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SMALLHOLDER FARMING AND CLIMATE-SMART AGRICULTURE

A VIEW FROM PEMAGATSHEL DISTRICT

June 2023

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FOREWORD

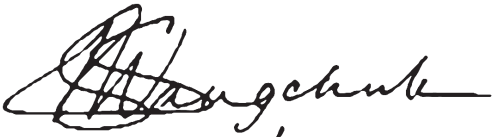
As talks on climate change and its impacts echo more than ever before, a book on climate-smart agriculture (CSA) could not have been better timed. This publication assesses vulnerability to climate change, impacts of climate change, and climate-smart agriculture adopted by smallholder farmers of Pemagatshel District.

This book provides readers with a snapshot of profiles of rural farmers, including their challenges and the rate of CSA technology adoption in the context of changing climate. Results are presented in simple descriptive tables and figures for general readers; nevertheless, the contents are rich in terms of information. The strength of this book is that the quantitative results are augmented with discussions using qualitative data from stakeholders' meetings and field observations made by the researchers. The book also includes policy recommendations for promoting CSA in the study area. I believe that the findings in this book will serve as a rich source of information for researchers, policy makers, planners, academia, and farmers.

It gives me a great joy to note that this publication is an output of a collaboration between the College of Natural Resources, the Royal University of Bhutan and the W.A. Franke College of Forestry and Conservation, the University of Montana under the Partnerships for Enhanced Engagement in Research (PEER) program funded by the United States Agency for International Development (USAID), with collaborating partners the National Academies of Sciences, Engineering, and Medicine (NAS) and Bhutan Foundation. I thank the collaborating partners and USAID for their dedication towards supporting Bhutan.

I also thank and congratulate the research team from the College of Natural Resources and the W.A. Franke College of Forestry and Conservation for bringing out this valuable book.

Tashi Delak!



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Our appreciation goes to the Ministry of Agriculture and Livestock (MoAL), particularly the Agriculture Research and Development Centre (ARDC), Commercial Agriculture and Resilient Livelihoods Enhancement Programme (CARLEP), Wengkhar and Regional Agriculture and Marketing Cooperatives (RAMCO), Mongar for their valuable inputs during the stakeholder meetings. Their expertise and experience helped us to identify the key challenges and opportunities for enhancing the resilience and adaptation of the farming communities in the region.

We would like to express our sincere appreciation to the Pemagatshel *Dzongkhag* Administration for their invaluable assistance and collaboration during the stakeholder meetings and field data collection. We are equally indebted to local governments, including *Gups*, *Gewog* Administrative Officers, Extension Officials, and *Tshogpas* (village heads), for their generous support, farmer mobilisation, and guidance.

We also like to extend our deepest gratitude to the enumerators for their hard work during the collection and tabulation of data.

We thank local guides and translators for their generous support during data collection in the field.

Our special thanks to the farmers for sparing their time to provide valuable information. We acknowledge the love, generosity, and warm hospitality of the farmers of the study sites.

Last but not least, we would like to thank the management of the College of Natural Resources, the Royal University of Bhutan, and the W.A. Franke College of Forestry and Conservation, the University of Montana, USA, for their constant guidance and support in successfully implementing this study.

EXECUTIVE SUMMARY

Like elsewhere, climate change threatens agricultural production and food security in Bhutan. As such, Bhutan identified climate-smart agriculture (CSA) as one of the primary measures for adaptation to climate change. However, Bhutanese farmers often lack the awareness, capacity, and resources to adopt CSA technologies. Moreover, Bhutan has limited empirical studies to make informed decisions while framing policies and implementing CSA-related projects. Thus, this research assessed the vulnerability of smallholder farmers to climate change, the challenges of climate change, and their willingness and preference to adopt CSA technologies. The study was conducted in Pemagatshel District in Eastern Bhutan by surveying 248 randomly selected farmers from Chhimoong, Chongshing and Yurung *Gewogs*.

The findings revealed that most households had less than three members, most of whom were married and between 18 and 60 years old. The farmers in the study area were predominantly small landholders and owned mostly drylands, wetlands (paddy fields), orchards and private forests. Land leasing was not prevalent. Small-scale animal husbandry was important given that farmers mostly reared local and improved cattle breeds. No farmer reared goats, sheep, bees, or fish. It was also found that the cultivation of cereals and value-addition were rare. Typical non-farm winter activities in the study area were weaving, wage labour, and brewing *Ara* (local alcohol). Remittances also provided non-farm income to households. Among the non-forest timber products, farmers collected fern, mushrooms, and *Damru* (a wild leafy vegetable), mainly for self-consumption. The study also revealed a matriarchal society, as women decided most household activities. The top five challenges identified by farmers include pests and diseases, conflicts with wildlife, a lack of irrigation water, labour shortages, and

post-harvest losses. Farmers also reported an increase in windstorms, hailstorms, and crop losses. The top five CSA practices that farmers adopted or were willing to adopt were seed saving, using farmyard manure, planting a mix of crops, improving crop varieties, and integrating livestock on the farms. Most farmers relied on extension personnel for any agricultural information.

In general, farmers had limited access to most of the technologies and training related to CSA. Therefore, there is a need to improve farmers' capacity to respond to the impacts of climate change through policy and programmes to provide CSA infrastructure and capacity development programmes.

TABLE OF CONTENTS

FOREWORD i
ACKNOWLEDGEMENTS iii
EXECUTIVE SUMMARY v
TABLE OF CONTENTS vii
LIST OF TABLES ix
LIST OF FIGURES x
LIST OF ACRONYMS xi
DEFINITIONS OF LOCAL TERMS xii

CHAPTER ONE: INTRODUCTION 1
General Background 1
Problem Statement 4
Study Objectives 5
Organization of Book 5

CHAPTER TWO: METHODOLOGY 7
Conceptual Framework 7
Study Area 8
Stakeholder Meetings 10
Target Population for Survey 12
Sample Size Determination 12
Sampling Technique 13
Questionnaire Design 13
Recruitment and Training of Enumerators 14
Pre-test of Questionnaire 15
Administrative Approval 15
Field Enumeration 15
Ethical Consideration 16
Data Cleaning and Analysis 17

CHAPTER THREE: RESULTS AND DISCUSSION 18
Respondents' Profiles 18
Family Members 19
Family Landholding 21
Domestic Animal Ownership 22
Domestic Animal Sales 24
Farm Machinery and Equipment 25
Other Household Assets 27
Non-Farm Activities and Income 28
Income from Other Sources 29
Sources of Agricultural Information 31
Household Decision Making 33
Challenges Faced by Smallholder Farmers 34
Pests and Diseases 35
Human-Wildlife Conflict 36
Farm Labour Shortage 37
Irrigation Water Shortage 39
Post-Harvest Losses 40
Trends in Events Related to Climate Change 43
Training Received on Climate-Smart Agriculture 43
Willingness to Adopt Climate-Smart Agriculture 46
Adoption Rate of Climate-Smart Agriculture Practices 47

CHAPTER FOUR: CONCLUSIONS AND RECOMMENDATIONS .. 50
Conclusions 50
Recommendations 51

REFERENCES 53
PROJECT TEAM 61

LIST OF TABLES

Table 1 . Participants of the stakeholder meetings 11
Table 2 . Sampling method and sample size 13
Table 3 . Respondents' profiles 19
Table 4 . Households' family member composition 20
Table 5 . Family landholding profile (% of Yes). 22
Table 6 . Domestic animal ownership 24
Table 7 . Domestic animal sales (% of Yes) 25
Table 8 . Farm machinery or equipment owned by farmers.....26
Table 9 . Other household assets owned by farmers 28

LIST OF FIGURES

Figure 1 . Conceptual framework....8
Figure 2 . Study area....9
Figure 3 . Non-farm activities and income....29
Figure 4 . Income from other sources....31
Figure 5 . Sources of agricultural information....33
Figure 6 . Household decision making....34
Figure 7 . Challenges faced by smallholder farmers....42
Figure 8 . Trends of events related to climate change....44
Figure 9 . Training received on climate-smart agriculture....45
Figure 10 . Willingness to adopt climate-smart agriculture....47
Figure 11 . Adoption rate of climate-smart agriculture....49

LIST OF ACRONYMS

AMC	Agriculture Machinery Centre
ARDC	Agriculture Research and Development Centre
CARLEP	Commercial Agriculture and Resilient Livelihoods Enhancement Programme
CSA	Climate-Smart Agriculture
FAO	Food and Agriculture Organization
FMCL	Farm Machinery Corporation Limited
GAO	*Gewog* Administrative Officer
Masl	Metres above sea level
MoAF	Ministry of Agriculture and Forests
MoAL	Ministry of Agriculture and Livestock
NAS	National Academies of Sciences, Engineering, and Medicine
NSB	National Statistics Bureau
Nu	*Ngultrum*
PEER	Partnerships for Enhanced Engagement in Research
RAMCO	Regional Agriculture and Marketing Cooperatives
RNR	Renewable Natural Resources
USAID	United States Agency for International Development

DEFINITIONS OF LOCAL TERMS

Ara	:	Locally brewed alcohol
Chiwog	:	Third-level administrative division that serves as the basic electoral precinct.
Damru	:	A wild leafy vegetable found in Bhutan (*Elatostema lineolatum*).
Dhung	:	Long-horn ritual trumpets made of copper decorated with silver brass and gilt and played by Buddhist monks during special events and ceremonies.
Dzongkhag	:	District
Gewog	:	Second-level administrative division comprised of a group of villages.
Gungtong	:	An abandoned or empty household due to the migration of an entire family.
Gup	:	An elected head of a *Gewog* administration.
Ngultrum (Nu)	:	Bhutanese currency (1$ = 82 Nu)
Tengma	:	A type of beaten maize that is locally produced, especially in Eastern Bhutan.
Thongsa Kamthama	:	Cloths woven with locally available raw materials i.e., naturally grown and naturally dyed cotton yarns, in Thongsa village.
Tshogpa	:	A village head who represents one or more *Chiwogs* determined by the *Gewog*.

Note*: All local terms used in this book are capitalized (first word) and italicized*

CHAPTER ONE

INTRODUCTION

General Background

Bhutan is a relatively small landlocked country situated in the Eastern Himalayas. Sandwiched between China and India, the country has a population of nearly 750,000 people and a Gross Domestic Product of *Ngultrum* (Nu) 178,201.89 (National Statistics Bureau (NSB), 2020). Due to its strong environmental protection policy, Bhutan has a huge forest resource covering 71% of its total land area (Amatya et al., 2018; Bruggeman et al., 2016). The environment is considered pristine, and water resources are abundant. Pollution is minimal, and biodiversity is immensely vast, making it one of the world's top tenth global hotspots and among the first declared carbon-negative countries (World Bank Group, n.d.; Tutton and Scott, 2018).

The diverse agro-ecological zones of Bhutan make it possible to grow a wide range of cereals, including red rice, millet, sweet buckwheat, bitter buckwheat, barley, amaranth, mustard, wheat, and maize. Bhutan also grows diverse tropical fruits, including pineapples, avocado and mangos and temperate fruits such as apples, strawberries, kiwis and grapes. The alpine region has an abundance of valuable medicinal plant species, including *Cordyceps sinensis, Picrorhiza kurrooa, Aconitum heterophyllum,* and many others (National Environment Commission (NEC), n.d.).

Over half of the Bhutanese population are mostly smallholder subsistence farmers tending crops and livestock and preserving forests (Food and Agriculture Organization (FAO), 2011; Katwal, 2013; NSB, 2019). Agriculture is the economic pillar contributing about 16% to the Gross Domestic Product (NSB, 2020). Cognizant of its geopolitical location and economic needs and realising the importance of food security and self-sufficiency, the Government of Bhutan has been emphasising the sustainability of the agricultural sector since the start of planned development in the early 1960s.

Agricultural development has been slow due to several constraints. For instance, agriculture is dominated by largely traditional smallholder subsistence farmers holding a per capita landholding of about 2–3.5 acres (0.81–1.42 hectares) (Tobgay, 2005; NSB, 2017). As a mountainous country, most agricultural lands are on rugged terrain, making it impossible to mechanise farming. Furthermore, the complex topography makes marketing and input supply difficult. Moreover, the huge forest cover shelters numerous wild animals that either forage on the crops at night or prey on domestic animals. The prevailing climate change further compounds these challenges.

There is adequate evidence of climate change and its impacts across the Himalayas, including Bhutan (Shrestha and Devkota, 2010; Lhendup, 2012; Chhogyel et al., 2020a). Since 2000, Bhutan has experienced a rise in temperature of approximately 1°C in summer and 2°C in winter (Bhutan Media and Communications Institute, 2016). As a result, there is an increase in changing rainfall patterns, drought occurrence, snow cover reduction, and glacier retreats (Intergovernmental Panel on Climate Change, 2007). It is also reported that mountain communities, particularly in the Himalayas, are more vulnerable to climate change impacts than other parts of the world (Kohler and Maselli, 2009). The dependency of

most people on agriculture within the context of the fragile mountain ecosystem makes Bhutan vulnerable to climate change.

Climate change is already affecting Bhutanese farmers. Bhutan is experiencing high winds and hailstorms, erratic rains, glacier outburst floods, and the appearance of new diseases and pests (Chhogyel and Kumar, 2018; Wangchuk and Wangdi, 2018). The changing climate in Bhutan interacts with various factors, such as land degradation in some areas, soil erosion, soil fertility decline, and shifts in the onset or offset of the rainy season (Bhutan Trust Fund for Environmental Conservation, 2019). Chhogyel et al. (2020b) reported that 10-20% of crop loss was due to weather events in Bhutan. Damages to crops, agricultural land, and irrigation channels were also reported in Bhutan (Chhogyel and Kumar, 2018). Indeed, recent studies in Bhutan have reported that Bhutanese farmers perceived that climate change and its effects have increased compared to the past (Chhogyel et al., 2020b; Chhogyel and Kumar, 2018; Wangchuk and Wangdi, 2018; Wangchuk and Siebert, 2013).

Amongst other factors, climate change severely affects the country's aspirations to strengthen food systems and achieve food self-sufficiency. For instance, Bhutan is not self-sufficient in almost all the major food commodities. In 2017, Bhutan imported major food items worth about Nu. 66.92 billion (FAO, 2020), mostly from the neighbouring country, India. The Food Corporation of Bhutan Limited, through its outlets located across the country, distributes these imported foods at a subsidised rate. The ongoing climate change situation provides an additional unprecedented shock to mountain food systems. Hence, food security has become a more heightened concern along with climate change, which has substantially motivated people to engage or re-engage in home gardening, farming, seed-saving practices, and climate-resilient agriculture.

One way to address climate change impacts on food security is by adopting Climate-Smart Agriculture (CSA). CSA refers to farming practices that aim to increase agricultural productivity and income while reducing greenhouse gas emissions, increasing the resilience of agricultural systems to climate change impacts, and enhancing the adaptation capacity of farmers. In short, CSA seeks to promote sustainable agricultural practices that are both environmentally friendly and economically viable and that contribute to climate change mitigation and adaptation efforts (CIAT and World Bank, 2017). CSA constitutes innovative practices and technologies, including crop rotation, cover cropping, multiple cropping, redesigning cropping patterns, agroforestry, conservation tillage, and rainwater harvesting amongst other practices (Katwal, 2013; Mizik, 2021).

Problem Statement

Food security issues cannot be achieved without addressing the impacts of climate change (Venkatramanan et al., 2020). The current climate variability has reduced crop production and threatened food security (Macchi et al., 2011). Thus, the concept of CSA has been developed to address food security, adaptation, and mitigation (FAO, 2013). The CSA is gaining considerable attention, especially in developing countries, due to its potential to increase food security and farming system resilience while decreasing greenhouse gas emissions (FAO, 2013; Lipper et al., 2014). Given the impact of climate change on Bhutanese farmers, Bhutan must also strive to promote CSA (Chhogyel and Kumar, 2018), and accordingly, the Government of Bhutan, in partnership with external agencies, is striving to promote CSA in various ways. Notably, Bhutanese farmers often lack the capacity and resources to adopt new technologies such as CSA. Additionally, Bhutan has limited empir-

ical studies to inform decision-making and frame policies and implement CSA-related projects.

Study Objectives

The current study aims to generate data to make informed policy decisions on CSA and generate location-specific CSA tools and practices. This research will also add scientific knowledge on CSA to the existing mainstream literature. As such, this study has three specific objectives:

1. To assess smallholder farmers' vulnerability to climate change.
2. To evaluate farmers' perceptions of the challenges and benefits of CSA practices in the project areas.
3. To determine farmers' willingness and preference to adopt CSA technologies.

Organization of Book

This book is organised into four chapters as follows:

1. Chapter One presents an introduction with a brief background describing the context of the study, problem statement, and the study objectives.
2. Chapter Two describes in detail the methodology to give readers a better sense of the methods and procedures for data generation and analysis. It also highlights the survey operation, including survey instrument, data collection, enumerator training, pre-testing, approvals from authorities, and ethical considerations.

3. Chapter Three presents the results and a discussion of the results. This chapter presents the detailed subject matter of the survey.
4. Chapter Four conveys concluding remarks, with attention to summarising the key findings and providing a set of recommendations.

CHAPTER TWO

METHODOLOGY

Conceptual Framework

The conceptual framework for organising the research implementation and data collection plans, including the approach to the study area, data sources, and study objectives, is illustrated in Figure 1. This study involves a cross-sectional survey, providing a snapshot of the existing situation of the proposed subject matter. The study was conducted in Pemagatshel district and covered three *Gewogs,* namely, Chhimoong, Chongshing and Yurung.

The study collected both qualitative and quantitative data. Enumerators and the research team collected quantitative data by interviewing smallholder farmers. At the same time, the research team collected qualitative data through stakeholder meetings and field observations. Quantitative data from the household survey were analysed descriptively to address the three pre-defined objectives of (1) assessing smallholder farmers' vulnerability to climate change, (2) evaluating smallholder farmers' challenges in the context of changing climate, and (3) assessing the adoption of CSA practices by farmers. Quantitative data from stakeholder meetings and field observations were used to triangulate survey data. Qualitative data were mostly used in discussing the results. Overall, this study builds useful baseline data from the less explored district of Pemagatshel for the scientific community and other relevant stakeholders.

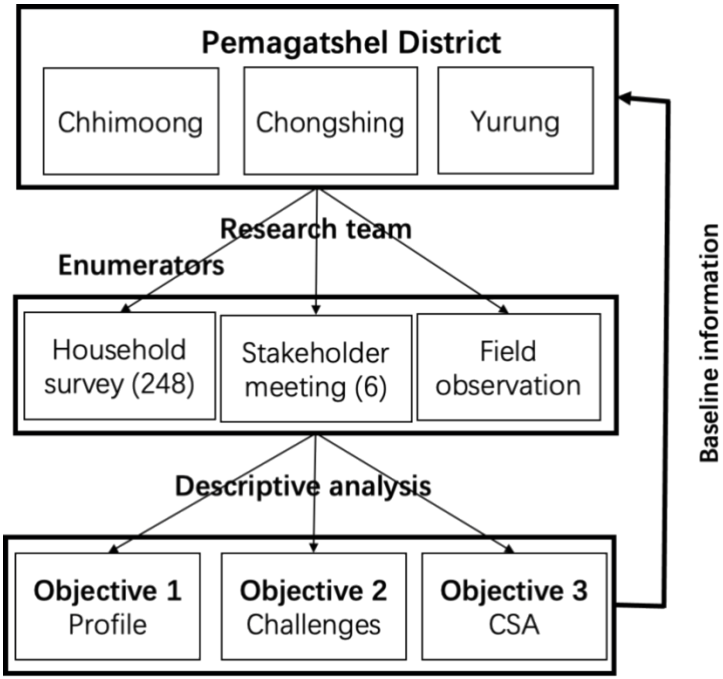

Figure 1. *Conceptual framework*

Study Area

Bhutan can be divided into four regions: East, West, South, and Central. This study was conducted in eastern Bhutan because much of the previous research undertaken in Bhutan has focused on Bhutan's West and Central regions. One factor limiting research in eastern Bhutan is accessibility; travel to the distant eastern regions of Bhutan is difficult, time consuming and intensive. This research sought to capture the perspective of this underrepresented area; hence, the study was conducted in the remote district of Pemagatshel (27° 02' 16.62" N, 91° 24' 10.98" E). The district has a population of 23,632 people (NSB, 2020), and it has one of the country's highest poverty rates at 29.9% (Bhutan Living Standards Survey,

2012). Researchers selected three *Gewogs*, namely Chhimoong, Chongshing, and Yurung (Figure 2), in consultation with the District Agriculture Officer. These *Gewogs* were selected because (1) they are marginalised *Gewogs* compared to those located in the proximity of the district headquarters, (2) farmers' livelihoods in these *Gewogs* primarily depend on agriculture, and (3) these *Gewogs* are adjacent to one another and more easily accessible.

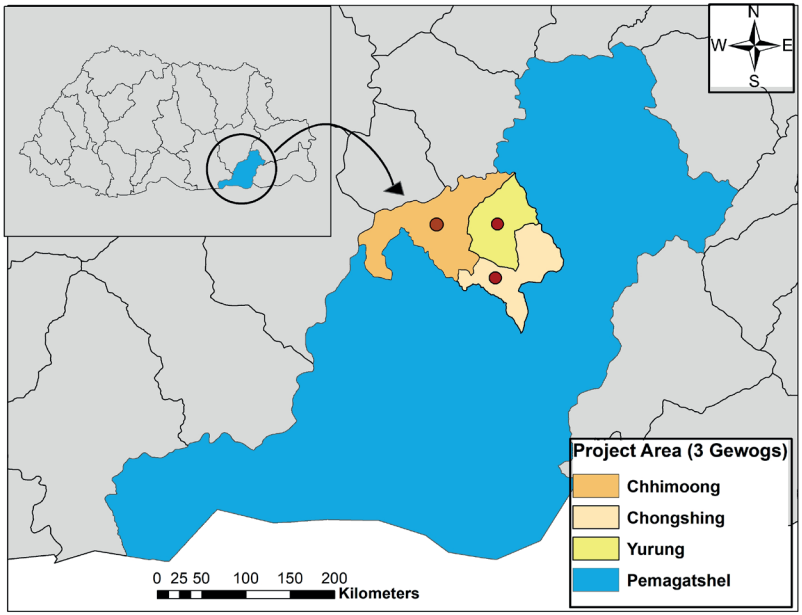

Figure 2. *Study area (Courtesy Tashi Tobgay)*

Chhimoong *Gewog* covers 52.8 Sq. km and has a population of 1,760 people. Maize is grown as the main cereal crop, while bananas and ginger are grown as the main cash crops. The *Gewog* has been facing water problems both for drinking and farming.

Chongshing *Gewog* lies between 250-2500 masl covering 249 Sq. km. The *Gewog* has a population of 2,287 people in sparsely distributed settlements. Like in Chhimoong *Gewog*, people cultivate maize as a staple crop and a few assorted vegetables for self-consumption. Mandarin oranges, potatoes, and more recently, cardamom are grown as cash crops. Women's and men's primary non-farm income sources are weaving clothes and other textiles and producing *Dhung* (the trumpet used by Buddhist monks). Yurung *Gewog* has an area of 28.42 Sq. km with an elevation ranging from 1,275 to 2,975 masl and is located 60 km north-west of the Pemagatshel District headquarter. The *Gewog* has a population of 2,742 people. People cultivate maize as a staple crop and assorted vegetables, mostly for self-consumption. Cash crops include cardamom, mandarin oranges, and potatoes. The popular off-farm activity for women is weaving clothes.

All three *Gewogs* have abandoned wetland paddy cultivation; hence, dryland farming is now dominant. Wetland cultivation abandonment is due to multi-facet problems such as irrigation water shortage, labour shortage, rural-urban migration, and human-wildlife conflict. Save for a few farmers, all farmers in these *Gewogs* have given up on pig and poultry rearing due to strong religious sentiments. Therefore, dairy farming is the dominant activity.

Stakeholder Meetings

The research team met with stakeholders, including sector heads of Pemagatshel district, local government officials, agriculture experts, and marketing officials. The meetings were conducted to familiarise the research team with past and ongoing CSA projects in the study area. The research team also solicited and confirmed support from the stakeholders in conducting the survey. Farming practices, climate change, and challenges and opportunities of

smallholder farmers were also discussed in the meeting. Information from the meeting provided a panoramic view of the grassroots community situation.

The research team also accessed other CSA-related information, such as the role of lead farmers and youth engagement in agribusinesses in Pemagatshel. Data from the stakeholder meetings helped triangulate results from the household-level survey. A total of six stakeholder meetings were conducted with more than 30 participants of various professional backgrounds. Table 1 presents the participants of the stakeholder meetings.

Table 1. *Participants of the stakeholder meetings*

Sl. No.	Stakeholder	No.	Background of participants
1	Sector heads of Pemagatshel district	10	Deputy district governor All sector heads *Gewog* Administrative Officer (GAO) from three *Gewogs*
2	Local government (Yurung)	3	*Gup* Agriculture extension GAO
3	Local government (Chhimoong)	3	Agriculture extension GAO *Tshogpa* (village head)
4	Local government (Chongshing)	3	*Gup* Agriculture extension Livestock extension
5	ARDC, Wengkhar, Mongar	10	Programme Director Agriculture experts Commercial Agriculture and Resilient Livelihoods Enhancement Programme (CARLEP) officials
6	RAMCO, Mongar	2	Executive Director Senior Marketing Officer

Target Population for Survey

The unit of focus in this research was the individual household, therefore, a list of households was compiled in April 2022 with the help of agriculture and livestock extension officials in the three selected *Gewogs*. The extension officials were able to confirm the total number of households in the three *Gewogs* to be 529 households.

Sample Size Determination

Including an adequate sample size is vital to generalise the results to the study area's population. Therefore, in this study, the minimum required sample size was determined by using the Yamane (1967) formula:

$$n = \frac{N}{1 + Ne^2} \quad \text{(Equation 1)}$$

Where,

n = minimum required sample size
N = target population
e = error term

Based on the Yamane formula, the minimum required sample size was 228 households, considering the target population of 529 households and a sampling error of 5%. However, considering the non-response rate of 8%, the minimum required sample size was increased and planned at 246 households. However, data was collected from 248 households. Since the inclusion of two extra households had no major implications on the results, all 248 households were considered for the analysis (Table 2).

Table 2. *Sampling method and sample size*

Gewogs	Population	Planned Sample	Actual sample	Response rate (%)
Chhimoong	131	61	61	100
Chongshing	175	81	80	98
Yurung	223	104	107	103
Total	**529**	**246**	**248**	**101**

Sampling Technique

A two-stage proportionate random sampling technique was employed to select the sample from the target population. In Stage 1, the number of households to be surveyed in each *Gewog* was determined proportionately based on the household list provided by the extension officials. After confirming the proportionate sample in each *Gewog*, a simple random sample using the lucky draw method was employed to select households for the interview in Stage 2. The proportionate random sampling ensured a representative sample from each of the selected *Gewogs*.

Questionnaire Design

Social science often uses semi-structured questionnaires as the standard method for household surveys (Barriball and While, 1994). Therefore, the current study used a semi-structured questionnaire, as it allowed the research team the opportunity to capture additional information that arose during interviews. The questionnaire was divided into four sections. Section 1 collected the socio-economic profiles of households, including family size, education, income, family head, landholding, and farming activities. Section 2 gathered information to assess smallholder farmers' vulnerability

to climate change. In Section 3, challenges faced by farmers due to changing climates were collected. Finally, farmers' willingness and current adoption of CSA technologies were included in Section 4. To ensure the content validity of the questionnaires, the research team and a senior expert from the ARDC, Bajo and currently working at the College, reviewed the questionnaire before the fieldwork. Thus, the questionnaire was further refined based on suggestions received from reviewers and insights gained during the pre-tests in the field.

Recruitment and Training of Enumerators

Four final-year students (three females and one male) pursuing a Bachelor of Science in Agriculture at the College of Natural Resources, Royal University of Bhutan, were recruited to collect data. This group of students was selected because they had prior data collection experience during their final-year research projects. In addition, they possessed basic knowledge of CSA technologies gained through their agriculture coursework and studies. Moreover, all four enumerators could speak the local language of the study areas, i.e., Tshanglakha.

A half-day training was organised in which the enumerators were introduced to the main topics and study objectives during the training. Training also familiarised enumerators with key concepts and definitions of technical terminologies. The training aimed to introduce enumerators to the pre-designed questionnaire's structure, flow, and content to ensure quality and consistent data. After the training, a few minor issues were pointed out and rectified in the questionnaire.

Pre-test of Questionnaire

The questionnaire was pre-tested with 20 small-scale farmers of Nahi *Gewog*, Wangdue Phodrang district. The pre-test was conducted for two days in April and May 2022, soon after the training. For instance, the pre-test enabled the research team to critically review the enumeration process, including the questionnaire's content, structure, and flow. It also helped estimate the average time enumerators needed to complete one interview. The pre-test helped to refine the questionnaire and coordinate the survey within the given time and budget.

Administrative Approval

Before the field survey, the research team got the necessary approvals to conduct research from relevant gatekeepers, including MoAF and administration of Pemagatshel district and selected *Gewogs*. Under the MoAF, approvals were also sought from the Agriculture Research and Development Centre (ARDC), Wengkhar and Regional Agriculture and Marketing Cooperatives (RAMCO), Mongar, to visit their offices and discuss their efforts towards promoting CSA in eastern Bhutan. Approvals were vital because the project team needed support for coordination and cooperation from stakeholders during the data collection.

Field Enumeration

The field survey was conducted from May to June 2022. The primary respondent in a household was the family head. The term "family head" can have two meanings. It could refer to the person listed as the family head in the census or the person who makes most decisions at home. In this study, we considered the second category of family heads due to their decision-making power and

agricultural participation. However, a competent family member with sound knowledge of agriculture was interviewed during unavoidable circumstances. Even national-level surveys also invite a competent family member in the absence of a family head (NSB, 2021a).

Given the high illiteracy rates in rural Bhutan (MoAF, 2019), a face-to-face interview approach using the paper and pen method was adopted. Enumerators asked questions and recorded responses of illiterate farmers. The presence of enumerators enabled respondents to clear their doubts about the meaning of questions. Local guides and translators were hired wherever necessary to ensure clear communication to capture the data accurately and complete the task on time and within budget. The research team from Bhutan also supervised the enumerators and validated the quality of the filled questionnaire. The livestock and agriculture extension officials and local leaders also assisted in translating and guiding the survey team and mobilising the farmers in their respective *Gewogs*.

Data collection was done in a single visit to the household. Enumerators rectified missing, incomplete, or inconsistent responses in the questionnaire by revisiting or through phone-calls with the concerned farmers.

Ethical Consideration

As the current research is part of a PEER program, the funder required all applicants to pursue training in research ethics involving human subjects. In addition, the study was reviewed to ensure compliance with research ethics guidelines and policies. A full ethics review and approval were waived for this study, due to its status of "Exempt" per policies of the Institutional Review Board

(IRB) at the University of Montana (IRB # 206-21). IRB is the institutional review body responsible for overseeing all research activities involving human subjects as outlined in the U.S. Department of Health and Human Services, Office of Human Research Protections. Moreover, all authors have completed the Human Subjects Protection Training (an online self-study course) as required by the funder. Consent from all farmers was sought before the actual survey. Participating farmers were allowed to withdraw their participation at any time during the interview process; however, none of them withdrew. The identity of respondents will remain confidential for all times to come. Photographs were taken with due verbal permission to publish in reports and other documents.

Data Cleaning and Analysis

After completion of the data collection, the same enumerators were engaged to manually punch the data to transfer responses from the questionnaire to the Microsoft Excel Spreadsheet. As the data quality is paramount for the accuracy, relevance, reliability, and validity of results, the consolidated data set was checked item-by-item for errors in data entry. All missing, incomplete, and inconsistent responses were then rectified. Data coding was also done in the Microsoft Excel Spreadsheet.

The final refined data set was then imported to R-Studio (R Core Team, 2020) for further analysis. Data were analysed using descriptive statistics (e.g., mean, standard deviations, frequency, and percentage) to keep it as simple as possible. Therefore, results are presented in tables and figures. ArcGIS was used to generate the study area map.

CHAPTER THREE

RESULTS AND DISCUSSION

Respondents' Profiles

Table 3 presents the demographic profile of the respondents. Of the 248 respondents, the majority were women (62.10%) compared to men (37.90%). This profile resembles national statistics. Nearly half, or 49.2%, of Bhutan's total population is employed in the agriculture sector. Among this population the proportion of female farmers is higher (57.8%) than male farmers (41.3%) (NSB, 2021a). Moreover, the total number of females (8,164) is slightly higher than males (7,843) in the Pemagatshel district (NSB, 2021b). Chhogyel et al. (2020a) also reported slightly more women participating in their study than men.

The majority of the farmers (71.77%) were younger than 60 years old. This indicates that around one-third of the farmers in Pemagatshel district are in the working-age group (retirement age for most civil servants is 60 years old).

More than half of the respondents (56.85%) had neither pursued formal nor non-formal education. This finding suggests that farmers in Pemagatshel are pre-dominantly illiterate. More illiteracy could be due to more females in the sample, as the general literacy rate for females (63.90%) is lower compared to that of males (78.10%) in Bhutan (Ministry of Education, 2021). Further, the literacy rate in rural areas is generally lower; for instance, MoAF (2019) reported a larger share (65.87%) of uneducated farmers. There-

fore, stakeholders concerned about the resilience of the agricultural sector should design future capacity development programmes that are inclusive of illiterate women.

Table 3. *Respondents' profiles*

Variables	Categories	Frequency	Percent
Gender	Male	94	37.90
	Female	154	62.10
Age	≤60 years	178	71.77
	>61 years	70	28.23
Qualification	None	141	56.85
	Non-formal education	49	19.76
	Primary school	39	15.73
	Secondary	19	7.66

Family Members

Table 4 presents the composition of households. More than 70% of the households had less than three members in the family. Family members in this study referred to only those individuals who regularly stayed at home in the past 12 months. The probable argument for smaller family size in the Pemagatshel district could be due to the outmigration from rural East to urban West of Bhutan, especially for work, marriage, family move, and education (NSB, 2018).

For the gender composition of family members, the number of females was slightly higher than males. Also, 11.69% of households had no males, while only 4.44% did not have female members. However, the result contradicts the statistics of the whole Pemagatshel district, where male (50.45%) and female (49.55%) population was almost equal (NSB, 2021a). However, anecdotal evidence shows

no apparent preference for a male or a female child in Bhutan.

Most households also had family members between 18-60 years old, revealing the prevalence of active people in the study sites (NSB, 2021a). Most households (80.65%) had married family members compared to households (67.74%) with single family members. Households comprised almost equal proportions of literate and illiterate family members.

Table 4. *Households' family member composition*

Variables	Categories	Frequency	Percent
Family size	≤ 3	176	70.97
	≥ 4	72	29.97
Male	None	29	11.69
	≤ 3	210	84.68
	≥ 4	9	3.36
Female	None	11	4.44
	≤ 3	220	88.71
	≥ 4	17	6.85
≤17 years	None	94	37.90
	≤ 3	149	60.08
	≥ 4	5	2.02
18 – 60 years	None	38	15.32
	≤ 3	202	81.45
	≥ 4	8	3.23
≥61 years	None	104	41.94
	≤ 3	144	58.06
	≥ 4	0	0

Variables	Categories	Frequency	Percent
Single	None	80	32.26
	≤ 3	153	61.69
	≥ 4	15	6.05
Married	None	48	19.35
	≤ 3	186	75.00
	≥ 4	14	5.65
Non-formal education	≤ 3	239	96.37
	≥ 4	9	3.63
Formal education	≤ 3	238	95.97
	≥ 4	10	4.03
Farming	≤ 3	210	84.68
	≥ 4	38	15.32
Non-farming	≤ 3	243	97.98
	≥ 4	5	2.02

Family Landholding

Table 5 shows that households in the project sites mostly owned dryland (97.98%). Ownership of wetlands, orchards, private forestry, and private pasture is minimal. Even leasing of land was minimal and was mostly restricted to dryland. Accordingly, most households (94.35%) have also cultivated dryland, followed by orchards (29.84%). In agreement with the current finding, owning and cultivating more dryland than other land use types in Pemagatshel district was reported by the agriculture ministry (MoAF, 2019). Therefore, the CSA technologies and capacity development programmes should be closely related to farming crops and animals on dryland.

Table 5. *Family landholding profile (% of Yes).*

Variables	Categories	Frequency	Percent
Land owned	Wetland	10	4.03
	Dryland	243	97.98
	Orchard	48	19.35
	Private forestry	33	13.31
	Private pasture	14	5.65
Rented out/ leased out	Wetland	0	0
	Dryland	7	2.82
	Orchard	0	0
	Private forestry	0	0
	Private pasture	0	0
Cultivated land	Wetland	1	0.40
	Dryland	234	94.35
	Orchard	74	29.84
	Private forestry	12	4.84
	Private pasture	5	2.02
Leased in	Wetland	2	0.81
	Dryland	38	15.32
	Orchard	4	1.61
	Private forestry	1	0.40
	Private pasture	2	0.81

Domestic Animal Ownership

About 42.34% of the households reared local cattle such as Jatsha-Jatsham, Yangku-yangkum, Doethra-Doethram, and Jaba. Another 40.32% of households reared improved cattle breeds, such as Jersey pure and Jersey cross. The rise in improved cattle breeds is attributed to the livestock sector's development policy, such as subsidies to source improved cattle breeds (Choden et al., 2017), to support fodder development, and to encourage the overall im-

provement of the dairy value chain in the country. About 35.89% of the households reared oxen, which indicates that rural farmers still rely on oxen for ploughing their fields despite increasing farm mechanisation. Raising poultry birds for egg production purposes is also popular in the study area. NSB (2021c) reported that cattle and poultry are the two most common animals reared in the country, including in Pemagatshel district.

Few households (2.42%) reared pigs because most respondents believed slaughtering animals was a sin. NSB (2021c) reported 127 pigs in entire Pemagatshel district, which accounts for only 0.55% of Bhutan's pig population. There is also a decline in the number of households rearing horses (0.81%). According to Dorji et al. (2017), the horse population declined largely due to rapid socio-economic development in the country, specifically the improved farm road connectivity. Thus, horses are now left to fend for themselves. None of the households reared goats, sheep, bees, and fish despite the interventions from the Department of Livestock. To this end, promoting CSA in the livestock sector in the project sites could be related mainly to cattle rearing, although beekeeping is also reported to be very lucrative and easy. Information on households rearing animals is presented in Table 6.

Table 6. *Domestic animal ownership*

Domestic animals	Frequency	Percent
Local cattle	105	42.34
Improved cattle	100	40.32
Ox	89	35.89
Goats	0	0
Sheep	0	0
Poultry	31	12.50
Beehives	0	0
Fisheries	0	0
Pigs	6	2.42
Horses	2	0.81

Domestic Animal Sales

This study also enquired about trade in domestic animals (Table 7). Only a few households reported selling local cattle, improved cattle, ox, and poultry. The farmers in the study areas rarely sold live animals; instead, they mainly sold animal products such as cheese and butter. Limited sale of animals also translates to less income from animal sources. Farmers resorted to selling live animals only during unavoidable circumstances, such as when they could not care for animals. A very few pigs were reared, and because they are not matured at the time of the study, none of the households owning pigs had sold their pigs. The limited sale of live animals is largely attributed to social-cultural taboos of killing animals in Buddhist communities. Although there could be a few incidents of selling and slaughtering animals during local festivals, obtaining information on slaughtering animals is difficult due to the socio-cultural stigma in Bhutan (NSB, 2021c).

Table 7. *Domestic animal sales (% of Yes)*

Domestic animals	Frequency	Percent
Local cattle	2	0.81
Improved cattle	2	0.81
Ox	2	0.81
Goats	0	0
Sheep	0	0
Poultry	2	0.81
Beehives	0	0
Fisheries	0	0
Pigs	0	0
Horses	0	0

Farm Machinery and Equipment

Farmers' ownership of farm machinery and equipment provides a wealth of information on access to modern technologies, which also partly indicates farm mechanisation. Farmers source farm machineries for use by hiring these from neighbours or the *Gewog* centres at a subsidised rate (MoAF, 2019). A declining labour force and increasing labour costs in the study area should encourage farmers to use more farm machineries. However, few farmers in the study area owned farm machinery and equipment (Table 8).

The polyhouse, millers, water sprinklers, insect nets and chainsaws were owned by 17.71%, 16.94%, 15.73%, 12.10% and 11.29% of the households respectively. Less than 10% of the households owned other farm machinery and equipment reflected in Table 8. None of the sampled households owned an oil expeller, trolley, thresher, disc plough, and weeder, which are becoming increasingly essen-

tial on the farms and are found in several western districts. This study confirmed that farmers in rural Pemagatshel district have less access to farm machinery and equipment. Validating the result, MoAF (2019) also reported more use of farm machinery and equipment in western regions of Bhutan, especially in Punakha and Wangdue Phodrang districts.

The prices of machinery and equipment are expensive for many small-scale farmers. Low adoption of machinery and equipment is also due to difficult terrain, as most agricultural land is on slopes greater than 50 degrees with narrow stretches. Thus, only selected farm machinery and equipment, such as power tillers, mini-tractors, mini-tillers, and hand tools, are mostly used in Bhutan (Ngawang, 2018). Importantly, Yangchen et al. (2021) also reported that Bhutanese farmers have limited knowledge of using smart technology for agriculture. Therefore, relevant institutions like Agriculture Machinery Centre (AMC) and Farm Machinery Corporation Limited (FMCL) should design their training, research and development, sales, and services to reach a wider section of the farmers in rural Bhutan.

Table 8. *Farm machinery or equipment owned by farmers*

Farm machinery or equipment	Frequency	Percent
Polyhouse	44	17.71
Miller	42	16.94
Water sprinklers	39	15.73
Insect nets	30	12.1
Chain saw	28	11.29
Plastic mulch	23	9.27
Water harvesting tanks	18	7.26

Farm machinery or equipment	Frequency	Percent
Drip irrigation	15	6.05
Power tiller	7	2.82
Grass cutter	7	2.82
Chemical sprayer	2	0.81
Tractor	1	0.4
Rotary Tiller/Rotavator	1	0.4
Oil expeller	0	0
Trolley/Wheelbarrow	0	0
Thresher	0	0
Disc Plough	0	0
Weeder	0	0

Other Household Assets

Access to general assets could influence family farming. Thus, this study gathered information on various general household assets (Table 9). Most households (92.34%) owned cell phones and television (51.21%). Some households (16.53%) that could not afford television used radios to keep up with the latest news. Ownership of these assets reflects improved agricultural information and communication in rural Bhutan. For instance, some Bhutanese farmers use telephone, television, and radio to market their agricultural produce (Yangchen et al., 2021). Owning vehicles such as cars, trucks, motorbikes, and bicycles indicate the arrival of farm roads in the rural communities of Bhutan.

Table 9. *Other household assets owned by farmers*

Other household assets	Frequency	Percent
Cell phone	229	92.34
Television	127	51.21
Refrigerator	84	33.87
Radio	41	16.53
Car	25	10.08
Washing machine	10	4.03
Truck	1	0.4
Motorcycle	3	1.21
Solar power	1	0.4
Bicycle	1	0.4

Non-Farm Activities and Income

It is vital to understand the nature of farmers' non-farm activities. The number and scale of non-farm activities carried out by farmers will partly indicate the time remaining for agricultural activities and alternative sources of income for farmers. Weaving is one of the non-farm activities pursued by most household women throughout the year. Women of Eastern Bhutan, including Pemagatshel district, are well-known for weaving. One of the popular cotton fabrics woven in the Pemagatshel district is the *Thongsa Kamthama* (Pemagatshel *Dzongkhag* Administration, 2022). Remittance is another important source of non-farm income for farmers in the study sites. Men in some households were also engaged in construction sites and as wage labourers. With the increasing developmental activities, such as the construction of farm roads and other public and private infrastructure, men usually engaged themselves in construction activities for additional household income. Men en-

gaging in construction activities is common in Bhutan due to the requirement of physical labour.

Other non-farm activities (Figure 3) were minimal, with less than 10% of the households being engaged. Non-farm activities were usually carried out in the winter during the off-season. Therefore, if there is any plan to engage farmers in programmes such as capacity building, the most suitable time would be in the winter because farmers will have relatively more free time with fewer agricultural activities.

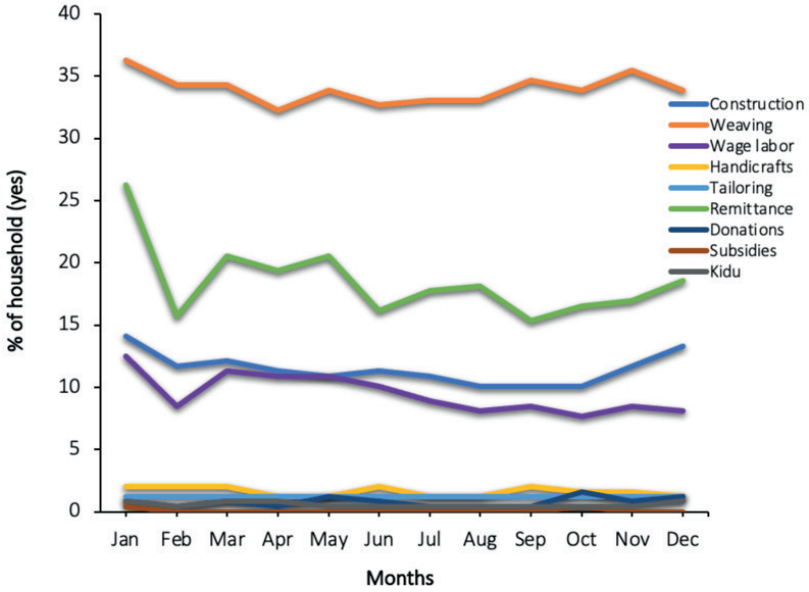

Figure 3. *Non-farm activities and income*

Income from Other Sources

The current study also looked at the sources of income from numerous agricultural activities in the past 12 months (Figure 4). The

results show that around 8% of the households brewed traditional Bhutanese alcohol known as *Ara* throughout the year. *Ara* plays important socio-cultural roles in Eastern Bhutan; it is served to deities during religious occasions. Another reason for its importance is that farmers in Pemagatshel district abundantly grow maize, which is the primary grain used in making *Ara*. Using maize alternatively for more profitable businesses could diversify their sources of income. For instance, a *Tengma*-making (beaten maize) machine could add value to maize.

Production of other cereals is also minimal in the study area. Accordingly, there was less activity related to cereals throughout the year, suggesting low income from cereals. Bhutan grows nine indigenous kinds of cereal: red rice, millet, sweet buckwheat, bitter buckwheat, barley, amaranth, mustard, wheat, and maize (MoAF, 2019). However, corroborating the current findings, the area of cultivation and production of most cereals has declined over the years in Bhutan (MoAF, 2019). Therefore, efforts towards reviving cereal production through the combination of support in production, value addition, and marketing are urgently needed.

Although a few households have reported collecting wild mushrooms, collecting other non-wood forest products was minimal. The project sites had minimal income from cereals and non-wood forest products.

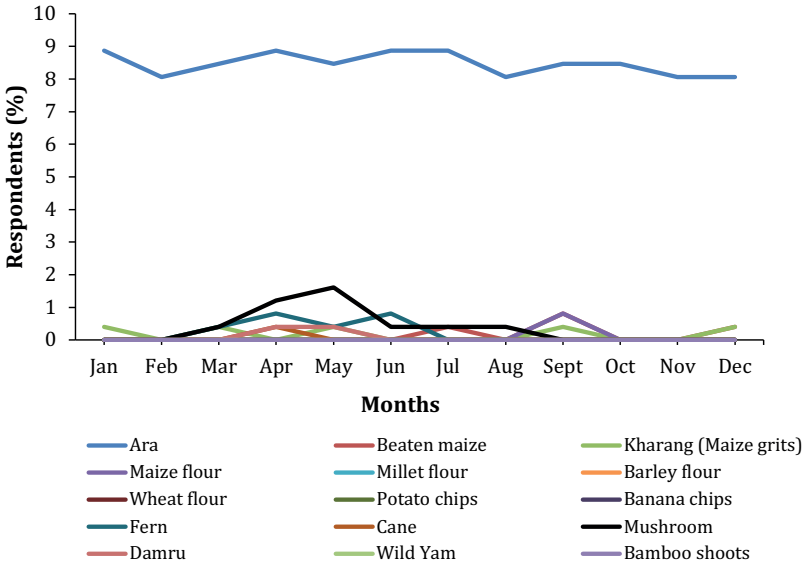

Figure 4. *Income from other sources*

Sources of Agricultural Information

Farmers most often seek advice and information about farming from various stakeholders. The results showed that most farmers (73.39%) rely on extension personnel for necessary information (Figure 5). This finding relates to the fact that agriculture extension officials in Bhutan are locally based in *Gewog* centres and serve as a bridge between the government and farmers. Extension officials are the first point of contact for farmers because they work directly with the farmers at the grassroots level. Moreover, due to their frequent interactions through outreach programmes, farmers have direct contact with extension officials and feel comfortable expressing their problems with them. Farmers reported that extension officials visited most villages multiple times a year for outreach programmes.

Farmers also seek information from their fellow farmers. The Agriculture Research and Development Centre based in Wengkhar, Mongar had trained selected farmers in a few villages on specific agriculture technologies. These trained farmers who are also referred to as lead farmers are expected to help other farmers in the community. Although lead farmers were unavailable in most study villages, farmers in those villages with lead farmers have reported seeking information and technical support from the latter. The study found that about 35.89% of the farmers seek agricultural information from their friends and lead farmers. The result suggests that developing specialisation among a few individuals from each village in different areas of agriculture technologies would supplement the efforts of the *Gewog* extension officials.

Notably, only a handful of farmers have sought information from online forums such as YouTube (7.66%), researchers (6.45%) and technical institutions such as agricultural research and development centres (2.42%). These trends could be either due to a lack of awareness and knowledge of these platforms as sources of information or a lack of confidence to enquire about agriculture related matters.

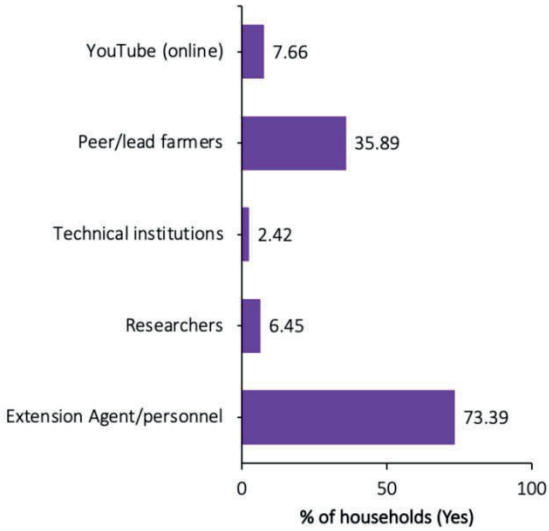

Figure 5. *Sources of agricultural information*

Household Decision Making

The degree of decision-making power of family members could influence the engagement of family members in farming. Figure 6 shows who (men or women) in the family usually decides on household activities. More women made decisions about most activities (three out of eight activities). Only three out of eight activities, including intra-household, resource control, and farm decisions, were mostly decided jointly. Overall, men have less decision-making power at the household level in the study sites. This could indicate a lack of discrimination against women and point to a more matriarchal society.

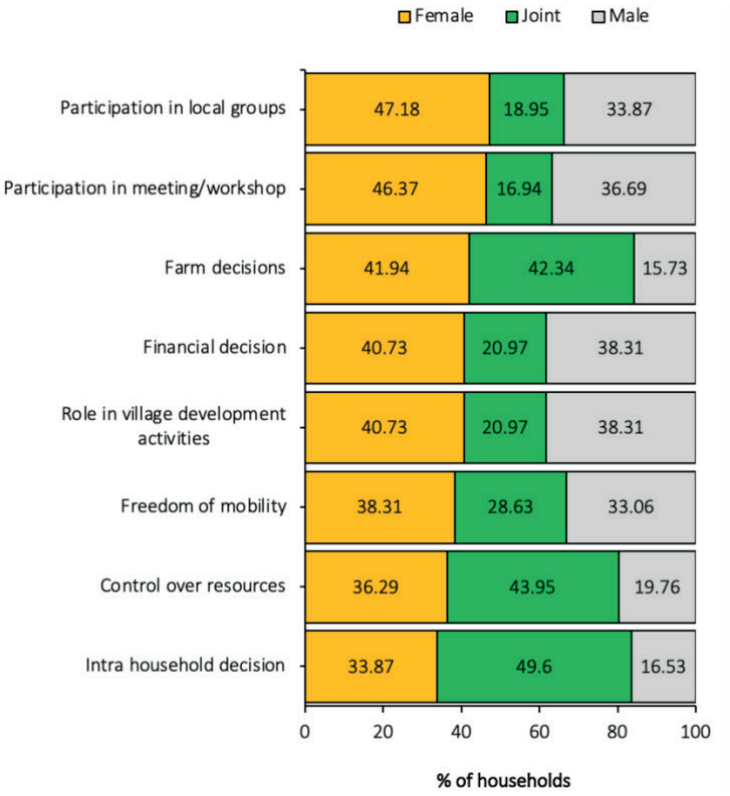

Figure 6. *Household decision making*

Challenges Faced by Smallholder Farmers

Bhutanese farmers practise a subsistence-integrated farming system where they grow varieties of crops along with a few domestic animals (Katwal, 2013). However, agriculture in Bhutan is constrained by numerous factors, including but not limited to difficult geographical terrain, small landholdings, labour shortage, ageing farming population, inadequate irrigation, pest and diseases, climate change, and human-wildlife conflict (Katwal, 2013; Chhogyel and Kumar, 2018; Wangchuk et al., 2018). In light of these realities,

one of the main objectives of the current study was to explore the challenges faced by smallholder farmers of the Pemagatshel district. Figure 7 presents smallholder farmers' challenges; however, only the top five challenges are discussed in this report.

Pests and Diseases

As shown in Figure 7, pests and diseases were a major challenge among majority of the smallholder farmers (95.56%). The farmers repeatedly reported incidences of new pests and diseases in their communities. For instance, armyworm (*Mythimna separata*) have infested huge acreage of crops, especially maize, the most abundantly grown cereal in the Pemagatshel district. The Northern Armyworm outbreak in 2013 devastated paddy and maize in 18 districts across the country. Bhutan could control the outbreaks through neem and synthetic insecticides (Suberi and Dema, 2022). However, the outbreak of a new armyworm called Fall Armyworm (*Spodoptera frugiperda*) was confirmed in Bhutan in 2019. It is reported to generally feed on maize plants. Mahat and Zangpo (2020) have developed a general management guideline for Fall Armyworms, and an in-depth empirical research is in the initial stage (Dorji et al., 2022). Thus, the authors observed that farmers had few options in response to the outbreak, given the lack of effective control measures.

Farmers perceived that the new pests and diseases were spreading into new areas with changing conditions. Chhogyel et al. (2020b) reported that Bhutanese farmers perceived increasing incidences of pests and diseases. Several earlier publications reflect pest and disease challenges to agriculture production in Bhutan (Katwal, 2013; Chhogyel and Kumar, 2018; MoAF, 2019; Chhogyel et al., 2020a; Dendup and Gyenzo, 2021).

The loss of crops to pests and diseases will compromise the food security of smallholder farmers in rural areas. In this regard, there is a need for climate-smart interventions to combat pests and diseases. For instance, the supply of pest and disease-resistant seeds and bio-pesticides to farmers and integrated pest management practices could be promoted besides implementing an early warning system for pest outbreaks due to changing weather conditions.

Human-Wildlife Conflict

Human-wildlife conflict, including depredation of crops, predation of domestic animals, and attacks on humans, is the second biggest challenge reported in almost all project sites. The common wild animals that destroyed crops were mostly porcupines, deer, wild boar, and monkeys. Wangchuk et al. (2018) and Feuerbacher et al. (2021) also reported that Bhutanese farmers conflicted with a similar list of wild animals. Increasing human-wildlife conflict in Bhutan could be attributed to its strong forest conservation policies, such as protected areas, biological corridors, and a nationwide ban on hunting wild animals. Loss of crops and domestic animals to wild animals diminishes farmers' interest in cultivating, and they look for alternative means of livelihood, thereby increasing fallow land. Fallow lands eventually led to more outgrowths, bushes, and forests, and more outgrowths meant more wild animals, as these outgrowths protected wild animals in and around villages. Hence, farmers face a vicious cycle of rampant human-wildlife conflict in rural Bhutan (Chhetri et al., 2013; Wangchuk et al., 2018).

Most farmers in the study-area controlled wildlife with scarecrows, stone or wooden fences, and guarding fields. Earlier studies by Penjor et al. (2014) and Feuerbacher et al. (2021) reported these mitigation measures to control wild animals. However, tradition-

al mitigation measures (e.g., guarding crops) were found to be labour-intensive in Bhutan (Roder et al., 2008; Feuerbacher et al., 2021).

Farmers were also using electric fencing to ward off wild animals. Bhutan's government supports farmers with subsidised low-cost electric fencing technology (Penjor et al., 2014). Materials such as energisers, wires, and nails are provided by government or non-government organisations, and locally available materials such as poles and labour are provided by the farmers (NPPC, 2017). Although previous studies reported the benefits of electric fencing in Bhutan (Penjor et al., 2014; Nima and Gurung, 2018; Feuerbacher et al., 2021), farmers in the study area complained about its inefficiency in controlling wild animals. Electric fencing requires frequent clearing of bushes along the fence, without which the fencing is ineffective. Farmers' poor management of electric fencing has compromised its effectiveness in controlling wild animals. Therefore, some farmers have resorted to corrugated zinc sheets and live plants for fencing. Farmers, local leaders, and experts have suggested the chain link (wire mesh) fence. The Government of Bhutan also plans to invest in the installation of chain-link fence to prevent the animals from damaging the crops (Yuden, 2022).

Farm Labour Shortage

Agriculture in Bhutan is still labour-intensive, but farm labour shortage was reported as the third biggesthighest challenge in this study area (Figure 7). Farmers repeatedly stated that farm labourers are limited in the villages and becoming more expensive. For instance, depending on the region, one day of labour for farming will cost anywhere between Nu. 450-1,000, a drastic increase from the past few years. Other studies have also reported farm labour

shortages as a constraint for agriculture development in Bhutan (Katwal, 2013; Chhogyel and Kumar, 2018).

Labour shortage could be largely due to the current trend of people migrating from rural eastern to urban western Bhutan. For instance, 141,000 Bhutanese people (43.8% of internal migrants or 19.8% of the resident population) migrated from rural to urban areas in 2017 (NSB, 2018). The outmigration of entire family members has resulted in *Gungtongs* in some communities. Although more of the active-age population resides in rural (65.9%) rather than in urban (34.1%) areas, it was reported that between 2020 and 2021, the working-age population in rural areas decreased by 0.7%, while in urban areas, the population increased by 2.2% (NSB, 2021a). The situation could be further aggravated because younger generations do not perceive agriculture as a promising career in Bhutan. The common reasons for Bhutanese youth opting out of agriculture are crop loss, lack of resources, parental pressure, and poor access to technical and financial support (Pelzom and Katel, 2018). The migration of economically active people leaving an ageing rural population is a serious concern for the future of agriculture in Bhutan.

Efforts towards retaining youths to promote agriculture can substantially enhance food security in Bhutan. In addition, we also recommend promoting any form of labour-saving technologies in rural Bhutan. Here, institutions like Agriculture Machinery Centre and Farm Machinery Corporation Limited could play a pivotal role, as the former deals with training and research, while the latter deals with the sale and services of farm machinery and equipment (Tariq et al., 2021). Farm mechanisation that is appropriate for Bhutan's unique geographical terrain has huge potential to address the labour shortage, enhance farm efficiency and upscale agricultural production.

Irrigation Water Shortage

Bhutan is blessed with glacial lakes, glaciers, and wetlands, providing the country with 70,576 cubic hectometers (hm^3) of freshwater annually. However, Bhutan uses only 1% of the total fresh water. Of the total water use, 86% (667 hm^3/yr.) of water, usually from small rivers, streams, and springs, is used in agriculture (National Environment Commission, 2016). The abundance of water has enabled hydropower projects to generate the highest revenue for Bhutan by selling electricity to its neighbouring country India (NSB, 2021b).

In contrast, the dearth of irrigation water was the fourth major challenge faced by the farmers in the study area. Elderly farmers shared that they used to have adequate water in the past; they blamed climate change for drying water sources and increasing water scarcity. It was disheartening to learn that portions of fertile lands were left fallow due to the shortage of irrigation water in the study area.

A women's group in Chhimoong *Gewog* had constructed a few polyhouses with external funding, but they were underutilised due to a lack of irrigation water. Settlements in the study areas are normally scattered and located on slopes far away from river valleys where irrigation water is plentiful. It is not surprising to come across agricultural land on slopes, as up to 70% of Bhutan's total agricultural land is on steep slopes (Dorji et al., n.d). The communities in the study area are no exception from the general situation of Bhutan, where large amounts of water flow in the deep gorges, making it inaccessible for many dispersed communities living on the mountain slopes (National Environment Commission, 2016). Also, the rising population, changing lifestyle, and increasing industrialisation in the country have further shot-up the demand for freshwater (Tariq et al., 2021). Making the situation worse, farmers depend on monsoon rains to irrigate their lands, which is common in Bhutan. In

addition, monsoon rains are also shifting and are less reliable and more irregular than in the past.

Problems of irrigation water shortage (mostly seasonal) are also prevalent in other parts of Bhutan (Chhogyel et al., 2020a; Dendup and Gyenzo, 2021; Tariq et al., 2021). Some villages have resorted to mutually agreed irrigation water distribution systems but increasing conflict among water users over inequitable sharing (Gurung et al., 2006) proves the severity of the water crisis in rural Bhutan. Therefore, we recommend that any interventions towards reviving water sources, supporting water harvesting infrastructure, and promoting water-efficient crops are desirable. As Tariq et al. (2021) recommended, relevant authorities could promote localised, small-scale water harvesting facilities for irrigation during dry seasons. Bhutan's government must continuously strive to address water shortage to realise its food security goal.

Post-Harvest Losses

Post-harvest losses of crops were the fifth challenge reported by farmers in the study area. Based on historical accounts of elderly farmers, remarkable progress has been made in terms of increasing production, especially the production of vegetables and horticultural crops. Unlike in the past, some farmers now cultivate cash crops, including citrus, cardamom, ginger, maize, potatoes, and leafy vegetables. However, due to small market and inaccessible or limited accessibility, the farmers are not able to dispose off all their produces. Those farm productes that are easily perishable are then lost as there areis hardly any processing plants or cold storage to extend the shelf life. The farmers are also not trained in small-scale home processing aspects. Poor distribution networks and glut supply in the market also contribute to post harvest losses.

Overall, post-production activities, including value addition, processing, packaging, and agro-enterprise development are negligible in the study area. All these overlapping issues caused losses of produce after the harvest. Dorji et al. (2020) also documented post-harvest losses in Eastern Bhutan. Their study reported on post-harvest losses of maize in the eastern areas due to insect damage followed by fungal infection.

In light of the compelling field data and observations, this study suggests the need to revive the cultivation of traditional drought-tolerant cereals such as sorghum, millet, amaranth, and so forth. At the macro level, support for drought-tolerant crops should be done through proper coordination among actors in terms of input, production, product development or value addition, packaging, and marketing. Contract farming should continue.

Greater consideration could be given to various ways of encouraging farmers to produce cereal crops. For example, subsidised agricultural technologies and machinery to support the cultivation of cereal crops could be provided. Examples of machinery include mustard seed oil expellers, cereal crop threshing machines, and maize pounding machines (*Tengma*-making). Maize is the predominantly grown crop in this area, and double-cropping of maize annually could potentially motivate community members to produce more cereals. Here again, some initial support to a few interested farmers with seeds for mass production could enable wider adoption.

Much post harvests issues could be addressed by strengthening the availability and accessibility of internal and external markets, especially for cereals and other cash crops such as fruits. The interventions could include improving infrastructure, branding, other arrangements such as school linking programs and contract farm-

ing with farmers' groups and forming cooperatives. Additionally, we suggest prioritising investment on import substitution and export promotion of in agricultural commodities.

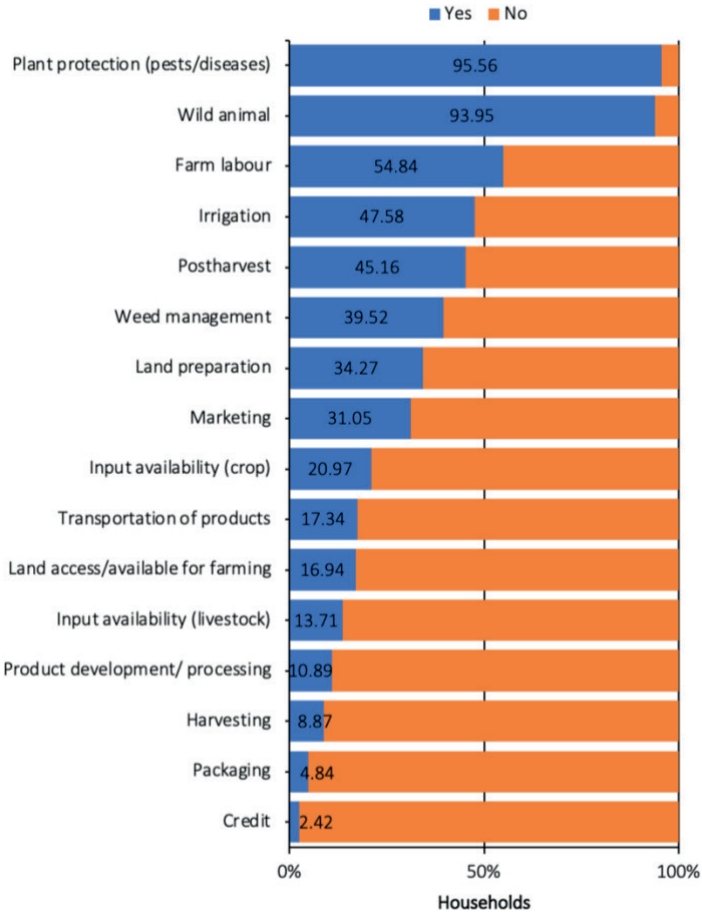

Figure 7. *Challenges faced by smallholder farmers*

Trends in Events Related to Climate Change

Trends in events related to climate change were documented based on people's perceptions and are presented in Figure 8. Most farmers have reported increasing trends of pests and diseases (89.52%), wildlife damage (86.29%), windstorm (62.10%), and hailstorm (52.82%). Crop yields also decreased compared to the past, as reported by 41.94% of the respondents. Surprisingly, however, most farmers reported that there was no change in events related to or triggered by climate change. About 47.98% of the respondents said that there was no soil fertility loss and about 62.50% said that there was no drought.

Nevertheless, it is to be noted that these events have increased in some of the villages, thereby hampering agricultural production. On the other hand, respondents observed a decreasing trend in forest fires in recent years.

Training Received on Climate-Smart Agriculture

Figure 9 presents details of training received by the farmers on CSA. Of the 248 farmers who participated in the study, very few of them attended training on most of the practices and technologies related to CSA. It could be due to the combination of non-availability of such training and lack of awareness or not having time to attend these training sessions. The top six CSA practices in which the farmers received training included agroforestry (11.69%), mulching (10.48%), tree pruning (8.47%), biogas production (6.85%), cover cropping (6.05%), and crop rotation (5.24%). Less than 5% of the farmers attended training on other CSA practices. None of the farmers had attended training on land fallowing, zero tillage, and beekeeping. The findings indicated limited training opportunities for farmers; therefore, more training on CSA practices should be made available to rural farmers in the study sites.

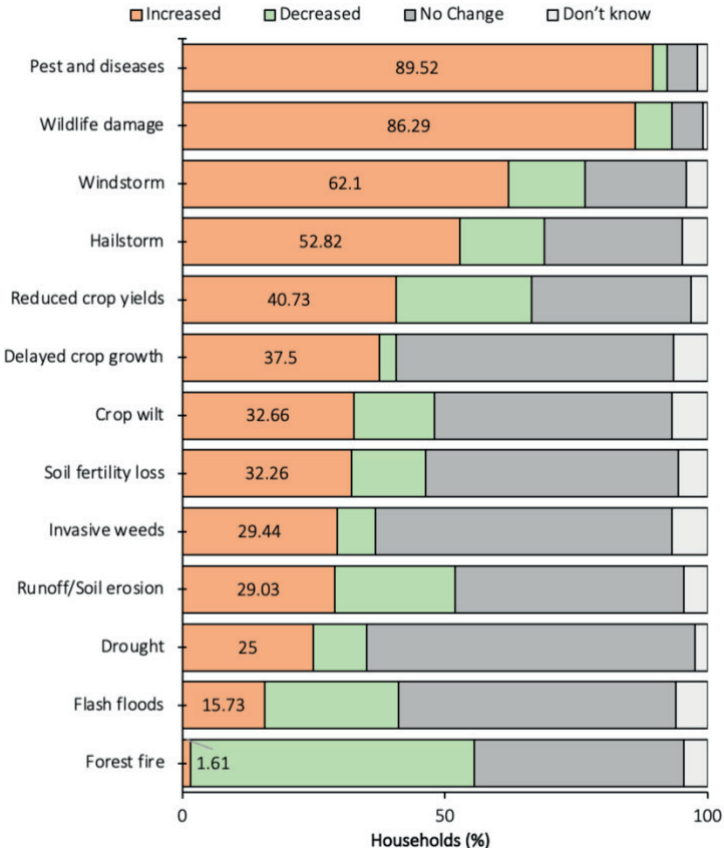

Figure 8. *Trends of events related to climate change*

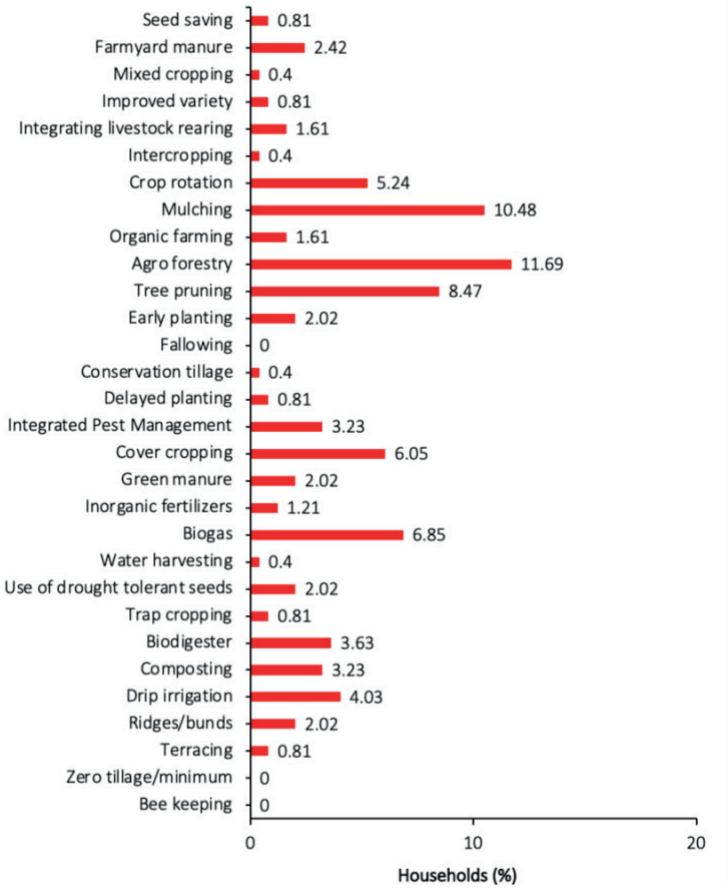

Figure 9. Training received on climate-smart agriculture

Farmers should be encouraged to participate in the training programmes. To foster active participation, we recommend farmer-to-farmer training or peer training. It is because farmers can share a common experience and can relate to each other's challenges and successes. This will lead to a more participatory and interactive learning process that can result in better adoption of new technologies and practices. In this line, we strongly recommend ARDC, Wengkhar to promote and strengthen the practice of

identifying needs and providing training by involving lead farmers in the study area.

Willingness to Adopt Climate-Smart Agriculture

The study also assessed the farmers' willingness to adopt CSA practices. As shown in Figure 10, the top five CSA practices which the farmers were willing to adopt were seed saving (93.15%), farm-yard manure production (87.90%), mixed cropping (77.82%), use of improved varieties of seeds (76.21%), and integration of livestock farming (71.77%). More than 50% of the farmers were willing to adopt intercropping, crop rotation, mulching, organic farming, and agroforestry. In contrast, less than 50% of the farmers were willing to adopt the remaining CSA practices presented in Figure 10.

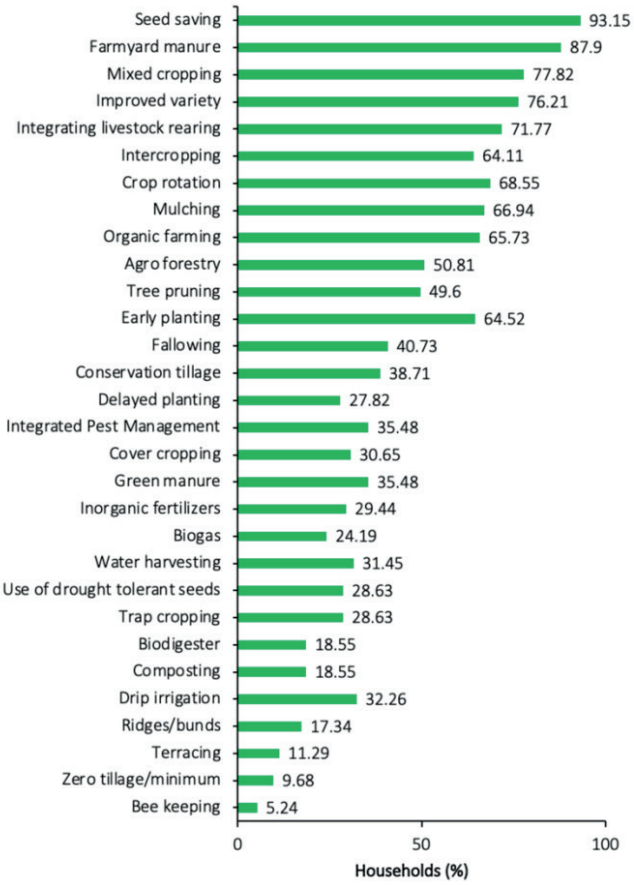

Figure 10. *Willingness to adopt climate-smart agriculture*

Adoption Rate of Climate-Smart Agriculture Practices

Figure 11 presents the CSA practices adopted by farmers. Nine CSA practices were adopted by more than 50% of the farmers. Of these, the top three CSA practices adopted by the farmers were seed saving (93.55%), use of farmyard manure (88.31%), and mixed cropping (77.02%).

Seed saving is quite common across the country as farmers traditionally saved seeds for the following season's planting. As such, the farmers were self-reliant on most local seeds. Informal seed saving by individual farmers boosts climate adaptability, nutrition, and health, thereby contributing to food security. Farmers may build more resilience and diversified food systems by storing, exchanging and trading seeds. This practice also helps preserve traditional and locally adapted crop types, which are often better adaptable to changing climatic circumstances and can bring nutritional benefits to communities.

Terracing, zero tillage, and beekeeping were adopted by less than 5% of the farmers. Whilst terracing and zero tillage are important practices on the slopes to prevent soil erosion, the farmers were unaware of the benefits of such practices or were not skilled in these practices. Other CSA practices, which are equally easy to adopt and require no additional investments, such as crop rotation and cover cropping, were not adopted, partly due to a lack of knowledge.

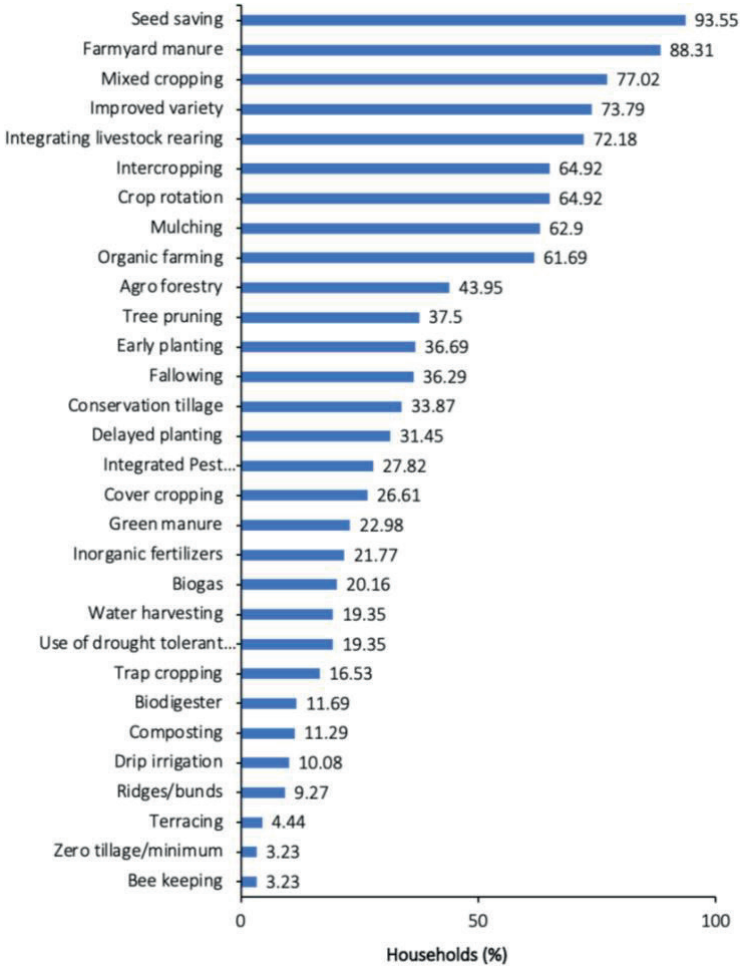

Figure 11. *Adoption rate of climate-smart agriculture*

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study was conducted in Pemagatshel district in Eastern Bhutan. A total of 248 randomly selected farmers from three *Gewogs*: Chhimoong, Chongshing, and Yurung were interviewed. The finding of the study showed that the study site is a matriarchal society dominated by a family size of equal to or less than three. Farmers were largely smallholders owning and cultivating mainly dryland. Except for maize, the cultivation of other cereals is insignificant. Farmers do not want to venture into livestock farming that involves killing animals; therefore, they mostly rear cattle. Most farmers faced challenges related to pests and diseases, wildlife damaging crops, lack of irrigation water, labour shortage, and post-harvest losses. Extension agents were the primary source of information related to agriculture for farmers in rural Bhutan. Farmers usually engaged in non-farm activity during their brief break from farming activities in the winter. Farmers were willing to adopt/continue the CSA practices that are currently being implemented. Overall, the farmers had limited access to CSA technologies and related training.

Recommendations

The research team proposes the following recommendations:

Authorities concerned should strive to design CSA technologies and capacity development programmes to suit Bhutan's agro-climate, topography, and small-scale farmers. For instance, women's engagement should be given equal importance because they are the decision-makers in the family. CSA infrastructure and training should target dryland farming and the revival of traditional cereal cultivation. Pasture development and promoting livestock that does not involve killing (e.g., layering poultry and apiculture) could be studied and promoted too.

As pests and diseases are a problem for majority of the farmers, integrated pest management, bio-pesticides, and field management should be further promoted. The feasibility of chain link (meshed wire) fences should be explored to minimise the human-wildlife conflict, as electric fences were found to be ineffective in controlling wild animals. Water-saving technologies, such as rainwater harvesting infrastructure, drip irrigation facilities, and polyhouses/greenhouses, could be promoted in communities with acute water shortages. Labour-saving tools and machines could also be supported to minimise the burden of farm labour shortage. Authorities concerned could also promote value-addition technologies and capacity development because the value-addition of agriculture and livestock products is minimal. For instance, this study recommends the maize pounding machines because maize is abundantly grown, but its usage was limited to brewing local alcohol for self-consumption. Likewise, there is a need to explore home-based value addition of milk for small-scale dairy farmers. Support in value-addition will significantly help address the post-harvest losses.

Farmers depended on agriculture extension agents for information related to farming. Thus, the engagement of extension officials in CSA programmes is vital for wider dissemination of information related to CSA technologies. Additionally, including extension agents would enhance their knowledge of CSA and could help to continue and sustain the training of other farmers who cannot be reached through the project.

Overall, farmers had limited access to CSA technologies and related training. Therefore, efforts must continue to support farmers with CSA technologies and training. However, training that is delivered must be context-specific as challenges differ from one community to another due to the difference in altitude, micro-climate, resource availability, and farming practices.

Agricultural fields are mostly on slopes. One of the straight-forward strategies is to intensify and upscale land development (such as terracing, rehabilitation, and consolidating existing land wherever feasible) and training through applications of technology and farm mechanisation in a complementary and synergistic fashion, which has proven to be a successful initiative in Bhutan.

To improve crop yield and quality, one of the prerequisites is good soil health. To monitor and improve soil health, soil testing has to be conducted regularly. It could be carried out every two years, if it is not possible to do so once a year.

The traditional cereals such as amaranths, millets, buckwheats, mustards, etc. are cultivated only by a handful of farmers in limited quantities. These are well adapted to the local conditions and in part because they require very limited moisture. These cereals are nutritionally rich and could be further promoted through seed-saving schemes and expanding the production area.

Farmers are relatively free in winter, giving them a brief break to pursue off-farm activities. Therefore, anyone planning to engage farmers for capacity development training or other programmes should plan to focus these activities during the winter months, i.e., December, January, and February. This will ensure maximum participation of the farmers for wider dissemination or adoption of CSA technologies.

Mixed traditional cereals such as barley, corn and soybeans which are roasted and mixed with peanuts are a healthy alternative to imported finger foods and snacks. Such locally made snacks could be promoted and marketed in innovative ways to not only improve good health but also to substitute imports.

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