFA management

2.1.7 Water Manager

i. Shall manage, maintain and mobilize beneficiaries for repairs of water infrastructure (water tanks, community own irrigation channels, water ponds, reservoirs etc.)
ii. Shall coordinate and mobilize water source protection
iii. Shall provide and allocate water for agriculture on need based basis
iv. Shall advocate on water saving and judicious use of water for agriculture

2.1.8 Electric fencing Controller

i. Shall assess crops depredation and conflicts between growers and wild animals
ii. Shall initiate meetings and assess benefits and motivate farmers for human-wildlife conflicts management strategies
iii. Shall manage, mobilize and maintain repairs of electric fenced area
iv. Shall monitor fields and encourage farmers to cultivate lands under fenced area
v. Shall mobilize beneficiaries in cleaning and clearing growths under electric fencing areas
vi. Shall coordinate closely for membership contributions and funds to manage electric fencing for increased food security

2.1.9 General members: The farmers participants and the CsFA office bearers are the general members of the CsFA

i. Shall attend discussions and planning meetings called by the CsFA management
ii. Shall work to promote CSA strategies and activities to increase production, post-production, utilization of land and sale of farm produce
iii. Shall contribute membership and other fees as per the agreement and bylaws for deposit in the CsFA account
iv. Shall support management and optimal utilization of CsFA facilities

3.0 Guiding principle for development of Bylaws

Bylaws shall be developed by the members themselves facilitated by a trained resource person (s).

Name of Farmers Association	
Guiding points	
CSA Farmers Association (CsFA) a) Brief background of the communities b) Constraints and prospects c) Climate change impacts to agriculture *d) Overall Objectives* *e) Specific objectives* f) Members/households g) Membership fee contributions h) Collection and contributions i) Management of books of accounts j) Operation of a Bank account k) Utility of the contributions for better investment l) Functions of the office bearers m) Penalty and incentives for the members n) Income generation activities and upscaling h/holds in CSA based activities	
Plan of Action 1. Climate resilient Crops (CrC): Promotion of climate friendly and water efficient production system for income generation and soil conservation. Drought may occur due to climate change both in wet and drylands due to low average rainfall that may range across locations and years from an average of about 300 to 800 millimeters per annum, but also because rainfall could be highly erratic, with storms during the cropping season followed by long dry spells. To address such situations, it is important that the farmers promote crops that can withstand soil moisture stress for longer period 2. Water management, harvesting-soil water conservation (WmM): water resource protection and maintenance, what, when, and by whom; water allocation from reserved for crop productions during dry season	

3. Livelihood options: business development, livestock, value addition to local materials, business, alternative source of income, prospectus business alternatives
4. Human-wildlife Conflicts Management (HwCM): Promote simple and cheap electric fencing for crop protection and relieving crop guarding; utilization of land under fencing; and monitoring and maintenance of e-fencing

Activity areas	**Intervention recommendation**
Climate resilient Commodities & technology (CrT)	• Conduct field research for adjustment of cropping calendar, encourage crop rotation (cultivation of lentil intercropped with maize in the low altitude areas immediately after harvest of rice) • Promote crops diversification, utilization of barren fallow lands, and use of waste land for bamboo & plantain crops. • Promotions and diversifications of crops that are short duration & can thrive under moisture stress for longer period of time: upland rice, millets, buck wheat, maize, cassava, Sorghum, grain legumes, barley etc. vegetables & other climate resilient crops • CSA field research
Water harvesting, management – soil water conservation (WmC)	• Collection of runoff water for its productive use (roof water, flood water runoff, wasted water, and the spring water collection at its lowest volume at the pick of the dry spell) • Maintain, mobilize and manage channels and initiate protection of water bodies and water saving • Fair allocation of water as per critical needs • Oversee production of *crops being managed from tanks water reserve harvested from the springs.* • Promote water saving technologies such as mulching by vegetation, plastics and developing shades for reducing evapotranspiration and loss of soil moistures
Livelihood options: processing, business opportunity & Value addition (LoV)	• Creating avenues for alternative livelihood sources for food and income in the event of crop failures due to climate change: arecanut plates, poultry, agro-forestry, value additions and other potential business development • Explore other safety nets such as credits and insurance schemes
Crop protection & soil fertility management (CpF)	• Organic ways to address pests and diseases.

	• Promote simple and cost effective electric/solar fencing to prevent wild animals from entering the fields • Mobilize and maintain electric/solar fencing • Upscale electric/solar fencing to protect crops from wild animals and to increase food security • Oversee full utilization of fenced area under crop production

4.0 Signatories for endorsement of CsFA Bylaws

i. CsFA Chairperson
ii. Geog Agriculture Extension Officer (AEO) or Dzongkhag Agriculture Officer (DAO)
iii. Gup or Tshogpa
iv. Planning Officer
v. List of CsFA members/beneficiaries

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