PhD

CLIMATE CHANGE EDUCATION FOR THE ADAPTIVE STRATEGIES OF FARMERS IN PANCHKHAL MUNICIPALITY, NEPAL

CLIMATE CHANGE EDUCATION FOR THE ADAPTIVE STRATEGIES OF FARMERS IN PANCHKHAL MUNICIPALITY, NEPAL

A Dissertation

Submitted to

The Office of the Dean, Faculty of Education

In Partial Fulfilment of the Requirements for the Degree of

Doctor of Philosophy in Geography Education

Kirtipur, Kathmandu

Nepal

By

Suman Kumar Shrestha

Tribhuvan University, Faculty of Education

Kirtipur, Kathmandu

December, 2025

2025

DECLARATION

I declare that this research entitled **"Climate Change Education for the Adaptive Strategies of Farmers in Panchkhal Municipality, Nepal"** is entirely my original work, whereby all the references have been cited and acknowledged. None of the parts or the whole report has been submitted or published previously for any other purpose.

Suman Kumar Shrestha

Degree Candidate

31 December, 2025

RECOMMENDATION

We hereby certify that **Mr. Suman Kumar Shrestha** a PhD degree candidate has prepared dissertation entitled **“Climate Change Education for the Adaptive Strategies of Farmers in Panchkhal Municipality, Nepal”** under our guidance supervision. I recommend the dissertation for acceptance for evaluation.


…


….

Prof. Damodar Jnawali, PhD
Thesis Supervisor
Central Department of Education
Tribhuvan University, Kirtipur, Nepal

Prof. Peshal Khanal, PhD
Thesis Co-supervisor
Central Department of Education
Tribhuvan University, Kirtipur, Nepal

31 December, 2025

APPROVAL LETTER

This dissertation entitled **"Climate Change Education for the Adaptive Strategies of Farmers in Panchkhal Municipality, Nepal"** for the degree of Doctor of Philosophy in Education has been approved.

Prof. Bed Raj Acharya, PhD
Chair Research Committee
Dean, Faculty of Education, Tribhuvan University

Prof. Damodar Jnawali, PhD
Supervisor, Central Department of Education, Kirtipur
Tribhuvan University

Prof. Peshal Khanal, PhD
Co-supervisor, Central Department of Education, Kirtipur
Tribhuvan University

Prof. Umesh Kumar Mandal, PhD
External Evaluator, Central Department of Geography
Tribhuvan University

Associate Prof. Rabindra Siwakoti, PhD
Research Committee Member
Director, Graduate School of Education

31 December, 2025 (2082-09-16)

DEDICATION

To

All Paragons of Virtue

My Universe

Special thanks to

My Wife Kumari Shrestha and Son and Daughter

Aadarsha Shrestha and

Apekshya Shrestha

My Parents and whole my family

ACKNOWLEDGEMENTS

First and foremost, I would like to express my profound gratitude to my PhD supervisor, Prof. Damodar Jnawali, PhD, and my co-supervisor, Prof. Peshal Khanal, PhD, for generously dedicating their valuable time to the supervision and guidance of this research. Their encouragement, constructive suggestions, and thoughtful feedback enabled me to carry out this study successfully. Their contributions were invaluable in fostering an academic environment throughout the entire research process, from beginning to end.

I am also grateful to extend my deepest appreciation to Prof. Bed Raj Achary, PhD, Dean of the Faculty of Education, for the invaluable opportunity to undertake this research. I am equally grateful to the members of the Research Committee for providing me with the opportunity to conduct PhD research and for their valuable feedback and ongoing support.

I would like to sincerely acknowledge the contributions of my Internal Evaluators, Prof. Shambhu Prasad Khatiwada, PhD, and Prof. Narayan Prasad Paudyal, PhD, as well as External Evaluators Prof. Umesh Kumar Mandal, PhD, Head of Geography Department and international evaluator Prof.Mahendra Bahadur Singh, PhD, Former Head of the Department Geography, BHU, and Varanasi, India. I am also grateful to Prof. Shiva Prasad Rijal, PhD, Asst. Deans Associate Prof. Jant Raj Karky, Dr. Abatar Subedi and Prof. Gem Prasad Gurung, PhD, whose encouragement was invaluable in guiding for the preparation of research and strengthening the overall quality of my research.

Furthermore, I extend my heartfelt thanks to Rajan Binayak Pasa, PhD, Madhav Kumar Shrestha, PhD, Mr. Kumar Narayan Shrestha, and Mr. Richan Shrestha for providing valuable information and guidance that greatly supported my research and writing.

I would like to express my heartfelt gratitude to my wife Mrs. Kumari Shrestha, son Adarsh Shrestha, daughter Apeksha Shrestha, and my entire family for their unwavering love, support, and encouragement throughout this research journey. Their continued faith in me has been a constant source of strength and inspiration, enabling me to overcome challenges and remain committed to my academic goals. In moments of difficulty, their patience and understanding provided comfort, while their motivation reminded me of the greater purpose behind this work. Without their sacrifices and steadfast belief in my abilities, the completion of this research would not have been possible.

I would like to acknowledge the invaluable support of experts, academicians, and librarians who consistently assisted me in preparing research tools and refining my writing. I sincerely thank the Mayor, Deputy Mayor, and members of Panchkhal Municipality, along with the dedicated agricultural staff, for their invaluable support in providing crucial information on climate change at the local level. I am deeply grateful to all those who contributed directly or indirectly to my research journey, offering guidance, encouragement, and practical support.

I especially thank my research participants and friends, whose willingness to share valuable data and insights - without hesitation or fear - even during the challenging period of the COVID-19 pandemic, made this study possible. Their cooperation and resilience have been a source of inspiration throughout my work. Finally, I extend my heartfelt appreciation to everyone who stood by me during this endeavor, strengthening both the quality and spirit of my research.

Suman Kumar Shrestha

The Researcher

31 December, 2025

ABSTRACT

Climate change has been emerged as a global issue that primarily focuses on human-induced activities, especially the burning of fossil fuels and deforestation, increase in greenhouse gases, global warming, melting of snow, seasonal changes in weather and climate, and disruptions to ecosystems. This study is an attempt to investigate the issue of adaptive strategies employed by farmers in the Panchkhal Municipality.

The study employed a concurrent mixed-methods research (QUAN+QUAL) design. Quantitative data were collected through surveys of 568 households, using Krejcie and Morgan's formula, while qualitative data were collected through interviews, observations, and focus group discussions. Secondary sources of data include meteorological records, reports, research papers, and international documents (UNFCCC, IPCC, and UNO). Data were analysed using SPSS (version 20) with descriptive, analytical, and inferential statistics, complemented by thematic analysis. Farmers' lived experiences, offering a comprehensive understanding of climate change education and its role in strengthening adaptive agricultural strategies were considered in the analysis.-

The findings indicate that Panchkhal Municipality has experienced a significant increase in vegetation, after farmers left their cultivable land fallow due to climate change. The process is particularly noticeable in the hilly area of Panchkhal. Many farmers have resorted to leaving their agricultural land for employment elsewhere. In this context, the gradual growth of small trees and shrubs eventually transforms into dense forests over time, with forest areas covering 51.5 percent of the land, primarily as a result of community forest development initiatives. The

residential areas in Panchkhal are expanding into fertile farmland, causing food shortages and greater climate change impacts.

The study reveals that the farmers have been informed about various impacts of climate change such as droughts, fluctuations in rainfall and temperature, insect attacks on crops and fruits, premature ripening of fruits, and the emergence of new diseases. These adverse activities have significantly affected agriculture, resulting in water shortages, crop destruction, and changes in growth patterns of crops, with 72.5 percent of farmers experiencing erratic rainfall.

The farmers are adapting strategies to the impact of climate change by utilizing tunnel farming, organic farming, and Integrated Pest Management (IPM). Many farmers are planting early-maturing crops and are using sustainable practices, with 78 percent utilizing indigenous knowledge systems. Crop diversification is a part of community-based adaptation efforts, though challenges like limited market access and low demand for crops persist.

The study reveals the importance of education and training in farming communities,-encompassing peer learning, community-based initiatives, mentoring, intergenerational knowledge transfer, and the use of media as informal education. These forms of learning provide farmers with practical skills and knowledge, enabling them to access important resources and strengthen climate resilience, thereby enhancing agricultural productivity in the face of climate challenges. The findings indicate that farmers who have received informal education, such as training, along with those possessing higher levels of formal education, are more capable of adopting effective adaptation strategies compared to untrained farmers and those with only school-level education. Moreover, education has played an important role to improve farmers' flexibility in coping with unpredictable weather and limited resources, thereby reducing the adverse impacts of climate change.

The study also recommends that the local municipalities similar to the study area have to prioritize climate adaptation in their policies and programs, while also preparing non- formal training initiatives for farmers that emphasize the protection of vital resources, including soil, water, and forests. Cooperation between the government and I/ NGOs is recommended, along with decentralized training centres, and financial support for climate-resilient seeds and irrigation technology. The study emphasizes the importance of education and community-led resource management in addressing climate challenges in Panchkhal, aiming to build resilience and ensure agricultural sustainability, thereby promoting sustainable practices. This study indicates that further research is essential to develop climate-resilient crop varieties and strengthen the adaptation of agricultural systems. Local agriculture practices will require a competitive yield and profitable crops for farmers to cope with the effect of climate change.

.

शोधसार

जलवायु परिवर्तन विश्वव्यापी मुद्दाको रूपमा देखा परेको छ जुन मुख्यतया मानव-प्रेरित गतिविधिहरूमा केन्द्रित छ |विशेष गरी यी गतिविधिहरू जीवाश्म इन्धन जलाउने र वन फँडानी, हरितगृह ग्यासहरूमा वृद्धि, विश्वव्यापी तापक्रम वृद्धि, हिउँ पग्लने, मौसम र जलवायुमा परिवर्तन, र पारिस्थितिक प्रणालीमा अवरोधहरू हुन् । यो अध्ययन पाँचखाल नगरपालिकाका किसानहरूले प्रयोग गर्ने अनुकूलनरणनीतिहरूको मुद्दाको अनुसन्धान गर्ने प्रयास हो।

यस अध्ययनमा समवर्ती मिश्रितअनुसन्धान विधि (QUAN+QUAL) प्रयोग गरिएको छ । क्रेजसी र मोर्गनको सूत्र प्रयोग गरेर ५६८ घरपरिवारको सर्वेक्षण द्वारा मात्रात्मक तथ्यांक सङ्कलन गरिएको थियो, जबकि अन्तर्वार्ता, अवलोकन रलक्षित समूह छलफलद्वारा गुणात्मक तथ्यांक सङ्कलन गरिएको थियो। तथ्यांकको माध्यमिक स्रोतहरूमा मौसम विज्ञान अभिलेख , प्रतिवेदन, अनुसन्धान पत्रहरू, र अन्तर्राष्ट्रिय कागजातहरू (UNFCCC, IPCC, UNO) समावेश छन्। विषयगत विश्लेषणद्वारा पूरक, वर्णनात्मक, विश्लेषणात्मक, र अनुमानित तथ्याङ्कहरू सहित SPSS (संस्करण २०) प्रयोग गरेर तथ्यांक विश्लेषण गरिएको थियो। विश्लेषणमा जलवायु परिवर्तन शिक्षा र अनुकूलन कृषि रणनीतिहरूलाई प्रभावकारी बनाउन यसको भूमिकाको व्यापक बुझाइ प्रदान गर्ने किसानहरूको जीवनका अनुभवहरूको अध्ययन गरिएको थियो।

जलवायु परिवर्तनका कारण किसानहरूले आफ्नो खेतीयोग्य जमिन बाँझो छोडेर अन्यन्त्र गएपछि पाँचखाल नगरपालिकामा उल्लेखनीय रुपमा वनस्पतिमा वृद्धि भएको अध्ययनले देखाएको छ। यो प्रक्रिया विशेष गरी पाँचखालको पहाडी क्षेत्रमा उल्लेखनीय रुपमा रहेको छ। धेरै किसानहरूले रोजगारीको लागि आफ्नो कृषियोग्य जमिन छाडेर अन्यत्र जाने गरेका छन् ।तसर्थ साना रूखहरू र झाडीहरूको क्रमिक वृद्धि भई अन्ततः समयसँगै घना जंगलमा परिणत हुने प्रक्रियामा

छ , जसमा वन क्षेत्रले मुख्यतया सामुदायिक वन विकास पहलहरूको परिणामस्वरूप ५१.५ प्रतिशत जमिन ओगटेको छ। पाँचखालको कृषि भूमि आवासीय क्षेत्रहरुमा विस्तार हुँदै गइरहेको छ, जसले गर्दा खाद्यान्न अभाव र जलवायु परिवर्तनको ठूलो प्रभाव देखा परिरहेको छ ।

अध्ययनले किसानहरूलाई जलवायु परिवर्तनका विभिन्न प्रभावहरू जस्तै खडेरी, वर्षा र तापक्रममा उतारचढाव, बाली र फलफूलमा कीराको आक्रमण, फलफूल समयभन्दा पहिले पाक्ने र नयाँ रोगहरू देखा परेको जानकारी गराइएको देखाएको छ। यी प्रतिकूल गतिविधिहरूले कृषिलाई उल्लेखनीय रूपमा असर पारेको छ, जसको परिणामस्वरूप पानीको अभाव, बालीनालीको विनाश र बालीको वृद्धि ढाँचामा परिवर्तन आएको छ, ७२.५ प्रतिशत किसानहरूले अनियमित वर्षाको अनुभव गरिरहेका छन्।

किसानहरूले सुरुङ खेती, जैविक खेती र एकीकृत कीट व्यवस्थापन (IPM) प्रयोग गरेर जलवायु परिवर्तनको प्रभावलाई न्यूनीकरण गर्न आवश्यक रणनीतिहरू अनुकूलन गरिरहेका छन्। धेरै किसानहरूले छिट्टो-पाक्ने बालीहरू लगाईरहेका छन् र दिगो अभ्यासहरू प्रयोग गरिरहेका छन्, जसमध्ये ७८ प्रतिशत किसानले स्वदेशी ज्ञान प्रणालीहरू प्रयोग गरिरहेका छन्। बाली विविधीकरण पनि अनुकूलन प्रयास मध्ये एक हो, यद्यपि सीमित बजार पहुँच र बालीको कम माग जस्ता चुनौतीहरू यथावत् छन्।

अध्ययनले किसानहरुमा शिक्षा र तालिमको महत्त्व प्रकट गर्दछ, जसमा साथीहरूको सिकाइ, समुदायमा आधारित पहलहरू, परामर्श, अन्तरपुस्तागत ज्ञान हस्तान्तरण, र अनौपचारिक शिक्षाको रूपमा संचारका माध्यमको प्रयोग समावेश छन्। सिकाइका यी रूपहरूले किसानहरूलाई व्यावहारिक सीप र ज्ञान प्रदान गर्दछ, जसले गर्दा उनीहरूलाई महत्त्वपूर्ण स्रोतहरू परिचालन गरी जलवायु लचिलोपनलाई प्रभावकारीबनाउन सहयोग पुर्याउछ र कृषि उत्पादन बढ्छ। अध्ययनको प्राप्तिबाट यो स्पष्ट हुन्छकि कि प्रशिक्षण जस्ता अनौपचारिक शिक्षा प्राप्त

गरेका किसानहरू, उच्च स्तरको औपचारिक शिक्षा भएका किसानहरूसँगै, अप्रशिक्षित किसानहरू र केवल विद्यालय-स्तरको शिक्षा भएका किसानहरूको तुलनामा प्रभावकारी अनुकूलन रणनीतिहरू अपनाउन बढी सक्षम छन्। यसबाहेक, शिक्षाले अप्रत्याशित मौसम र सीमित स्रोतहरूको सामना गर्न किसानहरूको लचिलोपन सुधार गर्न महत्त्वपूर्ण भूमिका खेलेको छ, जसले गर्दा जलवायु परिवर्तनको प्रतिकूल प्रभावहरू कम हुन्छन्।

अध्ययनले सम्बन्धित क्षेत्रसँग मिल्दोजुल्दो स्थानीय नगरपालिकाहरूले आफ्ना नीति र कार्यक्रमहरूमा जलवायु अनुकूलनलाई प्राथमिकता दिनुपर्ने, साथै माटो, पानी र वन लगायतका महत्त्वपूर्ण स्रोतहरूको संरक्षणमा जोड दिने तथा किसानहरूका लागि अनौपचारिक तालिमका निमित पहल गर्नुपर्ने कुरा सिफारिस गरेको छ। विकेन्द्रीकृत प्रशिक्षण केन्द्रहरूसँगै सरकार र /गैरसरकारी संस्थाहरू बीचको सहकार्य र जलवायु-परिवर्तन अनुकुलन बीऊ/बिजन र सिँचाइ प्रविधिको लागि वित्तीय सहयोग सिफारिस गरिएको छ। साथै पाँचखालमा जलवायु चुनौतीहरूलाई सम्बोधन गर्न शिक्षा र समुदाय-नेतृत्वमा स्रोत व्यवस्थापनको महत्त्वलाई जोड दिनु पर्ने देखिन्छ , जसले लचिलोपन निर्माण गर्ने र कृषि दिगोपन सुनिश्चित गर्ने लक्ष्य राख्दछ र यसले दिगो अभ्यासहरूलाई प्रवर्द्धन गर्दछ। यो अध्ययनले जलवायु-उत्कृष्ट बालीका प्रजातिहरू विकास गर्न र कृषि प्रणालीहरूको अनुकूलनलाई बलियो बनाउन थप अनुसन्धान आवश्यक रहेको संकेत गर्दछ। स्थानीय कृषि अभ्यासहरूले जलवायु परिवर्तनको प्रभावसँग सामना गर्न किसानहरूलाई प्रतिस्पर्धी उत्पादन र लाभदायक बालीहरू आवश्यक पर्नेछ।

TABLE OF CONTENTS

Declaration i

Recommendation ii

Approval Letter iii

Copy Right iv

Dedication v

Acknowledgements vi

Abstract viii

शोधसार xi

Table of Contents xiv

List of Tables xxii

Lists of Figures xxiv

List of Photographs xxv

List of Abbreviations xxvi

CHAPTER I : INTRODUCTION 1

Statement of the Problem 4

Research Objectives 6

Research Questions 7

Rational of the Study 7

Hypotheses of the Study 9

Delimitation of the Study 9

Operation Definition 10

Organization of the Study 15

CHAPTER II : LITERATURE REVIEW 16

Climate Change 16

Adaptive Strategies in Agriculture 24

Agricultural Livelihoods 35
Livelihood Diversification 37
Climate Change Education 39
Policy Implementation for Climate Change Education 43
Integrating Climate Change Education (CCE) 46
Theoretical Perspectives 47
Location Theory 48
Research Gap 50
Conceptual Framework of the Study 51
Conceptual Framework 51
Theoretical Framework 52
CHAPTER III : RESEARCH METHODOLOGY 54
Research Paradigm 54
Ontology 54
Epistemology 55
Research Design 56
Selection of Study Area 59
Unique Geographical Environment 59
Rapid Change in Agricultural Activities 59
Agricultural Super Zone 60
Access to Road and Market 60
Location of Horticulture Center 60
Profession 61
Field Observation 61
Vulnerability of Climate Change 61
Dependence on Agriculture 61
Local Impacts 61

Adaptive Strategies 62
Global Relevance 62
Nature of Data 62
Population and Sampling Procedure 62
Sources of Data 64
Primary Data 64
Quantitative Data 66
Household Survey 66
Qualitative Data 67
Key Informants' Interview (KII) 67
Mayor and Deputy Mayor. 68
Ward presidents. 68
Agricultural expert. 69
Farmers' Leader 69
J/TA Agriculture. 69
Teachers. 69
Focus Group Discussion (FGD) 70
Secondary Data Collection 70
Data Analysis 71
Reliability, and Validity 72
Validity 72
Reliability 73
Credibility and Dependability of Qualitative Results 74
Credibility 74
Dependability 75
Ethical Consideration 76
Chapter Summary 76

CHAPTER IV : RESOURCE CHARACTERISTICS AND UTILIZATION 78

Resource Characteristics 78

Location 79

Topography and Slope Gradient 80

Temperature 81

Rainfall 85

Natural Vegetation 90

Water Resources 93

Land Resources 96

Resource Utilization 96

Topography and Land Availability 97

Land Use 98

Typology of Agricultural Land 100

Ownership of Land 103

Irrigation System 104

Agricultural Practices 106

Resource Management 107

Economic Resource 109

Access to Markets 113

Value Addition 113

Human Resources 114

Labour and Knowledge 116

Population Distribution and Density 117

Age Group 117

Educational Status 118

Religion and Language 118

Discussion of Findings 119

Vegetation Gradually Increasing after Farmers Left their Cultivable Land Fallow ... 119
The Fertile Land Gradually Decreasing Due to the Urbanization Process ... 121
Chapter Summary ... 124
CHAPTER V : INFORMATION OF CLIMATE CHANGE AND ADAPTIVE STRATEGIES ... 127
Causes of Climate Change ... 127
Urbanization and Infrastructure Expansion ... 127
Vehicle Emissions and Road Traffic ... 129
Emissions from Brick and Industrial Kilns ... 130
Information Channels Used by Farmers to Learn About Climate Change ... 132
Perception of Climate Change ... 143
Information of Climate Change on Agricultural Production ... 145
Disease in Agricultural Crops ... 154
Other Diseases and Pesticides ... 158
Adaptive Strategies to Mitigate Climate Change ... 159
Indigenous Adaptive Strategies ... 159
New Adaptive Strategies ... 167
Water Management Practices ... 170
Improved Soil Fertility ... 176
Use of Climate-Smart Technologies ... 182
Crop Diversification ... 186
Selection of Market-Oriented Crops ... 191
Tunnel Farming, Organic and Off-Season Farming ... 191
Organic Farming ... 195
Agriculture Adaptation Strategies ... 198
Sources of Family Income ... 207

Tourism 209

Canonical Correlations 211

Multiple Regression Models -1 212

Discussion of Findings 215

Rising Temperatures. 217

Decreasing Rainfall. 218

Different Diseases and Pests have appeared in Agriculture 221

Information of Climate Change on Erratic Rainfall, Drought, Landslide, and Flood. 225

Drought. 227

Floods 228

Adoption of Climate Flexibility Crops 230

Improved Irrigation Systems 238

Chapter Summary 240

CHAPTER VI : THE ROLE OF CLIMATE CHANGE EDUCATION IN ENHANCING FARMERS' CAPACITY FOR ADAPTIVE AGRICULTURAL STRATEGIES 242

Role of Climate Change Education 242

Provision of Climate Change Education in Nepal 243

Formal Education 244

The Pace of Climate Change Education in School Curricula 249

Non-Formal Education 250

Agriculture Training 251

Market Support Technology 258

Role of GOs and I/NGOs 263

Informal Education 267

Peer Learning 268

Hobby-based Learning 270
Community-based Learning 271
Mentoring 273
Self-experience 274
Exposure Visit 275
Online Learning and Tutorials 277
Television and Radio 279
Knowledge Transfer 281
Newspaper 282
Challenges for Agricultural Production 283
Binary Logistic Regression Model - 2 293
Interpretation of the Result of Binary Logistic Regression 293
Discussion of Findings 294
Education Adopting Adaptive Strategies to Climate Change ...294
Government and Non-Government Organizations are Providing Training 297
Highly Eucated Farmers Adopt Better Adaptive Strategies 300
Chapter Summary 303
CHAPTER VII : JOINT DISPLAY, SUMMARY, CONCLUSIONS, AND IMPLICATIONS 304
Joint Display of the Findings 305
Summary 317
Resource Characteristics and Utilization 317
Information of Climate Change on Farmers' Adaptive Strategies 321
Role of Climate Change Education 322
Conclusion 324
Implication 328
Knowledge Contribution 370

REFERENCES **372**

APPENDICES **396**

Appendix A: Questionnaire for Household Survey 396

Appendix B: Key Informant Interview Guideline 410

Appendix C: FGD Guideline 414

Appendix D: Rainfall of Panchkhal Municipality 1980-2020 (mm) 414

Appendix E: Temperature of Panchkhal Municipality since 1980-2020 419

Appendix F: Status of Community Forest 423

Appendix G: Perception of Climate Change 425

Appendix H: School Curriculum Related Climate Change 426

Appendix I: Course Conducted by Lob Green Nepal 428

Appendix J: Other Diseases and Pesticides 430

LIST OF TABLES

Table 1 : Sample Households (HHs) Selection by Wards 64

Participants of the Key Informant Interview 70

Table 3 : Content Validity 73

Table 4 : Reliability 74

Table 5 : Average Monthly Temperature at Panchkhal 82

Table 6 : Distribution of Temperature by Decades 82

Table 7 : Average Monthly Rainfall at Panchkhal 86

Table 8 : Pattern of Decade-Wise Rainfall 87

Table 9 : Vegetation of the Study Area 92

Table 10 : Presented the Land Use and Land Cover Pattern 98

Table 11 : Irrigated (Khet) Land 102

Table 12 : Rain-Fed (Bari) Land 102

Table 13 : Ownership of Irrigated Land and Rain-fed Land 103

Table 14 : Distribution of Land Ownership 104

Table 15 : Agriculture Financing 109

Table 16 : Information Sources of Climate Change 134

Table 17 : Perception of Climate Change 144

Table 18 : Information of Climate Change 147

Table 19 : Disease in Crops 155

Table 20 : Indigenous Adaptation Strategies 160

Table 21 : New Adaptation Strategies 168

Table 22 : Water Management Practices 171

Table 23 : Soil Health Conservation Practice 177

Table 24 : Climate-Smart Technology 183

Table 25 : Crop Diversified 186

Table 26 : Tunnel, Organic and Off-Season Farming 193

Table 27 : Agriculture Adaptation Strategies 199

Table 28 : Households' Income Sources 207

Table 29 : Canonical Correlations 211

Table 30 : Model Summary 213

Table 31 : Coefficients of Linear Regression of Adaptive Strategies. 214

Table 32 : Educational Status 245

Table 33 : Dependent Variable 248

Table 34 : Types of Agriculture Training 252

Table 35 : Participation in Training 257

Market Support Technology 259

Table 37 : Financial and Technical Support 264

Table 38 : Challenges of Crop Production Caused by Climate Change 284

Table 39 : Binary Logistic Regression Model 293

LISTS OF FIGURES

Figure 1 : Conceptual Framework of the Study 51

Figure 2 : Theoretical Framework of the Study 53

Figure 3 : Research Framework 56

Figure 4 : Resource Characteristics 78

Figure 5 : Location Map of Panchkhal Municipality 79

Figure 6 : Elevation Map of the Study Area 81

Figure 7 : Temperatures in Panchkhal Municipality 84

Figure 8 : Rainfall in Panchkhal Municipality 89

Figure 9 : Resource Utilization 97

Figure 10 : Land Use Map of Panchkhal Municipality 101

Figure 11 : Human Resources 116

Figure 12 : Sources of Information on Climate Change 133

Figure 13 : Information of Climate Change 146

Figure 14 : Indigenous Adaptation Strategies 161

Figure 15 : Normality of Model 214

Figure 16 : Types of Education 244

Figure 17 : Types of Informal Education 268

LIST OF PHOTOGRAPHS

Photo 1: Natural Vegetation in Panchkhal 93

Photo 2: Dry Water Resources in Panchkhal (Jhikhu khola) 94

Photo 3: Radio. 137

Photo 4: Drought 147

Photo 5: Avocado 162

Photo 6: Asuro Plant 163

Photo 7: Insects Trap 163

Photo 8: Titepati Plant 165

Photo 9: Cauliflower Farming 169

Photo 10: Canal for Irrigation 172

Photo 11: Drip Irrigation 172

Photo 12: Dig Holes for Irrigation 173

Photo 13: Plastic Pond 175

Photo 14: Compost/Organic Manure 176

Photo 15: Plastic Mulching 178

Photo 16: Smart Farming Apps, Adopted Google 185

Photo 17: Seeds of DY 28 Paddy 185

Photo 18: Cauliflower Jyapu 188

Photo 19: Tunnel Farming of Tomato vegetable 194

Photo 20: Organic Farming of Cauliflower 196

Photo 21: Chemical Fertilizer 202

Photo 22: Water Boring 202

Photo 23: Organic Mulching 205

Photo 24: Aneikot View Tower 210

Photo 25: Palanchock Bhagawati Temple 210

Photo 26: Dragon Fruit 277

LIST OF ABBREVIATIONS

AAG	:	American Association of Geographer
ADB	:	Asian Development Bank
AEZ	:	Agro Ecology Zones
AFU	:	Agriculture and Forestry University
AGDP	:	Agriculture Gross Domestic Product
AMSL	:	Above Mean Sea Level
ANOVA	:	Analysis of Variance
BSc	:	Bachelor of Science
CBS	:	Central Bureau of Statistics
CC	:	Climate Change
CCE	:	Climate Change Education
CCESD	:	Climate Change Education for Sustainable Development
CEAPRED	:	Center for Environmental and Agricultural Policy Research Extension and Development
CTEVT	:	Center for Technical Education and Vocational Training
DADO	:	District Agriculture Development Office
DFID	:	Department for International Development
DHM	:	Department of Hydrology and Meteorology
ERPA	:	Emission Reductions Payment Agreement
ESD	:	Education for Sustainable Development
EU	:	European Union
FAO	:	Food and Agricultural Organization
FCPF	:	Forest Carbon Partnership Facility
FGD	:	Focus Group Discussion

GCM	:	Global Circulation Model
GDP	:	Gross Domestic Product
GHG	:	Greenhouse Gas
GO	:	Government Organization
LEESP	:	Lesotho Environmental Education Support Project
GoN	:	Government of Nepal, Ministry of Water Supply and Sanitation, Department of Water Supply and Sewerage, National Water Supply and Sanitation Training Centre
HHs	:	Households
HICAST	:	Himalayan College of Agriculture Sciences and Technology
HKH	:	Hindu Kush Himalaya
HYV	:	High Yielding Varieties
IASS	:	Institute of Agriculture and Animal Sciences
IFAD	:	International Fund for Agriculture
IFOAM	:	International Federation of Organic Agriculture Movements
IFS	:	Integrated Farming System
IIASA	:	International Institute for Applied Systems Analysis
IOF	:	Institute of Forestry
IOM	:	International Organization for Migration
IPCC	:	International Panel on Climate Change
IPM	:	Integrated Pest Management
IScAg	:	Intermediate of Agriculture Science
ISDR	:	International Strategy for Disaster Reduction
JT	:	Junior Technician

JTA	:	Junior Technical Assistant
KII	:	Key Informant Interviews
LAPA	:	Local Adaptive Plans for Action
LDC	:	Least Developed Countries
LINKS	:	Local and Indigenous Knowledge Systems Program
LRMP	:	Land Resource Management Project
MAPA	:	Most Advanced Parts of Agriculture
MoAC	:	Ministry of Agriculture and Cooperatives
MoAD	:	Ministry of Agriculture and Development
MoEWRI	:	Ministry of Energy, Water Resources and Irrigation
MoLRM	:	Ministry of Land Reform and Management
MPI	:	Multidimensional Poverty Index
NAPA	:	National Adaptive Plans for Action
NASA	:	National Aeronautics and Space Administration
NBS	:	National Bureau of Statistics
NCVST	:	Vulnerability through the Eyes of the Vulnerable
NGO	:	Non-Government Organization
NOAA	:	National Oceanic and Atmospheric Administration
NPC	:	National Planning Commission
NPI	:	Nepal Polytechnic Institute
NRB	:	Nepal Rastra Bank
NUDS	:	National Urban Development Strategy
NWSSTC	:	National Water Supply and Sanitation Training Centre
PMAMP	:	Prime Minister Agriculture Modernization Project
PPP	:	Public Private Partnerships

SDG	:	Sustainable Development Goals
SPSS	:	Statistical Package for the Social Sciences
TE	:	Technical Efficiency
TU	:	Tribhuvan University
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UNFCCC	:	United Nations Framework Convention on Climate Change
UNICEF	:	United Nations Children's Fund
UNO	:	United Nations Organization
USAID	:	United States Agency for International Development
WFO	:	World Food Organization
WFP	:	World Food Programme
WMO	:	World Meteorological Organization

CHAPTER I

INTRODUCTION

This study explores the role of climate change education (CCE) on enhancing farmers' adaptive strategies in Panchkhal Municipality, Kabhrepalanchok District, Nepal, aiming to assess how targeted educational initiatives can empower local farmers to respond more effectively to climate-related challenges. The study uses landscape ecology as a theoretical lens to examine the impact of spatial patterning on ecosystem dynamics in the study area. Geographers have used landscape ecology studies, driven by the need to evaluate the impact of rapid environmental changes, such as climate change, over the centuries. They employ a multidisciplinary approach to investigate the interplay between climate change, climate change education, and the adaptive strategies of local farmers in different parts of the world (Smith, 2020). Climate change is a global phenomenon affecting various sectors, including agriculture, especially in regions heavily reliant on traditional farming methods. Climate change refers to the long-term changes in Earth's climate system, primarily caused by human activities like fossil fuel burning.

Geographers are studying key concepts to understand the role of climate change education (CCE) in spatial agricultural adaptive strategies. Geography education utilizes a spatial perspective to analyse farmers' knowledge, skills, and resources required for food and fibre production. The production of these products varies significantly in both space and time due to the severe effects of climate change. In 2014, a renowned geographer, Julie Winkler, highlighted climate change as a key topic during her keynote address at the Tampa meeting. The discussion highlighted the significant impact on human adaptation, policy implementation challenges, and the growing importance of climate change in geography research.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change encompasses both natural and anthropogenic processes that affect global and regional climates over extended periods (IPCC, 2021). The Copenhagen Agreement and the Bali Action Plan aim to address the local impacts of climate change, with projections estimating a global temperature rise of 1.4-5.8°C by 2100. This phenomenon is expected to cause widespread yield losses in tropical regions and poses a significant threat to crop productivity (IPCC, 2001b; Wigley, 2005; NASA, 2021). In Nepal, climate change is reducing food production and exacerbating the vulnerability of the country's adaptive strategies. The nation has witnessed an alarming annual warming rate of 0.0368°C (max) and 0.0146°C (min), along with a decline in precipitation of -2.5458 mm per year (NHRC, 2018). These changes marked by rising temperatures and decreasing rainfall - are affecting crop yields and increasing risks such as floods, landslides, and droughts, underscoring the need to promote resilience and sustainability.

SDG 4 emphasizes Climate Change Education (CCE) as a crucial strategy for farmers to understand and adapt to climate change, enhance resilience, efficiency, and technology transfer, and promote inclusive, equitable, and quality education. Farmers must develop sustainable food and fibre production strategies to mitigate climate change by reducing greenhouse gas emissions from deforestation and industrial processes (United Nations Department of Economic and Social Affairs, 2017). Climate change education aims to enhance an education system's readiness and responsiveness to the challenges posed by climate change (Mochizuki & Brya, 2015).

Climate change education has emerged as a pivotal research theme within geography education, aimed at equipping farmers with the essential knowledge and resources to promote sustainable food and fiber production. In this context, UNESCO and the Sandwatch Foundation have collaborated with Rhodes University to develop a climate change education program that empowers young people to teach about the impacts of climate change both inside and outside the classroom (UNESCO, 2015). This initiative aligns with the goals of Education for Sustainable Development (ESD), which aims to support communities worldwide in mitigating and adapting to the diverse effects of climate change. According to article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) calls on nations to prioritize education, training, and public awareness as essential components of climate change response (Mochizuki & Brya, 2015). Advancing Climate Change Education for Sustainable Development (CCESD) requires strengthening learners' understanding of the causes and consequences of climate change and preparing them to take meaningful action.

Geographers are leveraging tools such as spatial analysis, remote sensing, and Geographic Information Systems (GIS) to assess farmers' adaptive strategies, identify areas vulnerable to climate change, and develop effective response plans. Collaborating with farmers, they are implementing sustainable agricultural practices to address the growing challenges posed by climate change (Jones & Miller, 2021). Farmers are utilizing adaptive strategies such as tunnel farming and agroforestry to mitigate the effects of climate change. Farmers are facing significant challenges in agricultural production due to climate change, including unpredictable rainfall, increased pest infestations, extreme weather events, and prolonged droughts, which threaten crop yields and sustainability. These issues highlight the need for a systematic approach to climate change education, which is essential for improving farmers' adaptive capacity and resilience and promoting sustainable agricultural practices (Shrestha & Devkota, 2020).

Climate change education is a multidisciplinary approach that is adopted to deal with adult and youth learners' knowledge and skills through formal, non-formal, and informal education. The school curricula, non-formal education, training, media awareness, exposure visits, networking, and participatory planning are examples of delivering climate change (Anderson & Williams, 2019). By doing so, young adults will be equipped with the concepts, ideas, and knowledge necessary to understand the potential impacts of climate change. Key agronomic adaptive strategies, such as drought-tolerant crop varieties, crop diversification, changes in cropping patterns, and improved irrigation efficiency, are crucial for mitigating the effects of climate change and are widely accepted in both developed and developing countries. In Nepal, the National Adaptation Programme of Action (NAPA) plays a vital role in coordinating and planning local adaptive measures within vulnerable communities to address the challenges posed by climate change since 2010 (Government of Nepal, Ministry of Environment, 2010)

In this context, this study seeks to explore how climate change education can be linked effectively to support farmers' adaptive strategies in Panchkhal Municipality. It investigates the local impacts of climate change on agriculture, assesses the current level of climate change awareness, and proposes educational interventions to enhance the farmers' ability to adapt to a changing environment.

Statement of the Problem

Agriculture is one of the key sectors of people's livelihood and food security in the national economy. Farmers in the urbanized area are highly vulnerable to all adverse impacts of climate change. Panchkhal in the Kabhrepalanchok district is one such urbanized area where agricultural activities are changing with increasing road access and markets. This municipality is very well known for its fertile midland valley, which is involved in commercial agricultural productions of potatoes, cauliflowers, tomatoes, and seasonal vegetables.

The local farmers are also being involved in market-oriented cash crops such as poultry, dairy, tunnel farming, agroforestry, and community forestry, to enhance farmers' productivity. Nowadays, there has been a disruption in agricultural activities due to the adverse effects of climate change. Farmers are feeling degradation in crop yield and farm productivity due to shifting climate patterns, increasing temperatures, erratic rainfall, longer droughts, and extreme variability of weather. Local farmers in Panchkhal Municipality are under pressure to adapt to climate change, though many of them lack the proper knowledge and resources for effective management of its impacts. Despite some adaptive measures, there is a significant lack of formal education and training on climate change that adequately addresses the farming population's needs.

This is primarily due to a lack of adequate education on climate-adaptive strategies, which seriously exposes the long-term sustainability of agriculture in Panchkhal. In this regard, the present study establishes a statistically significant relationship between CCE and farmers' enhanced adaptive strategies by depicting the crucial role it plays in the development of required knowledge and skills among them. The role of focused education in dealing with agricultural challenges such as weather changes and pest outbreaks is emphasized in the literature. There is a lack of relevant information regarding the existing state of awareness among farmers regarding climate change and its adaptation strategy. As such, the absence of evidence regarding awareness and adaptation to climate change and its challenges faced by farmers can also be identified as a gape study found a knowledge gap in the research about climate change education and its specific relation to farmers in the Panchkhal Municipality.

Few studies have been conducted on climate change and education, livelihoods, and adaptive strategies in the study area. My research has not yet yielded a spatial analysis of adaptive strategies in climate change education and agricultural research. Limited research on climate change education for farmers in this region utilizes spatial analysis, lacking knowledge on their current awareness and effective adaptive strategies. A review of existing literature in Panchkhal Municipality does not find a simultaneous study of climate change education and farmers' adaptation strategies in agriculture. These studies have not examined the impact of climate change on farmers' adaptive strategies from a geographical perspective.

In this context, a rigorous study is required to seek out how climate change education supports the adaptive strategies of the local communities in geographic space, i.e., Panchkhal Municipality of Kabhrepalanchok district. The research and studies so far have failed to identify appropriate adaptive strategies in climate change education and agricultural research in the study area. Farmers in Panchkhal Municipality need to adopt adaptive strategies to cope with climate change and its impacts on their livelihoods. Climate change education can help implement climate-resilient technologies like drought-resistant crop varieties and water-saving irrigation methods. This research aims to fill the knowledge gap and provide a spatial framework for climate change education, ensuring farmers' flexibility and sustainability in this vulnerable region.

Research Objectives

The main objective of the study is to analyse the impact of climate change education on adaptive strategies of the farmers of Panchkhal Municipality. The specific objectives are as follows:

i. To analyse resource characteristics and utilization in the study area.
ii. To assess the impact of climate change on farmers' adaptive strategies and the relationship between agricultural production challenges and these strategies.
iii. To examines the role of climate change education for enhancing farmers' adaptive agricultural strategies.

Research Questions

The research questions investigate how education programs focused on climate change assist farmers in developing adaptive strategies to these issues and, therefore, conduct sustainable agriculture while improving their flexibility. The specific questions are as follows:

i. What are the key features concerning natural and human resources present in the study area?
ii. How are these resources utilized at present in the study area by the local population?
iii. What is the information of climate change?
iv. What are the adaptive strategies adopted by farmers to cope with the impacts of climate change on agricultural production?
v. How does climate change education influence farmers' awareness and understanding of adaptive agricultural strategies?
vi. What is the role of training on climate change education regarding adaptive agriculture?

Rational of the Study

The study explores the impact of fertile and infertile soils and plentiful water sources on intensive, market-oriented, and subsistence agriculture farming in

Panchkhal Municipality. It focuses on the need for targeted development policies to improve livelihoods in both areas, addressing the spatial variations in agricultural practices and resource use.

In the context of climate change adaptation, this study is aligned with global priorities such as the Climate Action 2030 agenda, which focuses on empowering farmers with knowledge, skills, values, and attitudes to adapt to climate impacts. The Conference of the Parties (COP) 27, which seeks to transform education to address climate change, emphasizes the importance of Climate Change Education for Sustainable Development (ESD), focusing on four action areas: green schools, green learning, green capacity, and green communities. This framework responds to youth demand for quality climate education as a crucial element in global climate action (UNESCO, 2022).

At the national level, Nepal’s Fifteenth Plan (2019/20-2023/2024) promotes environment-friendly, clean energy-based development to reduce climate change effects. This study seeks to expose local, participatory, and indigenous climate adaptive practices in Panchkhal Municipality, providing insights into how climate change education can foster alternative strategies and promote successful practices at the policy level. This study is valuable for local stakeholders, researchers, and agricultural extension service providers in promoting agriculture-based activities for climate flexibility and mitigation planning. These are the impacts of climate change that farmers are facing: degraded soil in Nepal's central highlands, landslides, irregular rainfall, and water scarcity. Farmers use different strategies, such as the usage of chemical fertilizers, insecticides, and HYV seeds, to try and overcome such obstacles.

Hypotheses of the Study

This study has developed the following alternative hypotheses based on the research questions and objectives:

i. The agricultural adaptation strategies index is significantly described by the predicted variables (age, gender, and settlement, types of farming, caste/ethnicity, and training.

ii. The obstacles of agriculture production index are significantly described by the predicted variables (age, gender, settlement, types of farming, caste/ethnicity, and types of training and level of education).

iii. Formal education enhances adaptive strategies among farmers through improving their understanding and employing effective methods for responding to challenges resulting from climate change.

iv. Agricultural training has a positive effect on farmers' adaptive strategies, enabling them to adopt effective practices that help them cope better with the impacts of climate change.

Delimitation of the Study

The study has analyzed climate change education for adaptive strategies of the farmers in Panchkhal Municipality. They have been involved in the arrival of livelihood options to adapt to adverse effects of climate change. The study covers only the farmers involved in agricultural activities for their livelihoods. The following limitations are given below:

i. The research deals with climate change education and adaptive strategies of farmers in Panchkhal Municipality.

ii. Farmers were selected from core (Administrative center to 5 Km), semi periphery (6-10 Km) and periphery (> 10 Km) wards respectively

iii. Agriculture as a primary occupation and involving in commercial activities for ≥ 5 years

iv. The study focuses on selected resource attributes: forests, water resources, land, and population, while forest fires, glacial hazards, and snowfall, considered issues of climate change vulnerability, are out of its scope.

v. The 40-year temperature and rainfall dataset may include some errors in the calculated averages, as complete monthly data were not available for all years.

Operation Definition

An operational definition defines how a concept or variable is going to be measured or identified within a particular context. This helps avoid ambiguity and ensures the highest degree of consistency. In terms of climate change education for farmers' adaptation strategies in Panchkhal Municipality, an operational definition is as follows:

Independent Variables

Independent variables are the factors that can be manipulated or controlled in research studies to observe their effects on dependent variables. Several independent variables account for educational results and adaptive techniques in the context of climate change adaptive education.

Intermediate Variables

The intermediate variables mediate the association of independent variables with dependent outcomes. In climate change education for adaptive which are several intermediate variables that can hold the key to identifying effective educational interventions for specific adaptive strategies.

Dependent Variables

Dependent variables are the actual outcomes or the effects that researchers may like to explain or predict from variations in independent and intervening variables.

Climate Change Education for the Adaptive Strategies

Climate Change Education for Adaptive Strategies is a systematic process that aims at acquiring knowledge, skills, and awareness concerning climate change and its impacts, with the focus on adaptive strategies that increase the resilience of communities and agriculture. In this perspective are the empowerment of farmers and community members with the key potential to address challenges caused by climate.

Resource Characteristics

Climate is a resource for adaptive strategies because it makes variations in resource quality resource types and uses. It varies in the time and space of a particular geography, location.

Changing Climatic Conditions

Changing Climatic Conditions are operationally defined as the measurable and observable alteration of local climatic conditions that directly affects the environment, agriculture, water resources, and the livelihoods of a given place. It is very important to understand such changes in the course of developing programs of education for adaptive capacities within a community.

Water Resource Management

Water Resource Management is the strategies, practices, and educational programs put in place to ensure people sustainably use water resources, and thereby protect them from climatic change. The objective is to enable local communities to adapt to water scarcity, altered rainfall patterns, and increased demand for water due to climate change.

Soil Fertility and Conservation

Soil Fertility and Conservation refers to activities for maintaining and improving soil productivity and protection against degradation due to climatic changes that manifest through increased temperature, changes in rainfall patterns, and extreme weather fluctuations.

Technological Advancements

The development of modern tools and systems seeks to enhance community adaptability to climate change, mitigate its effects, and improve livelihood sustainability, especially in agriculture and resource management.

Government and I/NGO Support

Government and I/NGO Support are the activities, policies, resources, and programs within the government entities and I/NGOs themselves in promoting climate resilience, creating awareness, and increasing the capacity of the community in adapting to various impacts of climate change.

Economic Constraints

Financial constraint is one of the deterring factors that impede climate change adaptation, hindering the adoption of climate-resilient practices and access to resources, and, consequently, overall adaptive capacity at the individual, household, and community levels.

Knowledge and Awareness

Knowledge and Awareness are the understanding and being conscious of climate change, its implications, and strategies for adaptation, empowering communities to take active steps toward addressing challenges emanating from climate change.

Crop Diversification

Crop diversification is the strategic process of growing a variety of crops instead of relying on one; this is a way of being resilient to the current changing climate. This helps farmers not take risks that come with the variability in climate, like unexpected rain or lack thereof, drought, or even temperature changes.

Migration

Migration is defined as the movement of people from rural agriculture-based areas to cities and towns or other areas in response to the impacts of climate change on livelihoods, resources, and the environment. To this end, migration due to altered environmental conditions can be characterized as both a consequence and potentially an adaptive strategy.

Education

Education provides a process through which people gain knowledge, skills, and awareness regarding the impacts of climate change and feasible adaptive strategies. The education process should adopt formal, informal, and non-formal methods of teaching to endow individuals with the necessary skills to minimize risks due to climate unpredictability and generate resiliency.

Training

Training is the structured, practical, and focused means of trying to build the skills, knowledge, and capacity of individuals and communities to deal with the adverse impacts of climate change. Training programs focus on the fielding of local farmers, community members, and other stakeholders with relevant tools and techniques to implement effective adaptive strategies.

Experience

This is knowledge, skills, and practical understanding gained by individuals or groups through direct involvement in climate change adaptive activities over time. These include formal, informal, and non-formal experiences concerning agriculture, water management, disaster preparedness, and resource conservation.

Exposure Visit

An exposure visit is an organized trip or learning activity where individuals or groups visit other areas or projects to observe and hence learn about successful climate-adaptive practices.

Age

Climate Change Education defines the age brackets wherein the young generation is open to learning and new technologies, while the older ones depend on traditional knowledge. Their respective approaches shall vary according to the age bracket.

Ethnicity

Ethnicity is the collective culture, linguistics, and ancestry of a group of people. Ethnicity may cause inequality in resource access, decision-making participation, and knowledge related to climate change adaptation.

Sex

The difference in biological makeup between men and women influences gender roles related to agriculture, water management, and domestic work. This demands the consideration of gender roles in climate change education if equal adaptation is to occur; besides, women normally manage water resources in the home.

Livelihood Diversification

Livelihood diversification can reduce people's vulnerability by making it easier to adapt to changing environmental and economic circumstances. Farmers, workers, and the community will be trained in various aspects of diversification away from agriculture into activities such as handicrafts, small-scale business enterprise, agro-tourism, renewable energies, and carpentry, in order to deal with unpredictable weather conditions and water shortage.

Improved Irrigation

Improved irrigation is an environmentally friendly approach in agriculture, which enforces water distribution and management efficiency. The variation in climate conditions is already affecting the rainfall, which in turn affects the level of water scarcity. Climate change education trains farmers on drip irrigation, rainwater harvesting, solar-powered irrigation, and smart irrigation systems for maximum water utilization with a reduced application of non-renewable energy resources.

Tunnel Farming

Climate change adaptive farming uses cover structures like plastic tunnels to protect crops from adverse weather and pests, prolonging growing seasons, improving food security, and diversifying income.

Changing Cropping Calendar

Shifting cropping calendar is involves adjusting the timing of planting, growing, and harvesting crops in response to seasonal changes such as rainfall and temperature variations.

Organic Farming

Organic farming is one method of crop production that utilizes natural inputs, such as compost, organic fertilizers, and biological pest control, instead of synthetic chemicals for the ultimate goal of sustainable and environmentally clean crop production.

Organization of the Study

This study is organized into seven chapters. Chapter one presents the introduction, while Chapter Two reviews the relevant literature. Chapter Three outlines the methodology, and Chapter Four describes the resource characteristics and utilization of the study area. Chapters Five and Six present the results and discussions. Finally, Chapter Seven provides the joint display, summary, conclusions, and implications of the study.

CHAPTER II

LITERATURE REVIEW

A literature review is a survey or comprehensive summary of previous studies. It provides an overview of existing knowledge on the research topic and also helps select relevant theories, methods, and gaps. It provides overviews of conceptual, theoretical, and methodological perspectives on different thematic areas regarding climate change, climate change education, and mitigation to adapt to the impact of climate change.

Climate Change

Climate change involves reducing greenhouse gas emissions, switching to renewable energy sources, and implementing sustainable practices to reduce damage to the planet. The main cause of global warming in this area is the excessive use of chemical fertilizers and pesticides. In the context of climate change, long-term weather patterns can change owing to both natural and human-made factors, which are known as climate change (Skendzic et al., 2021). It indicates that climate change is one of the most important and serious global issues that affects both human and natural factors.

I support the fact that the government of Nepal has been using the training and tour system, integrated rural development, agricultural development, and traditional agricultural systems for the past four decades (Sen, 1981). However, such actions do not seem to bring any concrete results to effectively mobilize the majority of poor farmers in rural areas and increase agricultural production and productivity. All these reasons focus their attention on structural changes in physical resources and extension services to achieve their specified goals.

I uphold the idea that natural climate changes have led to ice ages and comparatively warm periods in temperate regions, while rainy and dry periods have alternated in Africa (Kemp, 1994). High-altitude populations in mountainous regions may be sensitive to the effects of long-term climatic change because climate plays a significant role in shaping the altitudinal zone of vegetation and living zones.

The present time has changed from earlier, and more women are involved in employment. But the nature of employment for men and women is often different. They tend to be underpaid or engage in low-quality work (Heintz, 2006; Abramo, 2003; El-Solh, 2003; Adger et.al.2003; Silveira & Matosas, 2003; Valenzuela, 2005; Xaba et al., 2002).

In this context, the global circulation model (GCM) indicates that the temperature in Nepal will increase between 0.5 to 2ºC and between 3.0º to 6.3ºC, with a multi-model mean of 4.7ºC, by the 2090s. GCM outputs suggest that the extremely hot days (the hottest 5 percent of days in the period from 1970 to 1999) are projected to increase by up to 55 percent by the 2060s and up to 70 percent by the 2090s.

The researcher expressed that the impact of global warming is already being felt by the most vulnerable-the world's poorest people and countries, and that its impact is severe in Nepal. Because of the geographical conditions, there is a high dependence on natural resources and a lack of resources to cope with the changing climate (Agrawala et al., 2003). Concerning my study of this area, the farmers depend on agriculture, which has an impact on the geographical structure because some places are flat and some places are vertical. A considerable amount of literature has been published on climate change. Due to climate change in Nepal, many lands have become barren due to a lack of timely rainfall.

I uphold that the more recent attention has focused on the issue of climate change. Due to the climate, the temperature has gradually increased over the past few decades. The locations in the northern hemisphere globally (WMO, 2004) express that while the increase in tropical countries was 0.2 percent to 0.3 percent per decade, worldwide precipitation has grown by 0.5 percent to 1 percent per decade. The trend over the past century has been erratic, but the warming tendency since 1976 is nearly three times that of the previous century as a whole. In the context of my study, farmers have expressed the opinion that they have experienced a gradual increase in temperature over the past decades, but the extent of the increase has not been measured.

The greater part of the literature on climate change is concerned with the greenhouse gas emissions that are gradually increasing year by year on Earth. Under a business-as-usual scenario, greenhouse gas emissions could rise by 25–90 percent by 2030, compared to 2000, and the Earth could warm by 3 °C this century (UNFCCC, 2007).

The IPCC predicts severe effects of a 1.25°C temperature rise, including reduced crop yields, increased hunger risk, climate-sensitive diseases like malaria, and extinction of 20-30 percent of plant and animal species. This study has shown that global warming will increase yields due to the "fertilizer effect", but will negatively influence poor farmers. The haphazard use of chemical fertilizers and pesticides in agriculture is a key cause of climate change (Droogers & Aerts, 2005; IPCC, 2006).

I experienced that the estimated average temperature of the Earth’s surface has risen by 0.74°C since the late 1800s (IPCC report & WWF 2007). The scientists predicted through the global climate models that the average global surface temperature would increase from 1.4°C to 5.8°C due to the supposed doubling of CO_2

concentration in the atmosphere by the end of the 21st century. Based on my observation, the study area is experiencing a gradual increase in temperature.

In recent years, there has been an increasing amount of literature on how the World Meteorological Organization (WMO) addresses the issue since GHG concentrations, which have already reached their highest levels in three million years, have risen and reached new record highs this year. In several industries, fossil fuel emissions have returned to their previous levels or have increased. Since meteorological observations began, the period from 2017 to 2021 will rank among the warmest on record for the entire planet. This warming is also being seen in various climate indicators, including melting glaciers, sea ice, and rising sea levels.

In the same way, the Local Adaptive Action Plan [LAPA] (2011) addresses climate change risks by identifying and addressing climate change risks, prioritizing adaptive strategies through community engagement, and integrating these plans into development planning processes. Furthermore, NAPA shows that temperatures are increasing in Nepal. Consistently every year, and based on statistics, the maximum temperature is increasing by 0.04°C to 0.06°C per year.

In this context of climate change, Regmi and Adhikari (2007) mention that the delay in the monsoon season has also made thousands of hectares of farmland fallow and reduced production due to the effects of climate change in Nepal. In my study, due to climate change and migration, some of the farmland has gradually fallen into fallow.

The greater part of the literature on climate change focuses on the average increase in temperature of 0.06 °C per year from 1975 to 2006, by 1.8 °C, which has been recorded in Nepal (Malla, 2008). Due to climate change, the nation has been dealing with issues like recurring drought, catastrophic flooding, landslides, and a variety of consequences for agricultural products. The yield of rice and wheat increased by 26.6 percent and 18.4 percent, respectively, due to doubling CO2, and by 17.1 percent and 8.6 percent, respectively, due to the temperature rise, according to a study on CO_2 enrichment techniques at Khumaltar.

In this situation, the impact of climate change in Nepal, as Practical Action (2009) has stated that rice production in the Eastern region of Nepal decreased by 30 percent in 2006, and heavy flooding in the mid-Western and far-Western regions in 2006 and 2008 destroyed crops in many places. There is also evidence that vector-borne diseases in livestock are increasing, forcing the livestock to eat less. The farmers mentioned that due to climate change in the study area, outbreaks of diseases in livestock are increasing, and some cattle died five years ago.

Climate change is affecting global food production by altering temperature and precipitation patterns, along with extreme weather events, which impact crop production. The study underlines how this makes agriculture-mostly in developing regions-highly vulnerable and urges the need for adaptive strategies as a mitigating measure (Lobell et al., 2008). It shows that the impacts of climate change in areas of production, water resources, and rising temperature are especially high, like in developing countries, compared to developed countries.

Agriculture in Nepal is facing many challenges in the coming years due to climate-related variability (WFP, 2009). Climate change is projected to exacerbate current problems such as soil erosion and increasingly scarce water supplies, making it more challenging to ensure food security for an expanding population. Recent extreme weather events caused by drought and floods between 2006 and 2009 have severely affected food production in Nepal.

In this regard, I espouse the challenge of enabling means embodied in a new climate change agreement (FAO, 2009). It will motivate farmers to produce these advantages in more unfavourable circumstances caused by the world's financial, food, and fuel insecurity. In this scenario, timely and suitable adaptive cues will encourage technology in the local population to alter crop production through farming practices, crop selection, and health hazard avoidance.

The researcher suggests some precise adaptive strategies that could be used to decrease the impact of climate change on global agriculture, which includes assessing crop vulnerability and enhancing breeding programs for climate-tolerant varieties (Lobell et al., 2011).

The researchers stressed that climate change's impact on weather patterns, which includes more extreme events, and its sectorial effects, like impacts on agriculture, water resources, infrastructure, and human health (Wilby & Keenan, 2012). It indicates that climate change is a burning issue, and its impact on different sectors, such as water resources and agricultural production, affects human beings. In this context, researcher focuses on the issue of how climate change is related to natural resources and ways to adapt mechanisms that would reduce the impact. In this study, researchers emphasize that ecosystems and human societies are supposed to adapt to climate variability in proper ways (Liu et al., 2015). It shows that human societies have adopted different adaptive strategies for the mitigation of climate change.

In this context the researcher focuses on how climate change generally accelerates hydrological processes. As consequences will include increased rainfall intensities and frequency; therefore, the consequence will be enhanced landslides, erosion, and floods contributing to worsening disasters in vulnerable countries like

Nepal (Sidle & Bogard, 2016). This suggests that climate change is causing various water processes, such as increased snow melting and rising water levels near coastal areas, which are affecting settlements near the sea and ocean.

In the same way, the researcher found that during the past 30 years, the annual mean temperature had climbed at a pace of 0.02°C/year while the annual mean rainfall had fallen at a rate of 10.21 mm/year. Over the previous 15 years, it has significantly decreased towards the start of the monsoon. In this context, the farmers experienced that the rainfall was changing and gradually increasing the erratic rainfall (Dhakal et al. 2016). It shows that due to climate change, the different climatic conditions while conditions impact agriculture production and become the livelihoods of the farmers.

According to the Climate Change, Agriculture, and Food Security (CCAFS), (2017)] report, nearly two-thirds of Nepal's population is heavily dependent on climate-sensitive agriculture. Due to climate change, there have been many disasters such as drought, erratic rainfall, floods, and landslides. In this condition, there are many challenges to implementing adaptive strategies in the agriculture sector.

I uphold the researcher's belief that the temperature of western Nepal found by a researcher is increasing by an average of 2.0°C each year. On average, the western part of Nepal increased the temperature every year by 1.2 °C over the last 36 years (from 1975 to 2010). This indicates that the hills and high hills are highly affected by climate change. The average annual rise in temperature in Nepal is 0.06 °C. Climate change increases the chances of a landslide, a disastrous flood, and drought. Hence, agriculture has been affected in Nepal due to high hills (NAPA, 2010).

The researcher upholds that, due to the climate, the planting time has moved forward, and the ripening time has also moved forward (Minoli et al., 2019). Studies show that due to the increase in the temperature of some crops, the period of ripening has decreased. It indicates that climate change alters the ripening and sowing times of crops, which is why appropriate changes in crops are needed to avoid reduced production.

According to the Ministry of Water Supply, Nepal (2019), the need for climate-resilient water safety plans, urging farmers to adopt conservation techniques like reservoirs and efficient irrigation systems to mitigate climate impacts.

I support that the climatic condition in the year 2020 was hotter by more than 1.2°C than the average year in the 19th Century (Gerretsen, 2021). The melting of ice, a sign of climate change that has been accelerating from the past to the present, is also a contributing factor. The sea's brilliant white ice is crucial for reflecting solar radiation into space.

The study suggests that assessing heat exposure's health effects in the context of climate change requires considering compound heat extremes. The Paris Agreement has sparked interest in limiting global warming to 1.5°C to 2°C, with Shenzhen experiencing a 31 percent increase in heat-related dispatches under a 2°C scenario by 2100 (Ling et al., 2021).

It concluded that climate change is a global issue. The temperature is gradually increasing around the world. The temperature is increasing in Nepal as well. The main reason for the rise in temperature in Nepal is due to human activities. The study shows that the temperature is increasing by 0.06°.

Adaptive Strategies in Agriculture

Adaptation is the process of anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. Thus, an adaptive strategy has been developed for expected climate change impacts in a specific area of possible concern. This site has been focused on finding possible ways to address recent threats and mitigate future threats resulting from the changing climate.

I uphold the impact of climate change on agriculture and identified several possible adaptive measures that include developing varieties resistant to altered climatic conditions, shifting plant and harvest dates, better irrigation management, and sustainable farming (Easterling et al., 2000). It indicates that due to climate change, farmers shift to other agricultural varieties to resist climate change.

A considerable amount of literature has been published since 2000. The studies explore climate change's economic impacts and potential adaptive strategies, focusing on agriculture's adaptation to minimize losses and maximize benefits (Mendelsohn et al, 2000). The farmers have adopted the strategies to mitigate the climate change while taking minimum loss and maximizing the profit according to climatic conditions in this situation.

In this context, several researchers have conducted several studies that started to examine how climate change affects human activities and land-use change within the context of developing countries. According to this study, one of the strategies for adaptation involves integrated planning and sustainable resource management (Lambin et al., 2001). It includes the integration of different elements, such as crops, animals, poultry, fish, and trees, in a complementary manner; hence, the available resources are better utilized with minimum wastage. It helps to minimize the loss from agricultural production.

Similarly, the researcher presented a framework of vulnerability to the global environment. The researcher has presented a conceptual framework for the risk of global environmental change. There are interactions between human systems on environmental stress and issues of social and ecological concern. As a result, it clarifies how people perceive environmental changes and social inequalities in rural and agricultural livelihoods (Turner et al., 2003 & O'Brien et al., 2004). It has been indicated that farmers have been adopting various approaches to adaptive strategies for good production according to the changing climatic conditions, such as local seeds shifting to hybrid seeds. Global investment in infrastructure, agriculture, public health, and climate resilience is now commanding attention at the global level. Included is the demand for investments in climate-resilient varieties of crops, better irrigation, and more sustainable practices-one that also reduces vulnerability, especially in the developing world (Stern, 2006). It also reveals that the farmers have adopted climatically tolerant varieties of agricultural seeds and plants, and the utilization of better water resources for good agricultural production.

Climate change is emerging as one of the most significant ecological and social issues of our time (Olmsted, 2007). As scientists continue to investigate the probable extent of climate change, the ecological maxim "adapt, migrate, or die" assumes a special significance and urgency. Many species, including those that do not include humans, will be compelled to follow one of the three paths of adaptation, migration, or mortality as a result of rising temperatures. According to the study, due to climate change, some of the farmers migrated (seasonally and permanently).

I assert that the aspect of ecological condition in the climate change-related literature of Jarvis et al. (2008) expresses that farmers use their knowledge of changing climatic conditions and stages of biotic stress tolerance and adaptability in their materials and work with plant breeders to develop varieties that are adaptations to changing local conditions and possess improved yields and quality.

In this situation, the researcher has shown that forest regeneration may potentially play a very crucial role in mitigating some impacts due to climate change (Chazdon, 2008). Forests generally act as carbon sinks through the absorption of carbon dioxide from the atmosphere into biomass and soil. Increased forest regeneration will likely lead to increased sequestration of carbon and reduced emissions of greenhouse gases. Forest regeneration helps maintain ecosystem services, which relate to hydrologic cycling, conservation of soils, and biodiversity. It reveals that forests play an important role in achieving environmental sustainability, protecting soils, and mitigating the greenhouse gas effect.

Regarding this matter, the researchers explore the relationship between climate change and food security in terms of the effects of climate variability on agricultural production. They proposed means through which the effects could be mitigated, among them development of drought-resistant crops, proper water management, and investment in early warning systems.

The study focuses on sustainable agricultural methods, including intensification, low-carbon technologies, food waste reduction, and dietary changes, to mitigate greenhouse gas emissions and prepare for climate change (Garnett, 2009). In this context, the different features are tropical deforestation, impacts on biodiversity and ecosystem services, reforestation, and forest management for adaptation to climate change (Rudel, 2009). The vulnerability to disasters such as floods and droughts has been significantly reduced.

I espouse the challenge of enabling means embodied in a new climate change agreement (FAO, 2009). It will motivate farmers to produce these advantages in more unfavourable circumstances caused by the world's financial, food, and fuel insecurity. In this scenario, timely and suitable adaptive cues will encourage technology in the local population to alter crop production through farming practices, crop selection, and health hazard avoidance. Climate change will affect livestock production through competition for natural resources, the quantity and quality of feeds, livestock diseases, heat stress, and biodiversity loss (Garnett, 2009). In my study, due to climate change, their agricultural production was reduced, and some of the farmers shifted crop production to livestock farming.

The community forestry program in Nepal is an effort made at the government level to reduce deforestation and improve the livelihood of the community in addition to sustainable development (Ojha, 2009). The two main goals of the Community Forestry Program are to empower local communities while promoting the environmental conservation benefits of Himalayan forests.

In this instance, the reduction of impacts of the various changing climates is a method adaptable towards mitigation, which is urgently needed in landslide-prone areas (Petley, 2010). It shows that the farmers have adopted different adaptive strategies according to the climatic conditions, which help to increase crop production and mitigate the impact of climate change. In this situation, the study addresses the need for flexible infrastructure in agriculture to deal with water availability variability, since climate change affects agriculture, further increasing dependence on rain-fed systems and enhancing food insecurity (Rodell et al., 2009 & Thornton et al, 2009).

I agree with the researcher's presentation that migration leads to a decline in both production and productivity in agriculture (Pant, 2013). Because the people who migrate are often young and educated, there are children and old people as well as relatively uneducated people, so the productivity in agriculture decreases.

I assert that the researcher emphasized an adaptive strategy for managing water supply, focusing on improved forecasting systems of climate change, conservation of water resources, infrastructure development, and removing the policy interventions, promoting sustainability in agriculture and urban centers for the mitigation of climate change (Trenberth, 2011). It indicates that the adaptive strategies were used by the farmers, which mitigated the impact of climate change according to the climatic conditions. SDG 13 is particularly relevant to climate action and focuses on addressing climate change and its impacts. Although Nepal does not contribute significantly to global greenhouse gas emissions, its geographical location and reliance on climate-sensitive sectors such as agriculture and water resources make it very vulnerable to climate change impacts.

Similarly, this study examines the impacts of climate change in Nepal, focusing on the most affected sectors, evaluating existing adaptive strategies, and proposing additional measures to strengthen resilience and facilitate effective adaptation to changing environmental conditions (Rai, 2011).

Climate change is urbanization, studied by Seto et al. (2011) on expanding cities as a critical component of environmental degradation. As such, they suggest that urban adaptive strategies should pursue a double position concerning mitigation-resilience through sustainable urban planning and infrastructure development.
The farmers develop seed systems by changing them according to the environment and market. A baseline study conducted in Vietnam, Peru, and Zimbabwe in 2013

showed that farmers are aware of climate change when farming and growing crops (Oxfam, 2013). To adapt to climate change, they use more flexibility in crops and crop varieties and use modified crops.

I espouse that this leads to a greater need to study the diverse influences of climate change on barriers for different social groups, stratified by wealth status, gender, ethnicity, or other demographic factors (Shackleton et al., 2015). It is necessary to understand the strategies under consideration for adaptation. In the context of my study, many diseases occurred in livestock, and some cattle died due to those diseases.

I uphold that adaptive studies do consider the reasons behind adaptation. As stated, studies on 'barriers' to adaptation have a long history. According to the work of Mesha and Van Laerhoven (2016) stated the types of studies tend to assume that obstacles have a uniformly adverse influence on all elements of climate change and tend to largely disregard the specific nature of such barriers' impacts on different elements. It shows that there are various obstacles to implementing agricultural adaptive strategies that reduce agricultural production. A considerable amount of literature has been published on adaptive strategies. One of the relevant pieces of literature (SDG, 2017) emphasizes that all countries will continue to strengthen resilience and adaptability to climate-related hazards and natural disasters. Concerning this study, farmers practice tunnel farming, seasonal farming, and organic farming as climate change adaptive strategies.

The researcher discusses challenges faced by Nepal, together with adaptive strategies related to agriculture in changing climate conditions. It identified the need for community-based adaptation, institutional support, and promotion of climate-resilient technology for sustainable agricultural output (Paudel & Regmi, 2018). It shows that the involvement of natives in adaptive measures, including indigenous knowledge, is critical to self-management and sustainable environments, in that it ensures the authenticity that solutions can cater to unique conditions.

In this context, drought-resistant crops like maize, millet, and pulses are being adopted by farmers in response to climatic changes. Rainwater harvesting is the cornerstone of adaptive measures in reduced rainfall areas. Agroforestry involves trees and annual crops together to enhance soil quality and reduce erosion. Other changes include changing planting dates, organic fertilizers, and terracing (Kundzewicz et al., 2019; Thapa & Regmi, 2018). This shows that the farmers have adopted drought-tolerant crops, which are suitable according to the weather, and will give a good yield according to the time.

I assert that the impact of climate change on agriculture and restructuring agriculture sector development strategies includes crucial interventions (Pokhrel & Pandey, 2011). The NAPA-Project for Agriculture and Food Security has carried out the identification of adaptive techniques. Adaptation measures those are adapted to the specific needs of the key agricultural subsectors, which will then be integrated into sectorial strategies.

In this regard, Varshney et al. (2011) emphasized the impact of climate change on agriculture, water resources, and human health, suggesting strategies for adaptation, including developing climate-resilient varieties and improving water management practices.

In this context, the farmers have used different types of adaptive strategies. Panday (2012) stated that adaptive strategies have been adopted in the principles and practices of sustainable agricultural technology. The main mechanisms for adapting to the effects of climate change on our agriculture are participatory promotion of local varieties or landraces, ecological pest control approaches, and sustainable soil management promotion technologies. Such actions assist in advancing the idea of food sovereignty, which is crucial in developing countries like Nepal. About my study, changing their adaptive strategies according to time is important. For example, in the past, farmers used off-season cultivation, but now some of the farmers are doing tunnel farming.

This study contributed to adapting because of climate change by evaluating risks to ecosystems, human health, agriculture, and infrastructure, and it pointed out the need for sound measures to combat the rise of extreme weather conditions (Field et al., 2012). It indicates that the adoption of effective measures concerning the increased incidence of extreme weather conditions; thus, pre-emptive steps are essential in responding to the risks of climate change. In this instance, the idea is that the mountainous region of Nepal is more susceptible to climate change than other areas (Gautam et al., 2013). Some of the previous research on climate change in this area has revealed that higher elevations are significantly warming, which would result in less snow and ice cover and a greater frequency of extreme occurrences like landslides and droughts. Their research on South Asian nations, particularly India, Nepal, and Bangladesh, shows how farmers there are adjusting to changing environmental conditions by utilizing established seed systems' traditional seed exchange processes.

Regarding this context, the researcher focuses on the enormous global water crisis and demands immediate attention and adaptation regarding climate change (Famiglietti, 2014). The shocking rates of groundwater depletion are major agricultural regions of the world, resulting from climate change, over-extraction, and ineffective water management. The focus is on improving water conservation strategies and utilizing data for climate change adaptive decision-making.

This situation involved a report analyzing the global impacts of climate change, focusing on adaptation plans, risks, and mitigation efforts in biodiversity, agriculture, and water resources. It focuses on the impact on ecosystems, water availability, and food security (IPCC, 2014). The study revealed that farmers have put in place various measures to confront the effects of climate change as a major problem.

In this regard, the researcher has stated that different adaptive strategies were used, such as the use of high-yielding varieties of crops, enhanced irrigation systems, switching to hybrid seed, and increased access to pesticides (Dhakal et al., 2016). As a result, the yields of major crops, including rice, maize, wheat, sugarcane, potatoes, and pulses, all showed increasing trends from 1999 to 2014. Regarding my study, in the past, farmers used local as well as organic fertilizer, but now they use hybrid seed, chemical fertilizer, and pesticides.

The researcher focuses on the conceptual framework that presents the underlying adaptive strategies to climate change, especially in those most vulnerable areas (Bhandari et al. 2017). The local community is grappling with the growing threat of climate change, which includes unpredictable weather, reduced crop yield, and water scarcity. Adaptive approaches have to be implemented at the grassroots level by considering social, economic, and environmental situations of the affected communities.

Concerning this, adaptive strategies to climate change in agriculture-based economies are highly emphasized by Gopal (2017). It looks at resilience building through the adoption of sustainable practices, better water management, and climate-smart innovations. Local-level strategies should entail capacity-building processes for adaptive and traditional knowledge at the community level.

I uphold the issue of how improving agriculture is necessary to guarantee the food safety of farming communities in many developing countries (Khanal, 2018). The study examines farmers' opinions and choices toward planned and autonomous agricultural climate change adaptations. According to the study, adaptive plays a significant role in explaining differences in farming households' technical efficiency (TE), as well as TE related to farmers' education levels, irrigation facilities, market access, and social capital like farmers' membership in relevant agricultural organizations and clubs. Based on these findings, several suggestions are provided regarding how Nepalese agriculture might be made more resilient to the effects of climate change.

I assert the study analysed Nepal's agricultural adaptive strategies, focusing on climate change, community-based practices, integrating traditional knowledge with modern techniques, resilient crop use, efficient irrigation systems, and agroforestry practices (Chae & Kim, 2020 & Dhungana et al.,2020). It indicates that the farmers have adopted the integrated traditional knowledge while integrating the old knowledge and the latest knowledge.

Adapting to climate change, according to the European Commission (2020), would result in a reduced vulnerability for these sectors: agriculture, water management, and urban planning. Strategies such as promoting green infrastructure, enhancing resilience against disaster, and ensuring climate-proof investments should come into play. The country, regional, and city levels must cooperate in the implementation of the adaptive measures on a mutual basis.

In this situation, the researcher found that the impacts due to climate change both on agriculture and water resources, underlining the requirement of traditional and modern adaptive measures against its temperature rise, rainfall variability, and depleting effects (Gautam & Koirala, 2020; Karki et al., 2020). It indicates that the farmers adopted the traditional and modern adaptive strategies, while such types of methods make the environment friendly and increase crop production, according to climate change.

I support the idea that organic farming is a production system method based on prevention, ecological processes, biodiversity, mechanical processes, pest control, and yield maintenance (Benbrook et al., 2021). It depicts that the farmers adopted organic farming while they utilized the compost manure and homemade pesticides, and healthy crop production.

In this context, the researchers involve the government and other institutions that popularize resilient crop varieties to climate change, precision agriculture practices, and climate-smart technologies, which can be employed in mitigating climate change; at the same time, this increases the resilience of crops (IPCC, 2022). It indicates that the government and non-government organizations provide the agriculture tolerance crops that adjust to the climatic conditions and provide good crop production.

Climate change is a challenging issue in the world as well as in Nepal. Due to climate change, many disasters are occurring in the Panchkhal Municipality. To mitigate climate change, the farmers have used different types of adaptive strategies. For example, off-season farming, tunnel farming, and the use of hybrid seed change their cropping patterns as well as cropping times.

Agricultural Livelihoods

A livelihood is securing the necessities of life, such as food, water, shelter, and clothing. It fulfils the essential activities of daily living that are carried out during a person's life. Such activities may include securing water, food, fodder, medicine, shelter, and clothing. It emphasizes the creation of opportunities that enable rural households to diversify their poverty reduction policies. The climate is gradually changing on Earth from the past to the present, from 2500 BC to 2300 BC (Curtin et al., 1978). For example, in the Sahara, the climate has rapidly changed from a situation in which wheat, millet, and guinea corn could be cultivated into a situation in which only livestock could be kept.

I uphold that the business of flowers is centered in the Kathmandu Valley and some of the urban areas of Nepal (Chhetri, 1999). This localization is mainly due to access to consumer orientation and favourable natural conditions. By and large, the establishment of such industries takes place wherever consumers with sufficient purchasing power live. The existence of most of the hotels, big business houses, and international houses helps to encourage the establishment of these industries in Kathmandu rather than in other places.

In this context, I uphold the view that farmers have adopted various adaptive strategies to mitigate the most severe impacts of climate change (Adge et al. 2005).The process of adapting to climate change results in a decrease in vulnerability and an increase in resilience in response to anticipated climate change and associated changing weather events. People who adapt to the climate depend on the availability of resources for their livelihoods.

A study was conducted to look at the practices of adaptation in the era of climate change involving cattle and crops (Reid et al., 2008). Severe land degradation is a result of human activities such as constructing communities, cultivating incline slopes, obtaining fuel wood, and building other infrastructure. Another issue in the mountainous regions is deforestation, which can result in up to 12,000 more landslides and floods annually.

Considering this the researcher focuses on the commercial vegetable farming has become an important asset of livelihood as it presumably supports food provision, income generation, and employment (Bhatta & Doppler, 2010; Asongwe et.al. 2014). In relation to my study, these days farmers are changing occupations from food crops to cash crops, especially vegetable farming.

They mentioned that mushrooms are the healthiest of the nutrient-rich vegetables. It can be used in everything from puffballs to truffles every day (Kimole, 2012). There are many varieties of fresh, canned, or dried. Beyond the diet, mushrooms feature in some types of traditional medicine. Poultry farming involves raising birds domestically or commercially, primarily for meat and eggs but also for feathers (Garrigus, nd). Chickens, turkeys, ducks, and geese are of primary importance, while guinea fowl and squabs (young pigeons) are chiefly of local interest.

Regarding this matter, I support that Nepal is facing the challenges of climate change due to high levels of poverty and vulnerability, especially in the Himalayan region. Nepal is also considered a high-risk country because it has the lowest greenhouse gas emission rate. In addition to climate adaptive programs such as the National Climate Change Strategy, the National Adaptive Program has introduced regional adaptive programs to manage forest resources (Nightingale, 2011).

The researcher focused on developing countries like Nepal with diverse ecological zones in their vulnerability to climate change impacts in rural and agrarian communities whose livelihoods are attached to natural resources (Shrestha & Paudel, 2020). This shows that the global environment is a diverse ecosystem, in which people depend on natural resources in rural areas. Since their livelihood depends on agriculture, climate change will have a huge impact.

The study explores climate change impacts on rural Nepalese communities, focusing on adaptive strategies to mitigate adverse effects on agriculture, hydrological resources, and livelihoods, thereby enhancing resilience (Regmi & Poudel, 2019 & 2021). This has shown that due to climate change, the water resources are drying up, and farmers have utilized other alternative adaptive strategies in mitigating the impact of climate change.

In summary, climate change awareness among farmers is important for resilience in times of crisis. Integrating climate change education into livelihood diversification allows farmers to explore alternative income sources and sustainable agricultural practices. The farmer should be adapted to local knowledge, socio-economic background, and environmental considerations. Sustaining livelihood diversification requires sustained support, sound policies, and active participation of various stakeholders. Promoting diversified livelihoods through climate change education improves the capacity of farmers to combat the challenges of climate change and secure future livelihoods.

Livelihood Diversification

Livelihood diversification includes a range of activities such as agriculture, livestock, fishing, artisanal production, small-scale industry, trade, and services such as tourism and transport. By engaging in multiple activities, households and communities can spread risk and improve resilience to external shocks such as droughts, floods, and market volatility.

Diversification of livelihoods also brings additional benefits, such as increasing household income, creating employment opportunities, and promoting local economic development. However, it requires access to resources such as land, capital, skills, and markets, as well as supportive policies and institutions that enable entrepreneurship and innovation (Ellis, 2000). The process of livelihood diversification is defined as a process in which rural households construct highly varied collections of farm and/or nonfarm activities over time to save their lives and improve their standards of living.

The researcher emphasizes the need for further research on local development and livelihood in development geography. In this situation, agricultural diversification tendencies are different in developed and developing countries (Barbieri & Mahoney, 2009). Farmers, even in developed countries, diversify not only for risk mitigation but also for better financial returns. About my study, the farmers have done agriculture diversification in poultry farming, vegetable farming, and paddy farming for profit motives.

In this scenario, livelihood diversification, demonstrated by shifting activities away from expected farming to other sectors, offers flexibility and well-being to livelihoods by widening the existence of options. The present trends in poverty incidence consistently illustrate the promise of this transition. A nationally representative survey shows a decrease in poverty prevalence from 42 percent to 25 percent between 1995–96 and 2009–10 (CBS, 1996; 2011). It shows that the farmers shifted the occupation of agriculture from a traditional occupation to a modern occupation for the mitigation of climate change and the increase of crop production.

In this context, the farmers adopted alternative crops, hybrid livestock, dairy farming, and micro-credit services (Upadhyay, 2019). They also updated their traditional agricultural methods to include crop variety cultivation on the calendar and agricultural diversification.

Climate Change Education

Climate change education for farmers is important for expanding income sources and agricultural practices, increasing flexibility to climate change impacts. Integrating climate change education into livelihood diversification encourages farmers to explore alternatives, promote adaptive and sustainable practices. Effective education must consider local socio-economic conditions and environmental nuances. Farmers have adopted the strategy of livelihood diversification. They have made good profits from diversifying their livelihood. Some of the farmers have done animal husbandry, poultry farming, vegetable farming, and paddy farming. Due to diversification of livelihood, farmers feel safe from loss in their profession.

Education plays an important role in understanding climate action. It helps people understand and address the impacts of the climate disaster, empowering them with the knowledge, skills, values, and attitudes needed to act as agents of change.

The SDGs (2017) emphasize education, awareness-raising, and the improvement of human and institutional capacity for climate change mitigation, adaptation, impact mitigation, and warning. One of the related works, such as Nelson et al. (1975), asserts that the report states that agricultural employees in developing countries are reportedly receiving very little education. In contrast to traditional agriculture, it greatly increases production in a modern context.

Education is found to have a higher payoff for productivity in a modernizing environment than in traditional agriculture. Higher education is important in a modernizing atmosphere, but not in a traditional setting. Agricultural productivity is positively impacted by both the worker and allocation impacts of education, although in both settings, the allocation effect is greater than the worker effect. In traditional areas, only the input-allocation component of the allocation effect matters, whereas on a modern farm, both the input-allocation and input-selection components are essential.

In this context, education can equip the person with the ability to understand and appreciate issues such as climate change and its associated risks so that he knows how to act on the problems. Climate change education should be integrated into all subjects in primary and secondary schools so that people can understand how the issue relates to them.

In this situation, the current study identifies education as one of the meaningful approaches to be implemented in building climate change awareness. It calls for the introduction of climate science, sustainable practices, and environmental ethics at all levels of education, from primary to higher education, to create adaptive capacity (UNESCO, 2006). It shows that education plays a significant role in selecting adaptive strategies, but it also helps to adapt strategies according to climate change.

In the same way, many studies have provided evidence that educational instruments enhance the knowledge of climate change and its consequences (Adams, 2009). Being educated allows recognize the factors and impacts of global warming, which enables them to adapt their daily practices and habits. Through the addition of climate change education into the school curriculum, people can comprehend more about climate change and its significance in their lives.

Similarly, the researcher involved the training of the farmers and adaptation to climate change by local leaders, as in the integration of traditional knowledge with scientific information through NGOs and government training programs (Shrestha et al., 2015). The government and NGOs are providing farmers with continuous training to help them adapt to strategies over time.

The researcher Shackleton et al. (2015) focuses that the climate change education and adaptation to socio-economic change are affected by several factors at multiple scales. That can act individually or together to obstacles the planning, implementation, or effectiveness of adaptive strategies. Similarly, agriculture provides nearly one-third of the national GDP and two-thirds of national employment (Thakuri, 2017).

The adaptive strategies of the respondent farmers are very much related to the educational background and indigenized knowledge. In most aspects, those farmers who have more awareness about climate risks and adaptive options responded effectively (Sujakhu et al., 2018). This depicts the fact that agriculture is the backbone of the national economy and that most farmers depend on it.

In this context, the researcher focuses on the connection between education and climate change adaptive strategies, highlighting how education enhances a community's ability to adapt to environmental changes (Adhikari & Shrestha, 2019). It shows that education, both formal and informal, is crucial for fostering climate resilience by fostering critical thinking skills and promoting innovative adaptive measures.

Kavre district is one of the primary vegetable-producing regions, playing a particularly significant role in potato cultivation alongside other vegetable crops. Research indicates that commercial vegetable farmers in this region are excessively and indiscriminately using pesticides and chemical fertilizers. The history of pesticide overuse in specific areas of the Kavre district has harmed the market price of vegetables produced and on consumer perception (Neupane, 2019). It depicts that the farmers used chemical fertilizers and pesticides for maximum agricultural production of agriculture, while this type of production is harmful and injurious to health. In this situation curriculum needs to be revised to implement climate education at all levels of the current education system. Incorporating climate education into the education system should empower youth to address climate change and other socio-economic crises. Education emphasized the importance of promoting optimism and adaptability to climate change, assessing the challenges faced by women and children, and the relationship between heavy rains and climate change (Shreya, 2022). It shows that education provides knowledge about climate change, which helps to mitigate the impact of climate change.

In this situation, the researcher emphasizes the need for climate change education, examining global customs, efforts, and sources. It aims to raise public awareness and encourage government efforts to teach young people about climate resilience.

In this way, climate change is a direct threat to humanity, with human activities weakening ecosystems. Countries must meet commitments, mitigate impacts, and build resilient societies. Developing countries, like Nepal, are particularly vulnerable. The Nepali government has added climate change education to school curricula (Samson, 2023). It shows that most of the countries applied different adaptive strategies to mitigate the impact of climate change. The Government of Nepal added new subject matter in order to mitigate climate change according to the climatic condition.

Climate Change Education (CCE) is crucial for farmers in the Panchkhal area to adapt to changing climate conditions and promote sustainable agricultural practices. By combining science and local knowledge, CCE enables farmers to effectively identify, mitigate, and adapt to climate-related challenges. Success depends on community engagement, continuous learning, policy support, and partnerships between academic institutions, local governments, and agricultural experts. CCE promotes farmer resilience and enables farmers to cope with evolving climate change.

Policy Implementation for Climate Change Education

Climate change education policy plays the leading role in providing farmers with the means for mitigating and adapting to the challenges brought about by the changing weather. The dominant parameters in the Panchkhal agricultural core area are influenced by changing environmental patterns and the effectiveness of adaptive measures.

The researchers have suggested that integrated water resource management is able to incorporate climate variability, effective policy, and community engagement in view of managing water resources on sustainable grounds, taking into consideration the development of infrastructure, irrigation efficiency, as well as distribution of resources in an equitable manner.

In this regard, among the majority of nations, Nepal also joined and signed the United Nations Framework Convention on Climate Change more than ten years ago to start mitigating global warming and employ adaptive techniques with whatever temperature increases are unavoidable. UNFCCC (2006), a recent modification to the pact known as the Kyoto Protocol, has just received approval from several countries. The average surface temperature of the Earth has risen by around 1.1°C since the late 19th century, according to the UNFCCC, primarily as a result of an increase in atmospheric emissions of carbon dioxide and other greenhouse gases.

In this situation, Government of Nepal, Ministry of Environment (2011&2019), emphasises the aims to climate change impacts through the process of adaptation, besides low-carbon socio-economic development. It focuses on the reduction of GHG emission, along with structural enhancement for resilience in their structure and capacity building of vulnerable communities by using clean energy, sustainable agriculture, and efficient utilization of water resources.

In this context, I undertake the National Adaptive Plan (2021-2050), adaptive to the adverse impacts of climate change, and it is the priority for Nepal. The National Adaptive Plan (NAP) sets out a framework to integrate adaptation across sectors and levels of government. The plan set out short-term priority actions to 2025, as well as medium-term priority programs to 2030 and a long–term strategic goal to 2050 that aims to assist Nepal to better integrate actions and strategies to address climate risk and vulnerability in development planning and implementation. The short-term and medium-term actions are designed to help the government of Nepal achieve the adaptive actions set out in its 2020 Nationally Determined Contribution (NDC). Strategies to adapt the country to the impacts of climate change in the short-term (up to 2025), medium-term (up to 2030), and long-term (up to 2050) have been formulated and gradually implemented.

In this context, the importance of local adaptive strategies to the regional impacts of climate change emphasizes the necessity of adaptive measures and early warning systems. They also emphasized the need for international cooperation and policy frameworks to support regional adaptive efforts and reduce climate change risks (Diffenbaugh & Field, 2013).

In this situation, the UN (United Nations) insisted on the need for the integration of global climate adaptive strategies into national policies and strengthening them for the attainment of sustainable development goals (UN, 2017). It indicates that the UN urges national policies for national policy integration by the implementation of international climate adaptive practices. Integration strategies at the national level would reach the SDGs and help to build resilience to ensure environmental sustainability and socio-economic development in the long term.

The capacity of LAPA to combine scientific approaches with traditional knowledge is one of its main achievements in Nepal. Tiwari et al. (2018) note that LAPA projects in Panchkhal train farmers to integrate traditional water conservation techniques with modern irrigation systems, promoting sustainable land and water management, and adapting to climate shocks.

Education allows the focus to enable the use of new technologies, sustainable methods of agriculture, water management, and disaster preparedness. As confirmed by Adhikari et al. (2021). The educated farmers adopt climate-resilient systems, early warning systems, and participate in community-based adaptive initiatives, enhancing their participation in policy advocacy for proactive climate responses.

SDG 4 aims to provide universal primary and secondary education to all children, regardless of gender, economic background, or geographic location. It aims at ensuring equal access to affordable and quality technical, vocational, and higher education, building and upgrading education facilities that is child, disability, and gender sensitive; it also provides more scholarships for information and communication technology, increases the number of qualified teachers-in particular in rural and disadvantaged areas-and ensures a supply by improving teachers' training.

Thus, climate change education policy should focus on community engagement, capacity building, and integration of existing agricultural practices with local strategies for farmers in the Panchkhal area. Long-term sustainability is important, and educational interventions must have measurable outcomes to measure their effectiveness. Partnerships between academic institutions, local authorities, NGOs, and agricultural experts can improve the quality of climate change education efforts. Policy should strengthen farmers' resilience, continuously improve based on feedback and research, and empower them to take proactive steps to adapt to climate change, ultimately improving their livelihoods and ensuring sustainability.

Integrating Climate Change Education (CCE)

Climate change is responsible for the irregularity in the pattern of rainfall, increasing cases of drought, a rise and landslides and floods. This is crucial for incorporating climate change into education and adaptive strategies. Climate change education in Panchkhal involves integrating climate change into school curricula, conducting community awareness programs, and promoting climate literacy. Schools educate students about the causes and effects of climate change, including the rise in temperature and changes in rainfall patterns. Community workshops and training sessions can help farmers adapt their farming practices. Collaboration between schools, local government bodies, and NGOs can raise awareness about sustainable farming, water management, and disaster preparedness.

Geographers, as experts in understanding earth dynamics, must integrate CCE effortlessly. This mixing not only increases the depth of research, but also contributes significantly to the understanding of the diverse effects of climate change on different geologic phenomena.

I espouse climate change as a major social science problem, mainly caused by human activities. Climate Change Education (CCE) has been introduced in countries like the USA, UK, and Germany. However, research on CCE in Korea is limited. This study analyses Korean and international CCE programs from the perspective of structure, content, characteristics, and comparison, to develop CCE programs in the future (Park et al., 2020)

In the same way, the study explores the relationship between environmental education and school geography in Lesotho, focusing on curriculum reforms initiated from 2001 to 2004 by the Lesotho Environmental Education Support Project (LEESP). It reveals synergy between LEESP policies and national education ideals, but also highlights problems (Raselimo, 2012).

The study examines climate change education in Swaziland's secondary school geography curriculum, revealing gaps and misconceptions among students and teachers. Teachers struggle with integration due to inadequate training, resources, and an overcrowded curriculum, requiring continuous learning (Dlamini, 2016).

I uphold this paper examining the integration of climate change content into the geography curriculum of Namibian schools. Based on the interviews with the teachers, it was found that the theme of 'climate change' was not fully integrated. Teachers face challenges in incorporating climate change content due to a lack of content knowledge, professional development support, and educational resources. The paper recommends greater consideration of climate change concepts and teacher professional development to mitigate the effects of climate change in Namibia (Tshiningayamwe, 2018).

I assure the industrial age brought rise in living standards and pollution of the environment, which in turn led to climate change. Developing countries are vulnerable and need to achieve the Millennium Development Goals while reducing carbon dependence and promoting climate resilience. We need development of green technology, government policy, education, and public awareness. By making small lifestyle changes, you can reduce greenhouse gas emissions and ensure a minimal quality of life.

Theoretical Perspectives

In this section, some related theories have been reviewed to prepare the concept for the research. In my study, the purpose of this work is to examine the quantity of theory accumulated about an issue, concept, and phenomenon. Theoretical perspectives such as place theory, spatial theory, and development theory can serve as a guide to educate farmers about climate change. Location theory explains how geographic location affects economic activity and decision-making, and helps farmers choose appropriate crops and livestock based on climatic conditions. Furthermore, Location theory analyses the spatial distribution of climate-related risks in Nepal and how spatial and spatial relationships influence behaviour and interaction. Similarly, Development theory focuses on social, economic, and psychological development and serves as a guide for creating educational programs tailored to the different stages of adaptation of farmers to climate change. These perspectives complement the development of comprehensive adaptive strategies for farmers of Panchkhal Municipality. The relevant theories used in this research are mentioned below:

Location Theory

Economic geography and regional economics frequently examine location theory. This highlights the significance of location. Its roots are in classical economics, and it is applied in German classical location theory. Location has a significant impact on economic activity, according to economists.

The heavier and perishable commodities would be produced close to the town, while lighter and more resilient goods may be produced outside the municipality (Thunen, 1810). The returns to the land in the outlying areas would decrease until, at a certain distance, land rent would become zero since it would be more expensive to deliver commodities to locations far from the city centre. The methods of cultivation, however, would be different, with land being farmed more intensively because the more valuable area would require a high rate of return. In the context of my study, location has not had a major impact on agricultural production because it is an urban area adjacent to Kathmandu Valley, but location has had some impact on agricultural production.

Agricultural place theory is how farmers allocate land for different uses and how that land is managed locally (Kellerman, 1989). Ricardo's theory of rent production emphasized the physical characteristics of land and urban demand as key factors. The theory describes the land as being divided into different purposes, such as poultry farming, crop production, and livestock farming for good profit.

A considerable amount of theory has been published on location theory. These studies analyse the rural development of the population and find that rapid urbanization puts enormous pressure on food supplies (Han et al., 2022). The Von Thünen model outlines the rural landscape of commercial farmers growing produce for the local market and proposes basic patterns and principles of agricultural land use. Thünen's theory was used to analyse agricultural locations and cultivation decisions at the two levels of local capitals and urban areas. Plant density was found to decrease gradually with distance from the city. Agricultural politicians should focus on the Von Thünen model for using land to optimize agricultural production.

I supported the idea that the central-place theory describes the primary purpose of a settlement or market town (Christaller, 1933). The towns that are centrally located and provide more goods and services than other places are called higher-order central places. Lower-order central places have small market areas and provide goods and services that are purchased more frequently than higher-order goods and services. Higher-order places are more widely distributed and fewer in number than lower-order places, and to analyse land use types and rent patterns, or bid rent curves. The maximum amount of rent any land use type will yield for a specific location (Alonso, 1964). Households, commercial establishments/industries compete for locations according to individual bid rent curves and their needs for access to the city centre. Outside of the city, the land is cheap, and poor families live there, while in the centre, the land is expensive, and rich families live there. Poorer households need greater access to the city centre and will therefore locate closer to the centre in competition with commercial and industrial establishments.

The location theory is applied to the study of the impact of climatic change on the use of agricultural land. It can find farmers' response toward changes in crop yield, land allocation, and relocation of crops for better reallocation of resources and practices both at the urban centre and markets (Von Thünen, 1826).

The research focuses on how climate change impacts urban growth, land use, demand, real estate values, and industries, which in turn affect economic activities due to higher temperatures and flooding (Alonso, 1964).

This would tend to create a segregated land use system, as households would not pay the price of commercial or industrial land for central locations.
Place theory focuses on place theory, which plays an important role in agricultural activities. The core area of a farmer's production produces perishable agricultural commodities such as vegetables, and the semi-periphery, while the peripheral area of a farmer's production produces non-perishable commodities such as potatoes.

Research Gap

Several studies have been conducted separately on the impact of climate change on agriculture and livelihood coping strategies. Research was conducted on climate change and education, climate change and livelihoods, and climate change and coping strategies, but the literature review did not find Climate Change education and adaptive strategies in agriculture. On the other hand, researcher also shows how climate has affected agriculture, where the metropolis has recently moved from rural to urban. Several research papers related to climate change from this municipality have been published. However, even now, research on Climate Change Education and climate change adaptive strategies has not been carried out simultaneously in this urban area, so this study is a new type and different from other studies. The dynamic nature of climate change, education on climate change, and the use of coping strategies provide excellent opportunities for this research in Panchkhal Municipality. The research is guided by the following conceptual framework.

Conceptual Framework of the Study

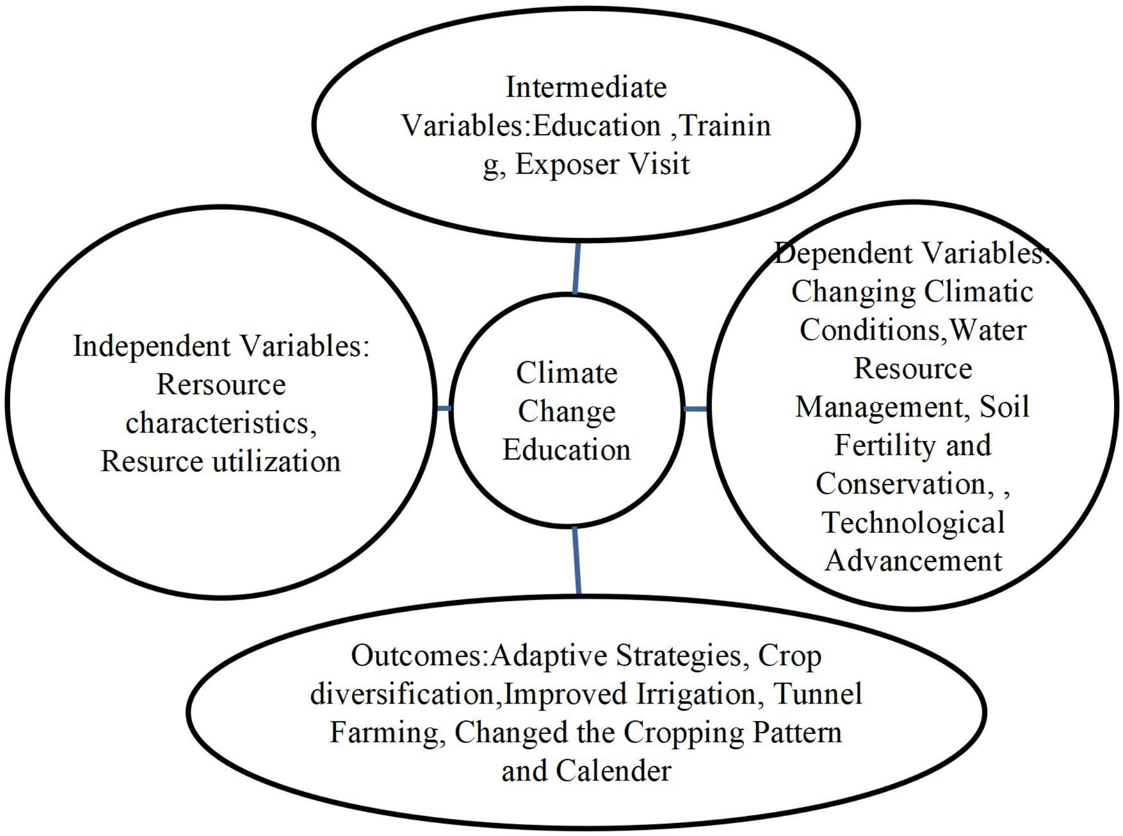
This study has developed a conceptual framework considering all factors related to climate change education for the adaptive strategies of farmers in Panchkhal Municipality. The framework paves a road map for the proposed research paradigm, method of data collection, and research issues in this study.

The severe impact of climate change affected the adaptive strategies of the farmers in Panchkhal Municipality, where agriculture is a major source of livelihood. In addition, they are also involved in agricultural entrepreneurship, labor markets, the nonfarm economy, and labour migration to supplement their incomes.

Conceptual Framework

Figure 1

Conceptual Framework of the Study



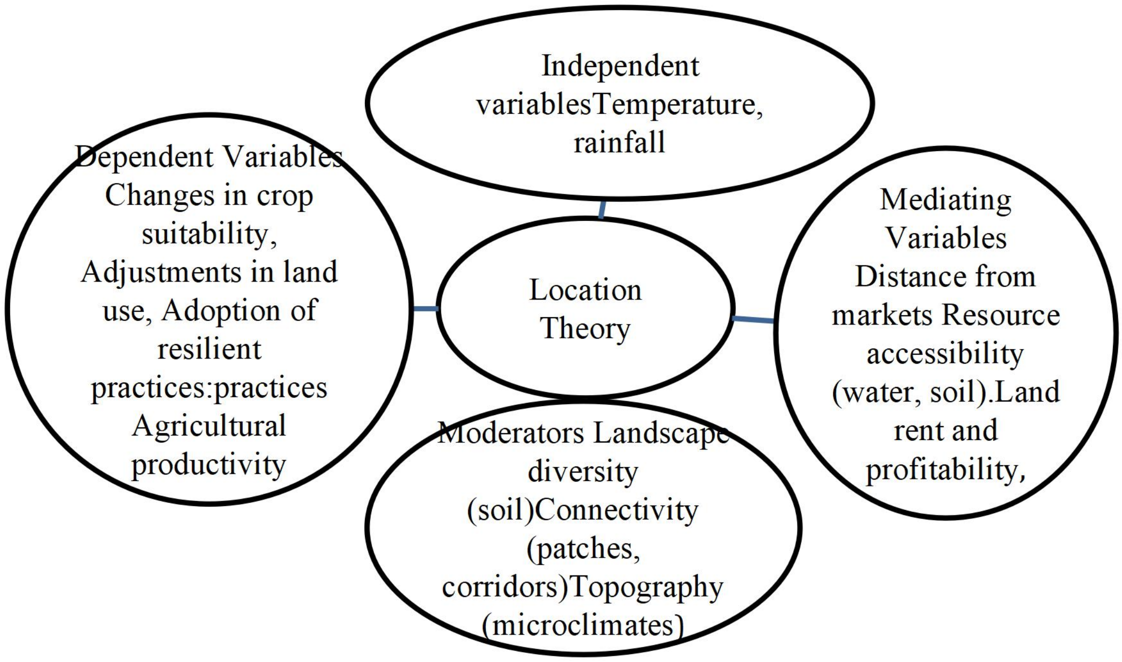
Considering all the factors, the conceptual framework for the study has been presented in Figure 1 as well. The figure has been considered a road map for the study. The framework tried to represent a picture of the research of independent variables, intermediate variables, dependent variables, and the outcome of the research.

Theoretical Framework

The theoretical framework of location theory is used to examine how climate change education can enhance the adaptation strategies of farmers in Panchkhal Municipality, offering a comprehensive understanding of the spatial and ecological factors that influence agricultural practices and the implementation of climate adaptation measures. By linking existing theories to the research problem, the framework establishes a foundation for understanding the key concepts, relationships, and mechanisms underlying the study, guiding its analysis and interpretation.

Figure 2

Theoretical Framework of the Study



CHAPTER III

RESEARCH METHODOLOGY

This chapter attempts to use the research methodology by focusing on triangulated quantitative and qualitative data of the Panchkhal Municipality. It gives detailed information about the selection of Field Survey methods, the use of study tools, and data collection and analysis procedures. In other words, the practice of using multiple sources of information or data from different methods, as well as perspectives, was used to gain a comprehensive and reliable understanding of the climate-related challenges and potentially adaptive strategies in that study area. In the study area, the mixed method involves integrating data from different sources to ensure a comprehensive and accurate assessment of local climate change impacts, with educational needs for effective implementation of researched measures. In addition, the validity and reliability of the study instruments are also discussed.

Research Paradigm

In my study, the research is based on the pragmatic paradigm and combines qualitative and quantitative approaches in different stages of the research process (Tashakkori& Teddlie, 2008). In my study, mixed methods of research to educate farmers on climate change and its adaptive strategies in Panchkhal Municipality consider the ontology pragmatism and pragmatic epistemology. The ontology and epistemology are described more explicitly as follows:

Ontology

Panchkhal Municipality has been focusing on enhancing farmers' adaptability to climate change through sustainable farming practices and risk management. The research explores education, media, technology, cultural dimensions, and community-based approaches in farming, focusing on local knowledge, practices, as well as collective action through farmer groups, cooperatives, and local government at the tiers of government. The interaction has empowered farmers in Panchkhal Municipality to tackle the challenges of climate change, focusing on empowering them to experiment with chemical fertilizers and pesticides in their agricultural practices. It also focuses on the empowerment of the farmers, enabling the experimentation of sustainable chemical fertilizers and pesticides in terms of agricultural practices in Panchkhal Municipality itself. As climate change and its consequences contribute to the sizable downtick of organic farming and insufficient production, farmers use large amounts of chemical fertilizers, pesticides to increase production. Such a type of scant production makes it difficult to sell the products produced. In exchange for the loss, farmers are habituated to using an escalated amount of chemicals. Therefore, use organic fertilizers and pesticides for better agricultural production.

Epistemology

The study explores climate change education among Panchkhal Municipality farmers, examining their understanding and application of knowledge sources, including formal education, experiential learning, and indigenous knowledge. This study investigates farmers' perceptions of climate change in crop selection with respect to rainfall, slope structure, water management, and different layers of knowledge and understanding.

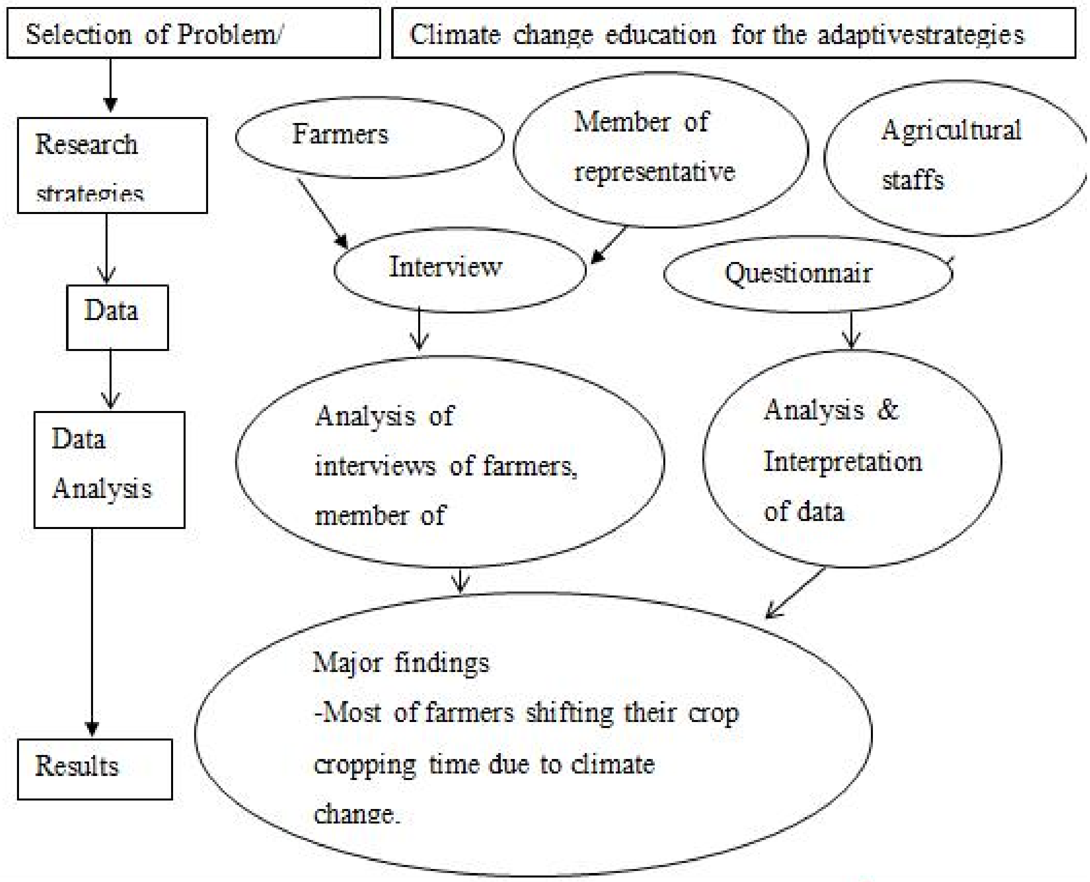
In simple words, there are two types of knowledge in the study area of farmers. Some farmers have received agricultural training, and some have not. Trained farmers adapt to climate change by adopting new methods and processes, while relatively untrained farmers continue to use traditional methods. Trained farmers cultivate by adopting new methods and processes according to climate change, while relatively untrained farmers cultivate by adopting traditional methods. The knowledge of those farmers has been drawn out through survey questionnaires, interviews, and FGD. The farmers acquired knowledge of climate change through different sources, such as radio and TV, newspapers, the internet, and related experts. They used different types of strategies to adapt to climate change. In the past, they planted traditional crops, but due to climate change, traditional agriculture is going to decrease, and these days, they have adopted alternative agriculture crop production, with the majority of farmers shifting from food crop to cash crop production for an increase in profit.

Research Design

In my research, I have used the concurrent research design. In this design, I included the simultaneous collection of quantitative and qualitative data. The two types of data are compared during data analysis to provide a comprehensive understanding (see Figure 3).

Figure 3

Research Framework



This study used a concurrent mixed-methods approach involving both quantitative and qualitative methods. In other words, concurrent mixed methods involve the simultaneous collection and analysis of both quantitative and qualitative data. The fieldwork elicited mostly quantitative data and simultaneously garnered qualitative information through key informants' interviews. This section describes the various methods and tools used in the study; Specific research methods are also described in chapters 4, 5, and 6 to describe specific analytical tools, models, and methods.

Participants' identities have been kept confidential by using pseudonyms. All English-language materials, including the questionnaire, key informants' interviews, and focus group discussion guidelines, were translated into Nepali. The consent from the participants has been obtained verbally for audio recording and photography during interviews, focus group discussions, and household surveys. The researcher has used a mixed-methods approach because the study deals with knowledge, perception, and agricultural adaptive strategies of the farmers that require data validation and triangulation. Triangulation of data and methods was performed not only to validate the results but more importantly to deeper understanding and justify the problem/knowledge. In contemporary social sciences, triangulation is understood less as confirmation than as a strategy for deepening understanding and justifying knowledge in qualitative research (Flick, 2004).

The specific data validation/triangulation acquired through the different data is described in further detail in Chapter 4 about the socio-economic status of the farmers. In addition, Chapter 4 also triangulates methods for assessing the socio-economic status of the farmers using interviews for qualitative information and quantitative analysis. Similarly, in Chapter 5, the information of climate change and adaptation strategies of the farmers is assessed through the household survey, meteorological data, and key informants' interviews by using descriptive and linear regression analysis statistical tools. Likewise, Chapter 6 analyses the role of education in the mitigation of climate change by using descriptive statistical tools.

Creswell and Plano Clark (2011) define mixed methods research as a research design with a clear set of hypotheses and research methods. As a methodology, it includes a philosophical orientation to the collection and analysis of information, while methodologically; it is the collection and analysis of quantitative data and qualitative information for a research study.

A mixed methods approach provides a better understanding of the research problem than a single approach. There are advantages and disadvantages of using mixed methods. A positive aspect is that it increases credibility and validity of the research from both perspectives (Creswell & Plano Clark, 2011; Newman, 2004). Qualitative research follows an inductive approach based on small sample sizes, which may make larger populations impractical. However, it goes deeper into analysing cause and effect relationships between variables and provides answers as to why things happen.

In contrast to the latter, quantitative research can reveal interrelationships between variables but does not provide micro-level context. As a result, mixed approaches are increasingly common in the social sciences (Creswell & Plano Clark, 2011). The negative aspect of a mixed methods approach is that it requires skills in both qualitative and quantitative methods, and requires more resources and time than local approaches.

A concurrent research design was used to collect quantitative data, the fieldwork and qualitative information simultaneously. In addition, quantitative and qualitative analyses were performed simultaneously, and the findings were mixed during discussion and interpretation. The data to be collected during each visit quantitative and qualitative data were collected.

Selection of Study Area

Panchkhal Municipality is located in the proximity of the Kathmandu Valley. This is an agricultural city that produces crops, especially vegetables, and supplies them mostly to the vegetables in the Kathmandu Valley. The reasons for choosing this municipality for research are as follows:

Unique Geographical Environment

Local relevance ought to be prioritized to address challenges and opportunities arising from factors such as hilly terrain, elevation change, and rainfall. In other words, recognizing the geographical diversity, there are various effects of climate change on agriculture, water resources, and biological diversity of this region. Local farmers and stakeholders need to be involved in identifying adaptive needs in line with community priorities. Ultimately, an interdisciplinary and sustainability-focused approach that considers long-term impacts will ensure a comprehensive and community-focused research approach.

Rapid Change in Agricultural Activities

In Panchkhal Municipality, there is a rapid change in agricultural activities according to time. Around 2035 years ago, the farmers used to focus on cultivating food crops. However, vegetables are now prioritized as a cash crop, and efforts are underway to meet the needs of residents living in Kathmandu Valley. Thus, this place has been chosen to study the rapid change in cash crops in this place.

Agricultural Super Zone

Panchkhal Municipality is a super zone area under the Prime Minister's Modernization Project for potato cultivation. Potatoes are produced more than other vegetables in this area. Therefore, the objective is to understand the contribution of potato production to both the local area and the Kathmandu Valley. To investigate what techniques are used for potato production? Similarly, to find out what the contribution of the super zone area is to the activities of the local economy? Likewise, the study addresses aspects of sustainability to investigate how resource management, soil fertility, pest control, and environmental impacts are managed by farmers to sustain consistently high potato yields.

Access to Road and Market

Araniko highway is a major highway with road transportation facilities, where road infrastructure has been developed by dividing the Panchkhal Municipality. In the same way, there are supporting roads connecting the Araniko highway. This road has helped to bring the agricultural products to the market and helped the people to go back and forth. This infrastructure connects municipalities with essential services and facilitates the transportation of agricultural products. Market access includes access to local markets and large commercial centers in the Kathmandu Valley, availability of goods, and economic opportunities for residents. Efficient transportation to these markets is critical to the success of agricultural activities and the overall well-being of the community.

Location of Horticulture Center

There is also a horticulture center for agricultural research in this municipality. I have also chosen this location to investigate how climate change is affecting this horticultural center.

Profession

I taught in the area for around 11 years. This is an agricultural green city municipality. There is a lot of potato production in this area. But there was a problem with the use of chemical fertilizers, pesticides/insecticides. So, I have chosen this area to understand the reality.

Field Observation

I went to this municipality in 2017 before choosing the research area. After that, I observed the area of subject matter and wanted to research whether it could be found or not. During this time, I had a separate discussion with some farmers, municipal officials, teachers, and municipal agricultural officers about the impact of climate change and the adaptive strategies adopted by the farmers and the efforts made to mitigate it. If the subjects, according to the purpose of the research, were found, then I chose this municipality for research.

Vulnerability of Climate Change

Panchkhal Municipality is at risk of the effects of climate change. Changes in temperature, rainfall patterns, and extreme weather events can have significant impacts on agriculture, which is the primary source of livelihood for many residents.

Dependence on Agriculture

Agriculture plays an important role in the economy and food security of Panchkhal Municipality. It was chosen to find out how climate change has affected local agriculture and what adaptive strategies have been identified.

Local Impacts

Research at the municipal level guides local policymakers, farmers, and communities to identify how climate change has changed their agricultural sector. It provides solutions for appropriate solutions to address the specific challenges faced by Panchkhal farmers.

Adaptive Strategies

The study of adaptive strategies for agriculture provides knowledge to develop practical and effective solutions to help farmers mitigate the negative effects of climate change. The farmers included crop diversification, improved irrigation techniques, tunnel farming, off-season organic farming, and the use of climate-resilient crop varieties.

Global Relevance

Lessons learned from climate change impacts like Panchkhal municipality can have wider implications for other areas facing similar climate challenges. Sharing knowledge and best practices can contribute to global efforts to address the impacts of climate change on agriculture.

Nature of Data

In this research, a mixed research method, including both quantitative and qualitative data, has been collected and analysed. The central premise of mixed-methods research is that the use of quantitative and qualitative approaches in combination provides a better solution to research problems. Quantitative and qualitative inquiry is philosophical assumptions; it explains the inquiry strategy, questionnaire construction, data collection methods, analysis, and data interpretation.

Population and Sampling Procedure

In my study, the researcher has used a multi-stage sampling method to determine the sample population and sample size (Burton, 2007; Best & Khan, 2004; Teddlie & Yu, 2007). During the sampling period of quantitative research, the researcher applied multi-stage and purposive sampling methods for determining the sample population and sample size, as mentioned in Table 1 (Burton, 2007). The total population of Panchkhal is 39,788, with 9,681 households (CBS, 2068). In the first stage, I selected Panchkhal Municipality through the purposive sampling method. In the second stage, I selected the entire 13 wards of the municipality and then, according to the agricultural experts of the municipality, 672 households were selected out of the total households that had agriculture as their primary occupation as a commercial and were engaged for more than five years. After that, it was generated using the sample size determination formula (Krejci and Morgan, 1970) with a 95 percent confidence level and a 5 percent margin of error, and 568 sample numbers (respondents) were selected randomly from 13 wards of the municipality in the third stage. The sample respondents were again categorized into three strata: core (N=242), semi-periphery (N=235), and periphery (N=91) wards based on spatial location. The core wards are located within a 5 Km area from the administrative center of the municipality. The semi-periphery wards are located 6-10 km from the administrative center, and the periphery wards are located above 10 km from the administrative center (see Table 1).

Table 1

Sample Households (HHs) Selection by Wards

Wards	Total (HHs)	Sample HHs	Sample HHs	Percentage
1	856	46	44	7.7
2	877	52	44	7.7
3	578	76	63	11.1
4	723	79	63	11.1
5	599	34	28	5.0
6	1110	77	63	11.1
7	773	54	44	7.7
8	708	33	28	5.0
9	779	48	44	7.7
10	487	33	28	5.0
11	681	34	28	5.0
12	1014	72	63	11.1
13	496	34	28	5.0
Total	9861	672	568	100.0

Source: CBS, 2068

Finally (Table 1) ward-wise sample numbers (568) were selected for collecting primary data, which is generated with a 95 percent confidence level and 5 percent marginal error by using a sample size.

Sources of Data

In my study, the researcher has used both primary and secondary data sources. The primary data were collected from field observations, questionnaires, interviews, FGD and KII and secondary data were collected through meteorological data and CBS data.

Primary Data

In this study, the researcher used field observation, questionnaire surveys, personal interviews, FGD, and KII to collect primary data. For this purpose, questionnaire forms, and guidelines for FGD and KII were prepared (Appendices A, B, and C). A fifteen days pilot-testing survey for questionnaires and checklists was organized before the field survey with 57 respondents in 2020.

The questionnaire is divided into four subsections related to socio-economic conditions, climate change variables, agricultural development, and adaptive strategies. The researcher used interview guidelines as well as key informant interview and focus group discussion (FGD) techniques and questionnaires as data collection tools. The guideline was relevant to the research question. These guidelines were used to elicit the opinions of protocol participants.

Starting the Fieldwork. The fieldwork was carried out over a period of six months (February–October 2020), emphasizing rapport building, household surveys, key informant interviews, and focus group discussions. Initially, I contacted the mayor and deputy mayor of Panchkhal Municipality, and they gave me permission for the research. After that, I contacted the agricultural officer of the municipality and provided the list and contact numbers of all the agricultural groups in the ward. Then I met the ward president of Ward No. 2, and he coordinated with all the agricultural groups of Ward No. 2. This helped me collect the household questionnaire. I spent a lot of time at the village tea shop, the diary collection center, where I had the opportunity to meet and interact with many people. Some of the people doubted and even asked if I was an NGO worker. At that time, I used to clear the doubts by showing and reading the letter from the Dean's office. They were surprised to learn about my PhD candidacy, and some even questioned, “Can someone be a student at your age?” As a result, ward presidents, members, teachers, and members of the agricultural group went to the research area many times to establish relationships and become familiar.

Quantitative Data

Quantitative data collection methods were employed in the study through a survey carried out among the households using a systematic approach to ensure the accuracy, reliability, and representativeness of the data collected. This was achieved by formulating a questionnaire that was well prepared to collect data from the households on the demographic factors, farming practices, perception of climate change, and adaptation strategies. Before the actual process of data collection, the questionnaire was pre-tested among a few households to improve the questionnaire and eliminate any potential biases. After formulating the questionnaire, the next step in the process of quantitative data collection was to select the households using a random sampling method to ensure the selection of diverse socio-economic groups. During the process of data collection, face-to-face interviews were conducted with the households where the researcher would explain and collect the data accurately using a standardized approach. Quantitative data was collected through the household survey using the following process:

Household Survey

The researcher used questionnaires as the main instrument for data collection in Panchkhal Municipality, Nepal. Thirteen wards were used in household surveys, with farmers selected on a random basis and questions posed in simple Nepali lnguage. The closed-ended questionnaire, once designed and pre-tested, comprised four parts: socio-demographic status, perception about climate change, priorities in input, and adaptation strategies.-Actually, the questionnaire has unique advantages, and properly constructed and administered, it may serve as the most appropriate and useful data-gathering device in a research project (Best & Kahn, 1999). A survey is a key tool for collecting data for quantitative methods, especially numerical data, and finding out its reliability and validity. Each survey questionnaire took 30–45 minutes and often included either household heads or actively engaged members; were included whenever possible. Farmers provided data through simple closed-ended questions and a 1–5 Likert scale (very dissatisfied, dissatisfied, undecided, satisfied, and very satisfied) measuring their satisfaction with climate change, agricultural investments, and adaptation measures. The responses were summarized and linked to the study's research questions and hypotheses (Appendix A). .

Qualitative Data

Qualitative data collection methods were used through open-ended questions to obtain farmers' experiences, perceptions, and narratives concerning climate change. In this regard, the researcher engaged the respondents in in-depth discussions to enable them to share their personal views, perceptions, and knowledge concerning climate change.Qualitative data was collected through the household survey using the following process:

Key Informants' Interview (KII)

In my study, key informant**s'** interviews are a qualitative, in-depth interview with people who know what is going on in the community. The purpose for the study was an attempt to gather information from different types and numbers of persons in society, including leaders within the community and those with first-hand information concerning the nature and processes within the community in question. Key informant interviews were conducted with different persons deemed knowledgeable with first-hand information concerning climate change and its dependencies within the community in question. The household members in question were equally interviewed with emphasis within their farming activities and experiences in society as a whole. The discussion and information concerning processes provided an understanding and knowledge concerning the different underlying processes applicable in society within the context set by theory in question (Yin, 2014). In-depth interviews resemble a conversation among acquaintances, allowing for a free Interviewers frame questions spontaneously, probe for information, and take notes, which are elaborated on later (USAID, 1996). The number of people to be interviewed largely depends on data needs, available time, and resources. Typically, 15–25 interviews are the most we need (University of Illinois Extension, nd).

Interviews are one of the most commonly used forms of data collection for needs assessments, research, monitoring, and evaluation. The goal of this interview is to explore the respondents' views, feelings, and perspectives in depth concerning the study area. It should be open-ended and exploration-oriented (Gurung, 2018). The researcher went to the study area and took 25 respondents for the KIS, and the questionnaire was administered according to the guidelines (Appendix B). This is the final stage of analyzing the household survey interviews, understanding the data analytically, and creating plots where all other codes and categories are integrated (Khanal, 2012). The researcher interviewed the following people in detail:

Mayor and Deputy Mayor. First of all, I took the time to interview the mayor and deputy mayor of the respective municipalities in the study area. I went in at the allotted time and introduced myself and sometimes discussions were held about the situation in the country and interviews were conducted as per the guidelines. During the interview, the mayor and deputy mayor answered more questions about the impact of climate change on agriculture than I had asked in the guidelines.

Ward presidents. There are a total of 13 wards in this municipality. I also conducted a survey questionnaire with the farmers in those wards. Those who did the survey questionnaire in the ward would take the time to interview the ward president at the same time. Although the interview was conducted based on the guideline, some ward presidents gave me more information than the guideline regarding the impact of climate change and agriculture.

Agricultural expert. There is also an agricultural expert in this municipality. They are civil servants of the Nepal government. I went to the office while collecting information. Coincidentally, I met him and he gave a lot of information about climate change and its effects.

Farmers' Leader. There are many agricultural groups in this municipality, through this group, they get fertilizer and seeds. Some groups also sell the products produced through this group. Four farmers' leaders were interviewed, mainly from this group. In which they have expressed that the main problem is not being able to get fertilizer seeds and pesticides on time, and sometimes they have to sell the produced goods cheaper than the cost price.

J/TA Agriculture. Different government and non-government organizations are working in agriculture in this municipality. I interviewed for a junior technician position in agriculture working in that organization. According to them, farmers use fertilizers, seeds, and pesticides on the recommendation of the shopkeepers who sell agricultural fertilizers, seeds, and pesticides rather than on our recommendations. As a result, some farmers have said that they use more than necessary and that the products produced are affecting their health.

Teachers. Two of the teachers who teach in this municipality were included in the interview. The biggest institution in this was the college, and the other was the secondary school. Climate change is the main problem in this region, that's having a huge impact on agriculture. But now, gradually, the awareness of the farmers has developed, and they have made and implemented adjustment strategies (see Table 2).

Table 2

Participants of the Key Informant Interview

Statement	Respondents	Number
Key Informants Interview	Mayor	1
	Deputy mayor	1
	Ward chairmen	13
	Agricultural officer	1
	Farmers leader	4
	JT/JTA agriculture	3
	Teachers	2
Total		25

Source: Field Survey, 2020

Focus Group Discussion (FGD)

I took three FGD groups in each cluster ward, including individuals representing different ages, genders, education levels, people representatives, farmers, teachers, and land holding sizes. I conducted group discussions with the support of a local facilitator. A focus group discussion was arranged to have an interaction session with the farmers, who had a wide range of experiences on the applicable and emerging adaptive practices to mitigate the climate change impact in agriculture in the study area. The sharing of ideas and interaction about the experience helped to broaden our understanding of the current climate change impact mitigation practice in Panchkhal Municipality. The facilitator asked the question based on guidelines (Appendix C).

Secondary Data Collection

In this study, the researcher performed secondary data collection using various methods, and during the survey period a district census (2068) was consulted, which provided information on population, natural resources, education, households, vegetation, and agriculture in Panchkhal Municipality. Similarly, 40 years of weather data from Panchkhal municipality are included. Additionally, data from UNFCCC, IPCC, DHM, and UNO were utilized, along with several online databases that provide access to Nepal's climate-related information. Historical data from different regions of Nepal were obtained through climate change–related websites. Other online resources include data from the Global Change Data Center and the National Geospatial Data Infrastructure.

Data Analysis

In this study, data were collected from climate change perceptions, impacts, and adaptive strategies of farmers, and analyses were performed on those data. Quantitative and qualitative data were analyzed simultaneously. During data analysis, individual data results were compared. Quantitative data collected through the household survey were entered into the Statistical Package for the Social Sciences (SPSS). The data were cleaned, verified, and additional variables were calculated based on the available data. The required variables for analysis were transferred from Excel into IBM SPSS Statistics 20. Quantitative data were analyzed for descriptive and inferential statistics. Descriptive statistics (frequency, percentage, mean, standard deviation, Student's t test, and regression) were used. Binary logistic regression was used to analyze the relationship between adaptive strategies (the dependent variable) and independent variables such as education, gender, and ethnicity. In my study, data analysis is the process of systematically retrieving and organizing structured data information, enabling researchers to expand their understanding and present generalized knowledge to others (Bogdan & Biklen, 1998).

Data analysis includes finding and organizing fields, creating interviews, field notes, and other materials related to the results. Depending on the type of research, data analysis may involve organizing the data into manageable units, coding, synthesizing, and looking for key categories of meaning (Shrestha, 2020). In the study, the questionnaire was arranged systematically into various headings and subheadings. Similarly, analysis and interpretation of collected data and information were generated by triangulating data collected from the Field Survey. In the research, a qualitative data analysis of farmers' perceptions of climate change, mitigation, and adaptive strategies adopted by them was conducted through thematic analysis.

Reliability, and Validity

In order to effectively understand the concepts of reliability, validity and trustworthiness in research, the explanation is given below:

Validity

Quantitative research can improve its validity through careful sampling processes, the application of appropriate tools and data collection techniques, and proper statistical analysis of the collected data (Cohen et al., 2007). The researchers themselves were the primary data collectors, editors, designers, and analysts. Employing multiple research strategies and multiple data sources increased internal validity and enabled us to answer research questions more effectively than data and information obtained by applying a single approach (Creswell, 2009; Daldeniz & Hampton, 2013). In quantitative research, validity can be improved through a careful sampling process, the application of appropriate tools and techniques for data collection, and the appropriate statistical analysis of the collected data. The adoption of an integrative or holistic approach and triangulation methodology has improved the reliability of this study (see Table 3).

Table 3

Content Validity

		Index_A	Index_B
Index_A	Pearson Correlation	1	.321**
	Sig. (2-tailed)		.000
	N	568	568
Index_B	Pearson Correlation	321**	1
	Sig. (2-tailed)	000	
	N	568	568

Table 3 presents the content validity of the research. Since Index_A and Index_B are measures of similar or closely related constructs within a content domain, a strong positive correlation between them indicates that both indexes tap similar or closely related aspects of that domain. It supports the content validity of the scale. However, it is important to further evaluate whether these indices truly capture all relevant aspects and dimensions of the content area being investigated. Content effectiveness does not simply involve correlation.

Reliability

Reliability is a level of consistency or reliability. A study is conducted to determine whether the results are biased. Conscious, deliberate, and consistent use of methods improves the accuracy of processes and advances credibility (Birks, 2014). The reliability of quantitative research can be measured by its reliability and reproducibility over time and across instruments and respondent groups. It is about accuracy and precision in measurements (Cohen & Morrison, 2013). Reliability is about the consistency of the instruments used in collecting data. A pilot study helped to check whether the collected data using similar procedures would yield similar results. Regular feedback from supervisors has further assisted in maintaining validity and reliability. There are three principal types of reliability: stability, equivalence, and internal consistency. In this research, the internal consistency measure (Cronbach's alpha) as an alternative measure of reliability was applied. It provides a coefficient of inter-item correlations that measures the internal consistency among the items. The formula (Cohen et al., 2007) is used to find out their liability.

Due to internal consistency, the Cronbach-Alfa test was used in the investigation. If the internal consistency of alpha values is found to be weak or less than 0.8, use the tool again before collecting data (See Table 4.)

Table 4

Reliability

Reliability Statistics	
Cronbach's Alpha	N of Items
.761	39

Source: Field Survey, 2020

Table 4 shows the reliability values. When calculating the 39 items of the study variable, the value of those variables is 0.761. This means that the results obtained from this study have been proven to be universal.

Credibility and Dependability of Qualitative Results

Indeed, the text has underlined that reliability and dependability are the ways to ensure the validity of the findings through qualitative research.

Credibility

In my research, credibility in qualitative research is the trustworthiness of the results. Building credibility is very important as it ensures that the data collected and the interpretations made are reliable and valid. Reliability and validity are not used in qualitative research the way they are interpreted and used in positivist research (Khanal, 2012). In the research, a qualitative study focusing on farmers in Panchkhal Municipality on climate change, the researcher's triangulation of data sources integrates various channels such as interviews with farmers, teachers, local officials, and collaboration with government officials to provide comprehensive insights into climate impacts and adaptive strategies. The researchers conducted key informant interviews and focus group discussions with local farmers to determine their perceptions and knowledge about the impacts of climate change on agriculture and their adaptive strategies. Then categorize similar perceptions and knowledge of farmers and form a theme. Then, the data was analysed, and preliminary results were presented to the farmer group for feedback. This process helped to validate the results and ensure that the findings matched the actual experiences and needs of the farmers.

Dependability

In my research, reliability in qualitative research is the stability and consistency of research findings over time and across different circumstances and situations. Regarding qualitative research, Lincoln and Guba (1985) repeatedly stated the criteria of reliability and validity as reliability, communication skills, reliability, relevance, and trustworthiness.

In the study on climate change education for adaptive strategies of farmers in Panchkhal Municipality, the researchers carefully documented each step of data collection and analysis. In my study, I utilized the field notes, and audio recordings were kept to create a clear record of the coding process of the qualitative information. Furthermore, peer reviews and external audits by experts in qualitative research strengthen the trustworthiness and reliability of the research outcomes.

In these contexts, this analysis uses data triangulation as a combined method (mixed method) and multiple sources of data collection strategies necessary to obtain a complete picture of relevant phenomena across the triangulation model. This used multiple data sources, such as interviews and focus group discussions. Researchers participated in this process and asked specific questions based on guidelines. This process increased the honesty of the results, making it a useful tool in this study.

Ethical Consideration

To maintain ethical considerations in their research, researchers deliberated on privacy issues and agreed to ignore transactions of any kind (Creswell, 2014). Almost all literature on research methodology in the social sciences emphasizes the duty of researchers to adhere to ethical standards in planning and research to protect the rights of research participants (Khanal, 2012).

For this research to be ethically acceptable, the researcher adhered to various ethical guidelines that regulate the conduct of research involving human subjects. For this research to be ethical, researchers adhere to various ethical guidelines governing the conduct of research involving humans. Adherence to ethical guidelines secures human subjects and strengthens research integrity (Shrestha, 2020).

The researcher wrote a letter to Tribhuvan University for permission to collect data in Panchkhal Municipality, Kavre. The University provided permission to collect data for research. After obtaining approval, the researcher approached prospective participants, fully informed them of the study and its purpose, and also mentioned the 2018 Statistics Act. During the period of the field survey, ethical considerations were observed. To convey ideas to the respondents, the Nepali language was used in the questionnaire. No one was identified by name for data protection. Personal data of the participants was not disclosed to maintain confidentiality. Wherever necessary, pseudonyms were used for discussion purposes. Finally, the necessary data were obtained with the consent of the participants.

Chapter Summary

This study used a concurrent mixed-methods approach involving both quantitative and qualitative (QUAN+QUAL) methods. The fieldwork elicited mostly quantitative data and simultaneously garnered qualitative information through key informants' interviews. The research was conducted in the entire 13 wards of Panchkhal Municipality, Kavrepalanchock, Nepal. The study area was selected based on purposive sampling, and households were selected based on random sampling. The sample respondents were categorized into three strata: core, semi-periphery, and periphery wards based on spatial location. The primary data were collected from field observations, questionnaires, interviews, FGDs, and KIIs, and secondary data were collected through hydrology and meteorological data as well as CBS data. Mixed-methods, involving quantitative data and qualitative information, were used to collect and analyze the information. A household survey through face-to-face interviews was used to collect the quantitative data, whereas field observation, focus group discussions, and key informant interviews formed the basis of the qualitative data sources. Quantitative data were entered into the Statistical Package for Social Sciences (SPSS) and analyzed for descriptive and inferential statistics. A qualitative data analysis of farmers' perceptions on climate change, mitigation, and adaptive strategies adopted by them was conducted through thematic analysis. The data, with a combination of computerized tools and manual techniques, includes the triangulation of information from the various research methods and approaches used in the study. The reliability and validity were established with content validity and Cronbach-Alfa alpha test.

CHAPTER IV

RESOURCE CHARACTERISTICS AND UTILIZATION

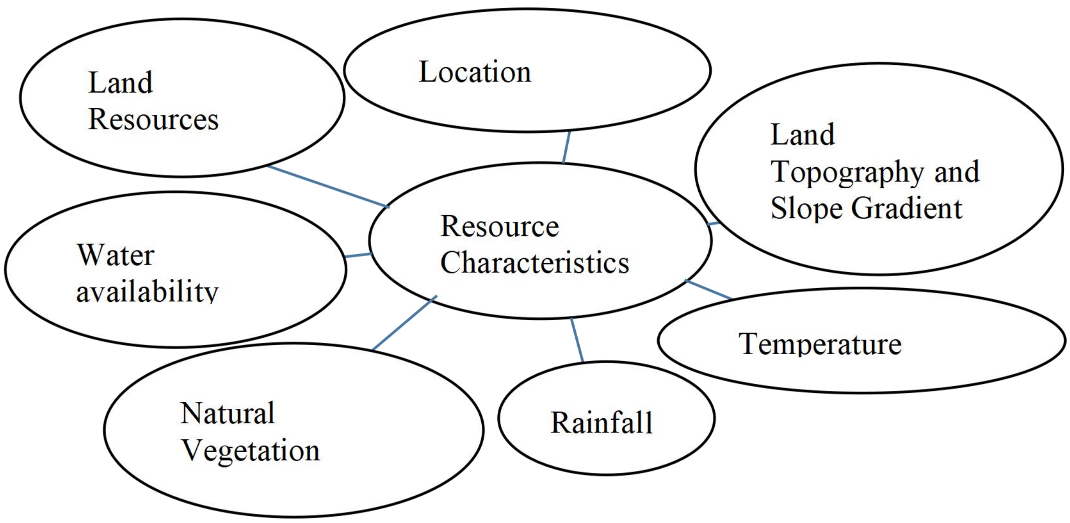
This chapter attempts to appraise resource characteristics and utilization practices in the study area.

Resource Characteristics

Resource characteristics refer to the natural, human, and economic resources available in a region, which are crucial for supporting livelihoods and development in Panchkhal Municipality. The spatial variations in resource characteristics between valleys and hill slopes in the study area are influenced by various interrelated factors. Valleys are more susceptible to flooding and landslides, while hill slopes are more susceptible to landslides and soil erosion, causing damage and reduced productivity. The study area experiences significant spatial variation in resource characteristics between valleys and hill slopes due to a combination of factors. The diverse environmental conditions have influenced the adaptive strategies of local farmers, who have had to adapt their agricultural practices, resource management, and land use. They are illustrated in the following schematic diagram:

Figure 4

Resource Characteristics

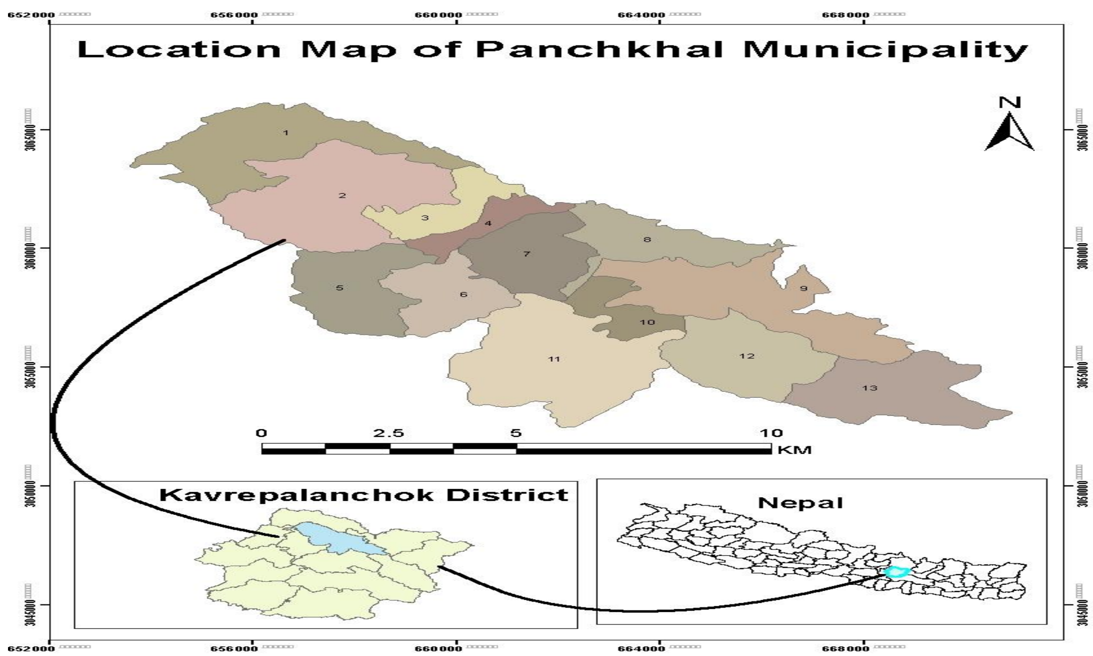


Location

Panchkhal Municipality is geographically unique as a small valley, centrally located, and fertile in terms of agricultural production. It is located in Kabhrepalanchok district of Bagmati Province, Nepal. It is situated at 27° 39' to 28°N and 84° to 85° 37' E latitude and longitude, respectively. Panchkhal Municipality was established in 2014 and 2017 by merging different village development committees from the surrounding areas (Urban Water Supply and Sanitation (Sector) Project, 2018). This municipality lies in the central hills of Nepal, with an altitude range from 585 m to 1435 m above mean sea level, and covers 103 square kilometers (Urban Water Supply and Sanitation [Sector] Project, 2018). The geographical feature comprises valleys, hill slopes, and tars (flat, rain-fed land). It provides sub-topical and temperate climatic zones. The municipality is divided into 13 wards (Figure 5). With this geographical characteristic, Panchkhal Municipality is situated in the central part of Nepal and has a unique type of climate such with summer warm and moist, and winter is cold and dry.

Figure 5

Location Map of Panchkhal Municipality



Topography and Slope Gradient

Panchkhal Municipality, situated east of the Kathmandu Valley, is an intermountain valley in Nepal's central hills, characterized by flatter valleys and steeper hill slopes. Valley soil is fertile, suitable for agriculture, while hill slopes have steeper, shallower, erosion-prone soils, requiring land terracing for soil and water conservation. Valleys and hill slopes have distinct agricultural practices, with valleys supporting a wider variety of crops and hill slopes facing cooler conditions, affecting water retention and evaporation rates. Valleys are intensively farmed due to productivity, accessibility, and modern agricultural practices, while hill slopes are subsistence-based, characterized by fragmented land ownership and customary rights. Additionally, the valleys benefit from better access to roads, markets, and infrastructure, enabling farmers to adopt intensive and market-oriented agricultural practices, including the cultivation of vegetables and fruits. Hill slopes, being more remote, rely on subsistence farming, where farmers grow resilient crops less dependent on market demand.

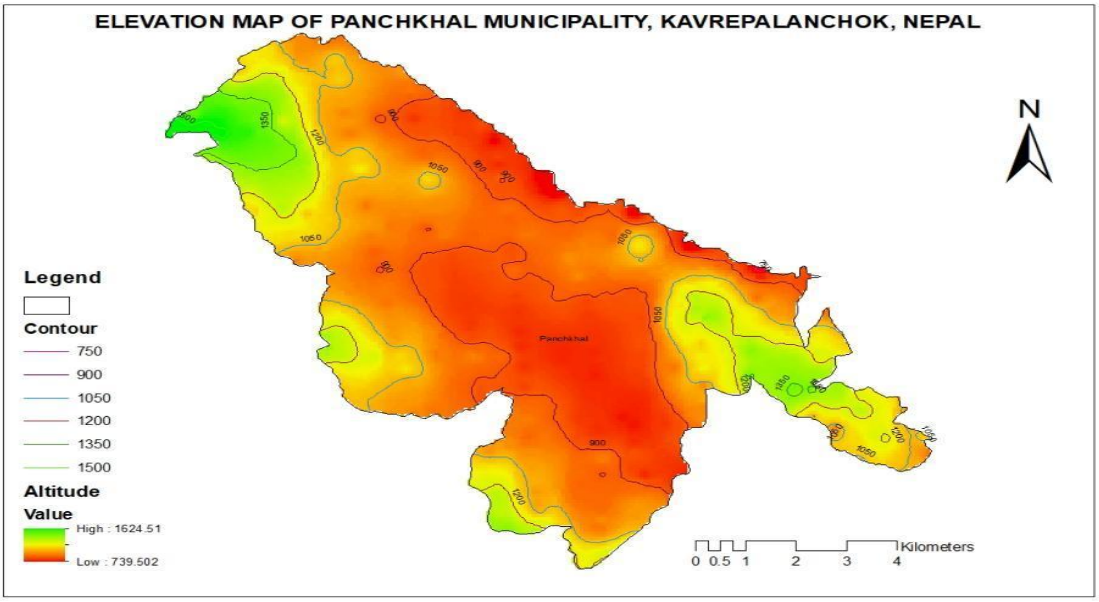
The biodiversity of these areas also differs, with the valleys supporting less diverse ecosystems and hill slopes promoting more diverse vegetation, such as subtropical deciduous forests. The geology of Panchkhal plays a significant role in its spatial variation. The region is composed of a mix of rocks, including micaceous quartzite, psammitic schist, metasandstone, and metasiltstone, with sediments of sand, silt, and clay dominating in many areas. The lowland valleys are suitable for agricultural production and dense human settlements, while higher elevations consist of low hills, which are less favorable for farming. Seasonal rivers, such as Jhiku Khola and Thokare Khola, flow through the municipality, providing irrigation facilities during the monsoon season.

Elevation in Panchkhal Municipality ranges from 750 to 1,500 meters, and this variation in altitude include valleys, forests, mountains, and rivers. The diverse landforms influence land use, with farmers selecting arable land based on landform and rock type to ensure good production. Natural hazards, such as landslides and floods, pose challenges in the low-hill areas, further affecting the suitability of the land for agriculture. In subtropical forests, species like rhododendron, salla, and chuletro adapt to climate conditions, with trees shedding leaves once a year in response to seasonal changes.

This spatial variation in topography, landform, and access to resources defines the distinct agricultural practices in the valleys and hill slopes of Panchkhal Municipality. The valleys, being more favourable, encourage intensive agriculture and higher productivity, while the hill slopes maintain traditional, subsistence-based practices, shaped by their more challenging terrain and limited infrastructure.

Figure 6

Elevation Map of the Study Area



Temperature

The valleys of Panchkhal Municipality are warm due to low altitude, while the hilly tracts are cooler due to high altitude and exposure to wind and vegetation cover affects the temperature variation. In my study, temperature plays an important role in understanding on going changes in climate change patterns and their impact on the environment and local farmers. The average maximum temperature of Panchkhal Municipality was recorded at 24.9°C and surged up to 38°C in 2008 (Ministry of

Water Supply, Nepal, 2019). The average minimum temperature was recorded at 11.7°C in and it fell to- -10 °C in 2008 (Ministry of Water Supply, Nepal, 2019). In my study, June is the warmest month with an average temperature of 26.1°C, and January is the coldest month with an average temperature of 13.0 °C (see Table 5). The temperature fluctuation in this municipality, along with other parts of Nepal, indicates a similar phenomenon.

Table 5

Average Monthly Temperature at Panchkhal (C)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.	13	15	19.9	23.5	25.2	26.1	25.3	25	24.3	22.2	17.7	14

Source: DHM, 2016

The study also reveals the average monthly temperature of climate change in Panchkhal Municipality. Table 5 shows the average monthly temperature at Panchkhal Municipality. It represents the climatic condition of the study area. The data indicate that the highest temperature was 26.1°C in June and the lowest temperature was 13 °C. °C in January. Generally, the data shows the highest temperature falls in summer conditions and the lowest temperature in winter conditions, like another place in Nepal (see Table 6).

Table 6

Distribution of Temperature by Decades (°C)

Decade	Pre-monsoon	Monsoon	Post-monsoon	Winter
1980	30.9	32.0	27.0	22.7
1990	29.8	31.8	27.7	21.9
2000	32.1	30.2	27.9	21.6
2010	29.6	30.1	26.7	23.4
2020	30.5	30.4	26.9	24.1

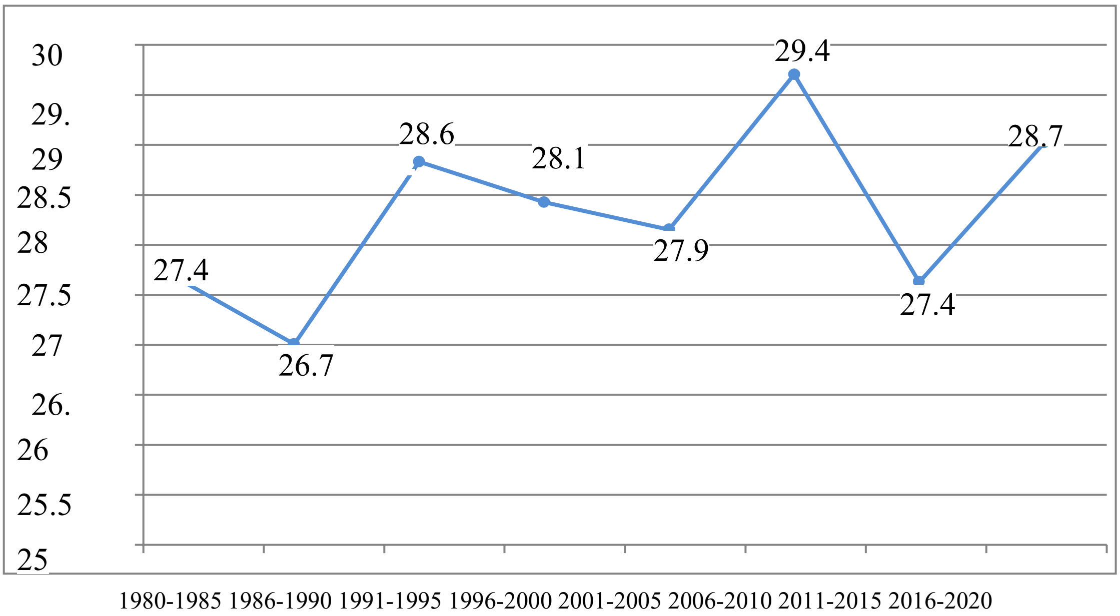
Source: DHM, 2021

Table 6 presents the temperature from 1980 to 2020 divided by pre-monsoon (March, April, and May), monsoon (June, July, and August), post-monsoon (September, October, and November), and winter (December, January, and February). Temperature variability is the degree of temperature deviation from the average, measured using statistics such as the standard deviation, range, and frequency of extreme temperature events. The temperature in Panchkhal Municipality fluctuates between 1980 and 2020, with some slight decreases and slight increases in the pre-monsoon, monsoon, post-monsoon, and winter seasons.

The study reveals that decade-wise temperature has been fluctuating; the farmers are using various agricultural adaptive strategies to cope with the effects of climate change. The average temperature pattern has been present in Panchkhal Municipality over the past decade. The table indicates that the highest temperature was recorded at 32.1°C, 27.9°C, and 32.0°C in the pre-monsoon, post-monsoon, and monsoon seasons of 2000, respectively, as well as 24.1°C in the winter of 1980. Similarly, the minimum temperatures recorded were 29.6°C, 30.1°C, and 26.7 °C in 2010 and 21.6°C in 2000 were pre-monsoon, monsoon, post-monsoon, and winter, respectively. It shows the decade-wise temperature fluctuation. The trend of temperature was increasing in pre-monsoon and post-monsoon and the decreasing trend in monsoon and winter seasons. The temperature in Panchkhal Municipality fluctuates over the years, with the highest temperature in 2006–2010 reaching 29.47°C and the lowest in 1986–1990 at 26.77°C. Indeed, overall, the data show the temperature is gradually increasing in the study area (see Figure 7).

Figure 7

Temperatures in Panchkhal Municipality



Source: DHM, 2021

The study reveals that as the temperature has been fluctuating, the farmers are increasingly using various agricultural adaptive strategies to mitigate the effects of climate change. Figure 7 presents the 40-year trend of the temperature in the study area. During this period, the highest temperature was 29.47°C in 2006–2010, and the lowest was 26.77°C in 1986–1990. In 1980-1985, the temperature was 27.48°C. and 28.79°C in 2016-2020. From 1980 to 2020, the temperature of Panchkhal Municipality has increased by 1.31°C.

The farmer noted that the temperature has been significantly fluctuating in recent days. The amount of temperature slightly increased until some years ago. The qualitative data also supported what the farmers experienced. One of the farmers shared his experience, "I felt that the increasing trends of temperature in the post-monsoon season during the last two decades. However, the trend of increasing temperatures varies from one season to another." This suggests that experiences and informal communication with farmers always provide important learning. While the farmers have several ways of learning, the increasing trends in temperature have been affecting agricultural production.

Temperatures have been increasing at different rates in different seasons for the past two decades. There is a significant increase in temperature during the post-monsoon season, a trend that varies seasonally. In this context, another farmer said, "*The increase in temperature is linked to a positive correlation with drought and soil moisture losses and affects agricultural production. In 2076, there was extreme heat in April, but no rain fell in time, and the corn plant dried up*." This experience suggests that informal communication and experience are always important knowledge for learning. Farmers have several ways of learning from friends who are significant in climate change strategies. In the past, farmers did not focus on drought-resistant crop varieties and soil moisture balance. During my field observation, I discussed with the farmers about the temperature in the study area. Since the establishment of the industry 20 years ago, farmers have been experiencing rising temperatures. The temperature fluctuates at various speeds, sometimes increasing and sometimes decreasing.

Rainfall

The rainy season is very erratic in Panchkhal Municipality, with heavy rainfall along sloppy areas and erosion, whereas the valleys receive consistent light rainfall and are good for agriculture. Rainfall significantly impacts climate, agricultural activities, crop development, water accessibility, and biological system wellbeing. It is an important climatic factor affecting various aspects of the life of the farmers of Panchkhal Municipality. Rainfall in the study area varies throughout the year, with a dry season and a rainy season. In my study, agricultural activities depend on adequate and evenly distributed rainfall, especially during the monsoon season, to ensure water supply and irrigation, and help maintain healthy ecosystems. While in my study, the nearest rain gauge and climatological stations of Panchkhal Municipality (station no. 1036) show the minimum rainfall was 7 mm (November) and the maximum rainfall was 305 mm (July) (DHM,2016). The average mean annual rainfall was 1020 mm in 2008 (Ministry of Water Supply, Nepal, 2019). Indeed, this figure was lower than the national average annual rainfall (1500 mm) in Nepal. In the context of Panchkhal Municipality, rainfall occurs during the monsoon season, and the rainfall is less in the western region than in the eastern region. The rainy season begins in June and ends in September when the monsoon winds across the Bay of Bengal and provide about 80 percent of the annual rainfall (see Table 7).

Table 7

Average Monthly Rainfall at Panchkhal (Station no. 1036)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Rainfall (mm)	10	16	29	54	100	194	305	229	191	63	7	18

Source: DHM, 2016

Table 7 also reveals the average monthly rainfall of climate change in Panchkhal Municipality. The Table indicates that July receives the maximum rainfall (305 mm) and November receives the lowest amount of rainfall (7mm). Therefore, in the municipality, there is a lot of rainfall in the summer season, which is favourable for agriculture, while in the winter season, it is unfavourable for agricultural production. The pattern of rainfall change is well-experienced by the farmers. As one farmer reported that the increase in rainfall for at least five years is quite prominent. He emphasizes, "We all experience an increase in rainfall during the summer season after the 2015 earthquake, which has made it easier to irrigate our agricultural systems, and agricultural production has also increased." Another farmer shared that the change in the decrease of rainfall causes drought, and he reported, "*Decrease in rainfall after the 2015 earthquake affected the quality of soil, making it dry and losing moisture in the soil"*. Both of these comments indicate that rainfall variability is a common phenomenon in the Panchkhal region that is affecting agricultural practices both positively and negatively (see Table 8).

Table 8

Pattern of Decade-Wise Rainfall (mm)

Decade	Pre-monsoon	Monsoon	Post-monsoon	Winter
1980	48.8	277	44.8	7.1
1990	88.4	247.2	61.9	11.6
2000	84.0	249.1	54.8	12.1
2010	83.8	254	56.8	3.3
2020	70.1	238.7	72.6	17.1

Source: DHM, 2021

Table 8 shows the decade-wise rainfall pattern from 1980 to 2020 is divided by pre-monsoon (March, April, and May), monsoon (June, July, and August), post-monsoon (September, October, and November), and winter (December, January, and February). Over the past four decades (1980–2020), the study shows fluctuating rainfall patterns in Panchkhal Municipality, while pre-monsoon rainfall was generally consistent from 1990 to 2010 and winter season fluctuations from 2000 to 2020.

The study has shown that a pattern of decade-wise rainfall *is needed* to deal with the effects of climate change, as the rainfall is unstable every decade. The pattern of rainfall is in Panchkhal Municipality from 1980–2020. The data reveals that the highest rainfall was recorded at 88.4 mm in pre-monsoon and 17.1 mm in winter in 2000. Similarly, 72.6 mm of post-monsoon rainfall in 2020 and 254 mm of monsoon rainfall were observed in 2010. The lowest rainfall was recorded at 48.8 mm in the pre-monsoon period in 1980, and it was 44.8 mm in the post-monsoon period of the same period.

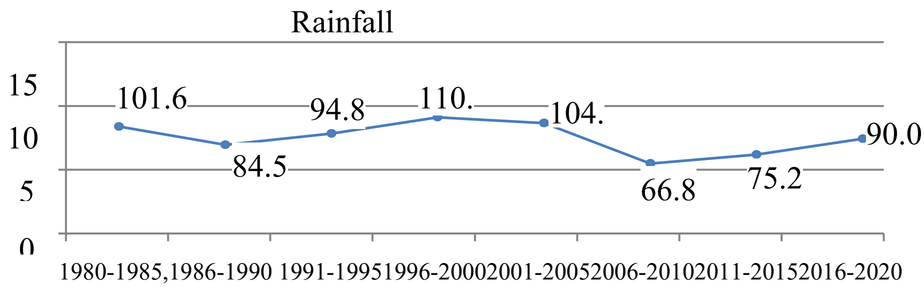
The data indicate a fluctuation of rainfall recorded over the decade, with decreasing trends in different seasons, such as the pre-monsoon and monsoon seasons, and increasing trends in the post-monsoon and winter seasons. The farmers have also perceived fluctuations in rainfall based on different seasons. They have reported that a high amount of rainfall occurred in the pre-monsoon and monsoon seasons as compared to a low amount of rainfall in the post- plastic ponds for water collection and irrigation, but after the 2015 earthquake, the water monsoon and winter seasons. A farmer reported *"A reversed decrease in rainfall following the 2015 earthquake, with annual rainfall now increasing more than ten years ago. The rainfall pattern varies across different wards, with a farmer from Ward no. 1 stating that a 2015 earthquake led to a water shortage in their river source."* This suggests that informal communications and experiences always provide important knowledge for learning. While the farmers have several ways of learning, informal learning from friends, inter-generational, radio, and TV are significant sources of knowledge about climate change of water resources. In this context, other farmers also have similar experiences in Ward No. 2: *"I have been utilizing underground water through boring techniques, which has significantly improved irrigation, particularly for vegetable farming*." This suggests that informal communications and experience always provide significant knowledge about water resources. While the farmers have several ways of learning through informal learning from experience is significant for climate change.

After the massive earthquake, water resources have increased in some parts of this municipality, helping to increase crop production. In this context, one of the farmers shared, "*From my experience, the rainfall has been decreasing steadily for at* *least the past ten years. As a result, the groundwater level has decreased, and the surface water bodies have dried up. The agricultural productivity has been impacted by climate change enormously*." This suggests that informal communications and experience are always important for learning. While the rainfall changes in the Panchkhal area cause drought and soil quality degradation, impacting agricultural practices by causing dryness and loss of moisture. Due to climate change, the underground water level has decreased and become a problem in irrigation. During my field observation, I interacted with the farmers about water sources during the dry season. The farmers said that the water source was sufficient even during the dry season before the massive earthquake. However, farmers are now finding it challenging to maintain agricultural production by irrigating their crops during the dry season.

The study examines the trends of rainfall in Panchkhal Municipality over the past four decades. The data reveal that rainfall patterns are affected by long-term changes due to global warming. The fluctuating rainfall patterns have affected the stream flow rate and hydrologic cycle. As a result, the municipality is fact severe impacts from cloudburst rainfall, erratic rainfall, drought, and floods that affect agricultural production.

Figure 8

Rainfall in Panchkhal Municipality



Source: DHM, 2021

Figure 8 presents the 40-year trend of rainfall in the study area. During this period, the highest rainfall was 110.12 cm in 1996–2000, and the lowest rainfall (66.86 cm) was in 2006–2010. In 1980-1985, the rainfall was 101.60 mm, and 90.03 mm in 2016-2020. From 1980 to 2020, the rainfall in Panchkhal Municipality decreased to 11.57mm. The data shows the gradual decline in rainfall over the past decade due to climate change in Panchkhal Municipality. Climate patterns, land use changes, and climate systems are all contributing to decreased rainfall. Urbanization and a lack of water resource management practices are also affecting rainfall patterns.

Natural Vegetation

Due to the different elevations and microclimates, hill slopes in Panchkhal Municipality have more diversified natural vegetation, whereas valleys have less diversified vegetation because of agriculture. Hill slopes have subtropical forest vegetation, but this is less native in valleys due to agricultural clearings.

While studying natural vegetation in Panchkhal Municipality, natural vegetation is the plant life that grows and exists in a specific geographic region without direct human influence or cultivation. In my study area, natural vegetation represents local and indigenous plant species adapted to local environmental conditions, including climate and topography.

It also includes the habitat of various plant species, birds, and wild animals for natural vegetation, including thick forests, weeds. In Panchkhal Municipality, about 44.0 percent of the total area is covered with natural vegetation [Department of Forest Research and Survey and Forest Resource Assessment Nepal (DFRS, & FRA, 2015)].

Natural vegetation includes all native plants, trees, shrubs, grasses, and other forms of plant life that occur naturally in a particular area or ecosystem. These plants adapt over time to local climate, soil, and environmental conditions. Nonetheless, natural vegetation is especially different indeed from one geographical region to another and plays an important role in maintaining the ecological balance of ecosystems. In my study, natural vegetation provides habitat and food for wildlife, helps prevent soil erosion, improves air and water quality, and helps to mitigate climate change. Natural vegetation on agricultural land mainly consists of widely managed grasslands, agroforestry areas, and all vegetation elements not used for agricultural production (García-Feced et.al, 2015). Different climate types support distinct vegetation types, and the Panchkhal Municipality is flourishing with different types of natural vegetation.

The prominent species are deciduous forests of Melastoma melabatricum (Rhododendrons), Pinusroxburghii (Rani Salla), Pinus wallichiana (Gobre Salla), Brassalopsis hainla (seto chuletro), Brassalopsis glomerulata (kalo chuletro), and Berberis aristata (koiralo). The forest-covered areas are managed by different community forest user groups (CFUGs). There are 52 CFUGs in this municipality that manage about 2754.37 ha of the total area (Appendix F).

Overall, the Community Forest in Panchkhal not only provides firewood, timber, litter, and fodders in this area but also plays a significant role in protecting carbon emissions and the greenhouse effect of climate change. However, the forest-covered area is decreasing due to the impact of urbanization, unplanned road construction, the extension of electric transmission lines, and gravity pipelines (see Table 9).

Table 9

Vegetation of the Study Area

Local name	English Name	Botanical Name	Life Forms
Bakaino	China Berry	Melia azedarach	Tree
Bot Dhaiyanro	Small Flowered Crape Myrtle	Lagerstroemia parviflora Roxb.	Tree
Champ	Golden Michelia	Magnolia champaca	Tree
Chilaune	Needlewood	Schima wallichii	Tree
Lapsi	Hog Plum	Choerospondias Axillaries	Tree
Paiyun	Wild Himalayan Cherry	Prunus ceratoides	Tree
Peepal	Sacred Fig	Ficus religiosa	Tree
Sal	Sal	Shorea robusta	Tree
Sallo	Chir Pine	Pinus roxburghii	Tree
Uttis	Nepal Alder	Alnus nepalensis	Tree
Aasuro	Malabar Nut	Adhotoda vasica	Shrub
Aiselu	Raspberry	Rubus ellipticus	Shrub
Gulaf	Rose	Rosa rubiginosa	Shrub
Simali	Chinese Chaste Tree	Vitex negundo	Shrub
Amliso	Tiger Grass	Thysanolaena maxima	Grass
Lajjavati	Shame Plant	Mimosa pudica L.	Herb/Weed
Dudhe Jhaar	Asthma Plant	Euphorbia hirta	Herb
Sajivan/Kadam	Oregano	Origanum vulgare L.	Herb
Sisno	Stinging Nettle	Urtica dioica	Herb

Source: Field Survey, 2020.

Table 9 reveals that the vegetation is a natural resource of Panchkhal Municipality. As for vegetation, there are tree, shrub, grass, and herb groups of vegetation found in my study area. Sal is found at the lower elevation, and *pine, uttis,* and *chilaune* are found at the higher elevation. The pine trees cannot be used for fodder for livestock. According to the members of the community forest, there is more emphasis on the indigenous species like *chilaune, champ, uttis, bakaino, paiyun,* and *lapsi* in the study area. In this way, different species of plants are found in Panchkhal Municipality. The members of the community are themselves engaged in planting, growing some indigenous species of plants and getting grass for cattle, as well as firewood as a source of energy. The vegetation plays an important role in keeping the environment favourable.

Photo 1: *Natural Vegetation in Panchkhal*

The pattern of vegetation is well-experienced by farmers. According to a farmer's report, the increase in vegetation area is quite prominent. He reported "*that the area of vegetation on private land has increased due to the migration of people to Ward No.9*." Another farmer said, "*The area of vegetation has decreased in urban areas on private land in Ward No*. 3". Both these comments show that the area of vegetation is variable in the Panchkhal region.

Water Resources

During the rainy season, the valley has plenty of water sources from rivers like Jhikukhola and Thokare, while during the dry season, rainfall and water flow are limited in the study area. While studying water resources in Panchkhal area, I focus on the natural resources available for use by humans and ecosystems. It includes various forms of water, including surface water such as rivers, lakes, and oceans, as well as groundwater, rainwater, snow, and glaciers. Water resources are essential for many uses, including drinking and certain industrial goods, generating hydroelectric power, maintaining ecosystems and biodiversity, and providing recreational opportunities such as swimming and boating.

In my study, water supplies are expected to decrease due to increased variability of rainfall, less snowfall, and rapid meltingof glaciers, thereby reducing groundwater recharge over time. The situation is expected to worsen globally due to climate change, which will eventually reduce water supplies and increase water demand (IPCC, 2007).

Photo 2: Dry Water Resources in Panchkhal (Jhikhu khola)

The carrying capacity of water resources, environmental sustainability, and response measures brought about by global climate change have been widely concerned and studied by many organizations and researchers (Bibi & Rahman,2023). In my study area, there is no permanent source of drinking water or irrigation. However, the Sunkoshi River is the only permanent source of water flowing from about 2.5 km away. Jhiku Khola and Thokare Khola, tributaries of the Sunkoshi River, are the primary sources of water for irrigation in this municipality. Those two seasonal rivers flow especially in the summer season and are affected by flash floods during the rainy season. In the study area, farmers irrigate their cultivated land with the help of wells or small canals. Most of the area of Panchkhal Municipality depends on rain during the dry season. If the water does not fall at the right time, the crop production cannot be good (Government of Nepal, Ministry of Federal Affairs and Local Development (2013). In the context of the study area, a new irrigation and water supply plan is being started in this municipality with the help of various organizations, in which the Urban Water Supply Plan 2019-2024 has been implemented with the investment of the World Bank.

In the study area, the new system, with the help of lifting the surface water source of the Sunkoshi River, is arranged to supply water directly from the Sunkoshi River to the collector or reservoir tank. The drinking water needs of millions of people are fulfilled by the rivers coming out of the mountains, but due to climate change, the amount of water in the rivers is decreasing, so there is a shortage of water in the urban and rural areas (IUCN, 2013). Due to climate change, the water source in this municipality is drying up. The people are meeting the need for drinking water in some wards by boring and extracting water from wells to extract underground water, while in some wards, people have migrated due to a lack of water. Similarly, a wet climate is found in places with water, which is suitable for human habitation as well as for agricultural activities, while in places without water, there is dry air, which is unfavourable for living and agricultural activities. It means there is a positive relationship between water resources and climate.

Water is one of the most important factors in irrigation and drinking water for agriculture. Climate change has given way to erratic rainfall, extended drought periods, and increased water scarcity in Panchkhal Municipality. Adaptive strategies for the proper utilization of water resources become very important for ensuring agricultural productivity. Others include the application of efficient irrigation methods such as drip irrigation and rainwater harvesting. Climate change education has equipped farmers in Panchkhal Municipality with ways of collecting, storing, and utilizing rainwater during the rainy seasons when there is scant or no rainfall at all. This adaptive strategy will ensure the crops get enough water regardless of unpredictable rainfall. Such practices reduce water wastage, improving water conservation and hence ensuring sustainability in agriculture within the region.

Land Resources

Panchkhal Municipality is a primarily fertile valley area, and large-scale agriculture is being carried out, the sloping land of this municipality is not fit for farming. At the same time, the productivity of land has decreased during recent years as a result of changes in rainfall patterns and soil degradation. Some adaptive strategies include improved land use practices, which prevent land degradation and utilize available land to maximum productivity. For example, terracing is one of the conventional land management practices that have been disseminated through education on climate change as one of the helpful options for minimizing erosion of soil in hilly areas. Farmers in Panchkhal are also encouraged to perform crop rotation and agroforestry-planting trees alongside their crops for the protection of the soil and improvement of fertility. More efficient and sustainable use of the land by the farmers promotes productivity despite climate-induced challenges. Cultivation, forest management, river management, and built-up areas are some of the uses made of the municipality. The result reveals that the land use and land cover of this municipality have changed over the centuries.

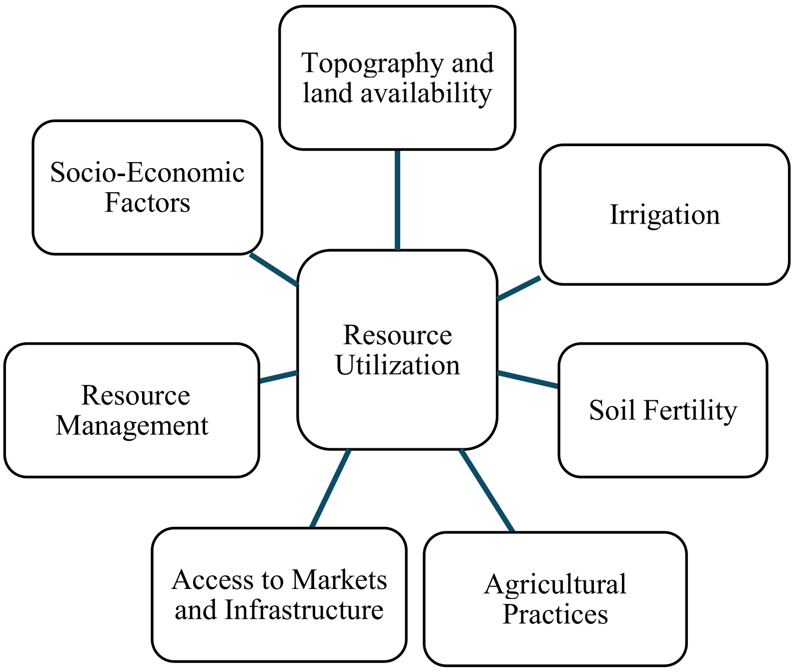
Resource Utilization

Resource use in Panchkhal Municipality, Nepal, is influenced by environmental, social, and economic factors, including topography, climate, and socio-economic dynamics. The utilization of resources in the study area varies significantly due to various factors across the valleys and hill slopes. The valleys and hill slopes in the municipality have distinct agricultural practices, with valleys focusing on commercial agriculture and market integration and hill slopes relying on traditional resource management.

Resource utilization is the use of natural, human, and financial resources to cope with the changed climate, especially in agriculture. Climate change has affected traditional ways of using such resources within Panchkhal Municipality, developing a need for new adaptive patterns. Climate change education guides the community in effective ways of sustainable resource management and utilization for adaptation. The following schematic diagram illustrates the resource utilization in Panchkhal Municipality:

Figure 9

Resource Utilization



Topography and Land Availability

Spatial variations in topography and land availability between valley and hill slopes in the middle hill Municipality of Panchkhal in Nepal are influenced by several factors. Further, these factors influence the use of land for agriculture, settlement, and resource management, leading to differences in land use patterns between the valley floors and surrounding hill slopes. Elevation, slope gradient, soil fertility, and water availability, along with climate and access to infrastructure, determine the variation in topography and land availability between valley and hill slopes. Due to these variations, land utilization in agriculture, settlement, and resource management has taken distinctive roles, hence creating different patterns of land use in valleys and hill slopes. It is also specific to the role of agricultural uses within the broader landscape, representing the valley as more intensive in cultivation and commercially oriented, whereas hill slopes rely on subsistence agriculture and traditional land-use practices, expressing great geographic and environmental diversity within the region.

Land Use

The study reveals that there are various land distributions available in the study area. The land includes forest, agriculture, pasture, and other (road, urban area, and river). Forest cover is a vital component in enhancing biodiversity and providing habitats for various plant and animal species. The dominant position can hinder agricultural development and land use planning; necessitating careful management strategies (see Table 10).

Table 10

Presented the Land Use and Land Cover Pattern

Land Use	Area (km^2)	Percent (%)
Forest	53.0	51.5
Agriculture	48.0	46.5
Pasture	1.5	1.5
Other	0.5	0.5
Total	103.0	100.0

Source: IRSC, 2008

Table 10 presents that a large part of the land (51.5%) is covered by forest to include small trees and large trees. The area of forest is gradually increasing in this area due to climate change. Some people have gradually migrated. Climate change is causing the drying up of water sources, affecting agriculture, and people are migrating without selling their land. For example, due to climate change, food shortages are increasing due to which has led farmers to migrate within and outside the municipality without selling their land. As a result, the increase in wild animals and the increasing problem of destroying crops are due to this issue.

The forest helps to mitigate the impact of climate change. As the land is mainly used for agriculture, effective land management is important to prevent soil erosion, conserve biodiversity, and ensure long-term agricultural viability. The 46.5 percent of the land is used for agriculture, primarily for planting crops. The crops grown on farmland are influenced by factors such as climate, soil conditions, and local preferences in the study area. The various crops, such as rice, wheat, vegetables, and fruits, are produced in this municipality. This municipality is particularly known for its focus on vegetable farming. For example, the farmers of Panchkhal Municipality own agricultural land and can cultivate crops such as paddy during the monsoon season. To increase their income, they cultivate vegetables like potatoes, tomatoes, cauliflower, and cabbage according to their local climate. Similarly, 1.5 percent of land is utilized for pasture, which is then covered for animal pasturing. The pasturing land also gradually increases in the dry wards, especially in 1, 9, 10, 11, and 13, due to migration without selling the land. For example, especially pasture land in wards no. 1 and 13 is located on that land; farmers graze livestock and help in their livelihood.

Farmers are using roads and settlement areas less due to legal and administrative limitations, restricted access to land, pollution threats, and limited water resources. The small numbers of farmers (0.5%) have utilized other areas such as the road and settlement area. In the settlement area, the populations build houses and industry.

The result indicates that 518 households have access to cultivated land as compared to 50 households without cultivated land. The land of this municipality is variously used for cultivation, forest, river, built-up areas, and others. The result reveals that the land use and land cover of this municipality have changed over the centuries.

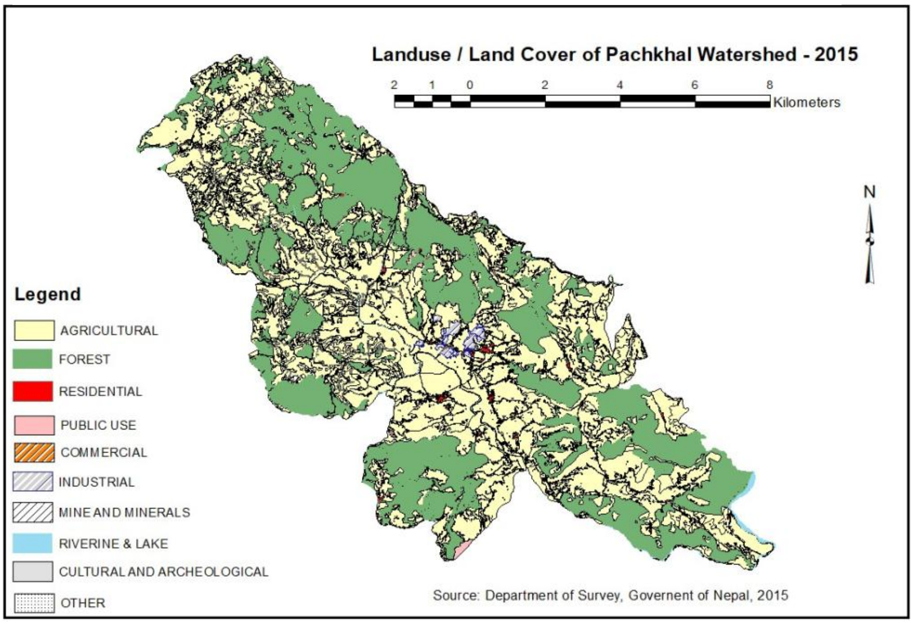
The study reveals that the land is a precious and finite natural resource provided for free by nature. It includes soil, rock, and mixed organic remnants. Soil is the solid and relatively stable surface of the Earth, composed of soil, rock, minerals, water, and vegetation. It includes all the physical features of the Earth's surface, from mountains and plains to forests and deserts. It serves as a base for ecosystems, human settlements, agriculture, and various natural resources. The term landscape often implies a comprehensive interrelationship of humans with the natural and physical environment (Stenseke, 2016). Land is a prominent natural resource in Panchkhal Municipality. Land is the main basis of people's livelihood. While people still consider land an integral part of their existence, it also determines the community's wealth and social status in this municipality. Therefore, most of the land is covered by forest. Forests play an important role in making the environment friendly and help to mitigate climate change.

Typology of Agricultural Land

While studying the nature of land in Panchkhal Municipality, the focus is on the land as the most important resource for livelihoods since life in urban areas depends on it for survival, and its ownership describes the wealth and status of the family. In the context of the study, a vast majority of the agricultural population has been residing in the hills, where the average land holding is less than 0.5 hectares, compared to 1.7 hectares in the Terai (CBS, 2068). In Panchkhal Municipality (hill region) of Nepal, are generally characterized by two distinct and dominant land-use systems: (i) Bari (rain-fed uplands with maize-based cropping systems) and (ii) Khet (irrigated lowlands with rice-based cropping systems) (Basu et al., 2004). The lower elevations have irrigated land, while the higher elevations have relatively rain-fed land found in this municipality. The typology of land is divided into two categories, such as irrigated (Khet and non-irrigated (Bari) which are presented below:

Figure 10

Land Use Map of Panchkhal Municipality



The irrigated land includes land used for growing adapted crops. In addition to providing fertile land for growing suitable crops, irrigated land plays an important role in sustaining local agriculture, ensuring food security, and enhancing economic stability. More of the population resides in this municipality on irrigated land than on rain-fed land. Since this municipality is close to Kathmandu valley and is an agricultural town, this municipality has more irrigated land (see Table 11*)* than other local levels in Kavrepalanchok district.

Table 11

Irrigated (Khet) Land

SN	Land (in ropani)	Responses (n=568)	Percent
1	Below 5 ropani	242	42.6
2	6-10 ropani	92	16.2
3	Above 10 ropani	21	3.7

Source: Field Survey, 2020

Table 11 reveals the Irrigated (Khet) land of the farmers in Panchkhal Municipality. The highest numbers of farmers (42.6%) have had below 5 ropani land with farmers and a few farmers (3.7%) have had above 10 ropani. Therefore, it becomes clear that the farmers are economically normal.

In the context of non-irrigated land associated with rain-fed agriculture, it is revealed that farmers in rain-fed lands rely on rainfall for agricultural production. In my study area, farming on such land is somewhat risky because if the rainfall is erratic or insufficient, the crop will fail (see Table 12).

Table 12

Rain-Fed (Bari) Land

SN	Land (in ropani)	Responses (n=568)	Percent
1	Below 5 ropanis	227	40.0
2	6-10 ropani	118	20.8
3	Above 10 ropani	42	7.3

Source: Field Survey, 2020

Table 12 reveals the rain-fed land of the farmers in Panchkhal Municipality. The highest numbers of farmers (40.0%) have had below 5 ropani land with farmers and a few farmers (7.3%) have had above 10 ropani. This data suggests that the farmers in the Panchkhal area belong to middle-class families having properties and wealth of an average size.

Ownership of Land

While studying ownership of land in this municipality, land ownership is the legal land, and is associated with owning real estate or a specific asset. Land ownership can represent a form of wealth and investment. It plays an important role in determining individual and social relationships with the environment, in shaping economic opportunities, and influences on social status. Land ownership represents the status of farmers in the community. As a historical and cultural significance of the farmer is also attached to the ownership of the land, the private land of the farmer contributes to the livelihood of the community (see Table 13).

Table 13

Ownership of Irrigated Land and Rain-fed Land

Ownership of land	Irrigated land (n=568)		Rain-fed land (n=568)	
	Holding	Percent	Holding	Percent
Male	196	34.5	226	39.8
Female	95	16.7	106	18.6
Male and Female Joint	65	11.4	57	10.0

Source: Field Survey, 2020

Table 13 shows respondents' higher ownership of irrigated land and rain-fed land. A large number (34.5%) of the 568 respondents are owned by men. The least number of respondents, 65 (11.4%), have their land in the joint names of women and men. The majority of the respondents have male ownership. This suggests that the ownership of both kinds of land is higher among males than among females. I also looked at the ownership of the land based on the settlement cluster, such as core, semi-periphery, and periphery (see Table 14).

Table 14

Distribution of Land Ownership

Land	Ownership of land	Total (n=568)	Percent	Total (n=568)	Percent	Total (n=568)	Percent	Total	Percent
Irrigated land	Male	111	19.5	33	5.8	52	9.1	196	34.5
	Female	50	5.8	20	2.3	25	2.9	95	16.7
	Male and female	31	3.6	8	0.9	26	3.0	65	11.4
Rain-fed (Bari) land	Male	109	19.1	56	9.9	61	107	226	39.8
	Female	49	5.8	32	3.8	25	2.9	106	18.7
	Male and female	26	3.0	8	0.9	23	2.7	57	10.0

Source: Field Survey, 2020

Table 14 shows the land ownership in the study area according to the cluster. The majority of respondents' irrigated land and rain-fed land are owned by 34.5 percent and 39.8 percent of males, respectively. Similarly, the least of the respondents (11.4% and 10.0%) of land is owned by a combination of males and females, respectively. The data indicates that women are the second-largest landowners, with most respondents owning land. Especially, as Nepal is a male-dominated society, although the literate population is gradually increasing in the study area, it seems that most of the land is still owned by men. But this situation is gradually changing, and ownership of land in the name of women is increasing.

Irrigation System

Access to water from rivers and streams is easy in valley areas, making irrigation systems easier to connect and maintain. This easily allows farmers to cultivate crops with high-water requirements, such as rice and vegetables, especially during the monsoon season. Water is much more irregularly distributed on the hills lopes. Farmers often rely on rainfall from the seasons or small local streams.

Constructing large-scale irrigation systems is mostly difficult and not very feasible in these areas; therefore, crops on the hill slopes are less intensive in water use, and farming depends quite heavily upon rain-fed agriculture.

In my study area, there is no permanent source of drinking water or irrigation. However, the Sunkoshi River is the only permanent source of water flowing from about 2.5 km away. Jhiku Khola and Thokare Khola, tributaries of the Sunkoshi River, are the primary sources of water for irrigation in this municipality. Those two seasonal rivers flow especially in the summer season and are affected by flash floods during the rainy season. In the study area, farmers irrigate their cultivated land with the help of wells or small canals. Most of the area of Panchkhal Municipality depends on rain during the dry season. If the water does not fall at the right time, the crop production cannot be good (SEMP, 2020). In the context of the study area, a new irrigation and water supply plan is being started in this municipality with the help of various organizations, in which the Urban Water Supply Plan 2019-2024 has been implemented with the investment of the World Bank.

In the study area, the new system, with the help of lifting the surface water source of the Sunkoshi River, is arranged to supply water directly from the Sunkoshi River to the collector or reservoir tank. The drinking water needs of millions of people are fulfilled by the rivers coming out of the mountains, but due to climate change, the amount of water in the rivers is decreasing, so there is a shortage of water in the urban and rural areas (IUCN, 2013). Due to climate change, the water source in this municipality is drying up. The people are meeting the need for drinking water in some wards by boring and extracting water from wells to extract underground water, while in some wards, people have migrated due to a lack of water. Similarly, a wet climate is found in places with water, which is suitable for human habitation as well as for agricultural activities, while in places without water, there is dry air, which is unfavourable for living and agricultural activities. It means there is a positive relationship between water resources and climate.

Water is one of the most important factors in irrigation for agriculture and drinking. Climate change has given way to erratic rainfall, extended drought periods, and increased water scarcity in Panchkhal Municipality. Adaptive strategies for the proper utilization of water resources become very important for ensuring agricultural productivity. Others include the application of efficient irrigation methods such as drip irrigation and rainwater harvesting. Climate change education has equipped farmers in Panchkhal Municipality with ways of collecting, storing, and utilizing rainwater during the rainy seasons when there is scant or no rainfall at all. This adaptive strategy will ensure the crops get enough water regardless of unpredictable rainfall. Such practices reduce water wastage, improving water conservation and hence ensuring sustainability in agriculture within the region.

Agricultural Practices

Spatial variations in agricultural practices within the valley and hill slopes of Panchkhal Municipality are influenced by a set of topographic, climatic conditions, social, and economic factors. The valley soils are fertile, with better access to water and proximity to the market, whereas hill slopes have steep gradients with needy soils and poor access to infrastructure. These variations determine the nature of agricultural practices-commercial farming and higher-order crops in the valley, while subsistence farming with traditional land-use techniques is practiced in the hill slopes. Larger and more consolidated landowners are generally acceptable to practice commercial farming due to their size and consolidation. Farmers in the valley can cultivate larger fields, often with more advanced technology and higher yields. The rugged terrain on hill slopes leads to smaller and more fragmented landholdings. The farming is often very much of a subsistence nature, and crops are grown primarily for household consumption. Land plots remain small, terraced, and labour-intensive because mechanization is difficult. Farmers have utilized various types of land for cultivation, including fertile and infertile areas. The land in the valley is fertile and farmers have planted cash crops and food crops according to climate change, which are more profitable crops according to climate change. The land in the valley is fertile and farmers have planted cash crops and food crops according to climate change, which are more profitable crops according to climate change.

Resource Management

Community resource management is a collective undertaking of local communities in the management and utilization of resources in a sustainable manner, especially as a response to environmental issues such as climate change. Due to increasing climate change, the incidents of landslides and soil erosion are increasing; therefore, hilly areas are being affected in Panchkhal, while communities are developing collective ways of managing forest resources to protect their agricultural land. Community resource management focuses on the protection of forests, acting as natural barriers to environmental hazards. While management strategies in forest and land management secure the continuous access of the community to their essential natural resources and protect the environment in the Panchkhal Municipality. Climate change education focuses on these groups to apply best practices in conservation methods in the context of forests and land management. For example, Community Forest User Groups (CFUGs) protect these forests by helping people to prevent climate change, soil erosion, and landslides through strategic plantations on hillsides, allocation of firewood, grass, and other essential resources, as well as water resources for agriculture.

Similarly, due to climate change, the farmers of Panchkhal have begun group farming. They share information, knowledge, exchange resources, and help each other with labour. This group-based approach helps to develop their ability to adapt better to fluctuating weather conditions. Farmers are now starting to adapt to adaptive measures that involve resource and information sharing in dealing with risks arising from climate change. Collectively, therefore, it enhances the resilience at the community level, where farmers can learn from one another and spread the burden of adaptation. For example, farmers in Panchkhal are adopting drought- and heat-tolerant crops with the help of cooperatives and training in climate change. Cooperatives offer a conduit through which farmers can purchase seed in bulk, share knowledge and experience in sustainable farming methods, and share machinery, reducing the fluctuation in yields between years.

Meanwhile, Panchkhal Municipality's water management is crucial for several reasons, given the variation in climatic conditions and inconsistency in rainfall. Overall, the community-managed irrigation systems can distribute the limited water supply most efficiently in the dry season. While the irrigation systems facilitate the prudent use of water and equality in ways of irrigation, allowing farmers to be productive under the unfavourable conditions brought about by a changing climate. Community governance evokes principles of fairness in the distribution of water, mitigation of conflict, and a collective adaptation to the fluctuating climate conditions. As irrigation schemes managed by the community have been developed by the farmers in Panchkhal, through which they distribute water from rivers and rainwater harvesting systems. Climate change education has ensured efficiency with the use of drip irrigation in meeting crop needs, should droughts arise.

Economic Resource

The municipality is endowed with economic resources characterized by lively local markets where farmers sell their agricultural produce, although recently with increasing attention to the promotion of local products. Besides, access to financial services provided by microfinance institutions and cooperatives offers the necessary credit and saving opportunities, supporting agriculture and economic development in general. While local farmers are using various agriculture financing practices, such as finance, agriculture groups, banks, co-operatives, and microfinance.

The farmers are promoting sustainable investment practices in agricultural strategies for climate change and include agricultural financing as an important part of their adaptive strategies (see Table 15).

Table 15

Agriculture Financing

Statements	Response	Numbers (n=568)	percent
	Financing	501	88.2
	Agriculture group	313	55.1
Institution	Bank	179	31.5
	Co-operatives	173	30.4
	Microfinance	136	24.0

Source: Field Survey, 2020

Table 15 shows that most of the farmers (88.2%) have taken loans for agricultural finance practice. Farmers are increasingly utilizing agricultural groups for investment loans, which are used to finance agricultural activities, purchase inputs, invest in equipment, or expand farm operations. Among the taken loans, many farmers (55.1%) have taken loans from the agriculture group for investment in the agricultural process and production. The farmers of the community form a group and raise money to invest in agriculture. The group meets every month, and if a member lacks money to invest in agriculture, the accumulated amount is given a loan at a 12 percent interest rate. In this context, one of the farmers shared, "*I have taken 50,000 rupees from the agricultural group for vegetable farming at a 12 percent interest rate. The loan I used for cauliflower farming provided me with a significant income. I was repaying the loan monthly within one year.*"

These suggest that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for agriculture financing. During my observation, I interacted with the farmers about the financing practices in agriculture. The farmers said we took the loan from the finance because there is an easy processing system for the loan. Therefore, there is a higher interest rate than other financing institutions, but also, we are attracted to take a loan in finance.

Farmers are using bank loans to increase agricultural investments, recognizing the importance of financial support in modernizing and expanding farming operations, including purchasing seeds, fertilizers, machinery, irrigation systems, and land expansion. About thirty-two percent of farmers have taken loans from banks for investment in the agricultural process and production. Only a few farmers have received concessional loans at a four percent interest rate for agriculture.

These suggest that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. During my observation, the farmers had secured bank loans and utilized the funds to purchase agricultural materials such as seeds, fertilizers, pesticides, and to lease or improve land.

The co-operative of Panchkhal Municipality offers financial support to farmers, promoting agricultural investment through loans for agricultural inputs, operational expenses, and farm infrastructure investments. About thirty percent of farmers have taken loans from the co-operative. One of the farmers shared,

> *I have taken loans for agricultural production from the co-operatives in which provide farmers with access to financial services, lower interest rates than microfinance, flexible terms, and community support. The interest rate was higher than the bank, with a cooperative rate between rupees 11-15 percent.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. During my observation, the farmers have taken the loan from the cooperative and invested in the agriculture inputs such as seeds, fertilizer, pesticides, labour, and irrigation. In fact, the farmers are getting successfully invested in vegetable farming like cauliflower, potato and brinjal and earn a good income.

Local farmers are utilizing microfinance for financial empowerment to farmers with limited access to traditional banking services, enabling them to access agricultural advances at competitive interest rates, contributing to agricultural practices, economic development, and poverty alleviation. Few of the farmers (24.0%) have taken loans from microfinance. Microfinance provides small loan amounts suitable for farmers with small holdings or farmers who need financing for general agricultural activities in the study area. One of the farmers shared,

> *I have taken a loan of 50,000 from Microfinance at 15 percent interest. By taking a loan through a quick, easy, and simple process, I have used the loan for purchase of urea and DAP fertilizers and pesticides as well as labour cost.*

These suggest that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from sharing ideas with friends is significant for the financing practice. In this context, another farmer said, "*Despite the high interest rates, farmers have taken loans from microfinance institutions to cultivate vegetables such as cauliflower, potato, cabbage, radish, and carrot, and have been earning considerable income from agricultural products.*" These suggest that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. During my observation, the farmers are taking loans from various organizations to reduce the impact of climate change and increase agricultural production.

The study reveals that the farmers have taken loans from banks, co-operatives, and microfinance for their agricultural production. Despite the low bank interest rates, few farmers have accessed loans from banks due to the complex loan process. The increase in agricultural production costs is causing concern among farmers. The current situation is making it challenging for farmers to adjust to the changes in agricultural production.

Overall, the study reveals that financial practices enable farmers to secure funds for climate change adaptation in their agricultural practices. Farmers invest their financial resources in drought-resistant crop varieties, irrigation systems, and soil conservation measures to achieve good production.

Access to Markets

The proximity of the study area to roads, markets, and transportation networks assures the farmers' easy access to inputs like seeds, fertilizers, and tools that enhance efficient marketing to nearby towns. Farmers cultivate vegetables, fruits, and cash crops such as potatoes for urban and local markets. The hill slopes are relatively difficult, with limited access to various markets and infrastructures. Because of this, farming here is more resistant and less dependent on market demand. Subsistence farming is a prevalent practice in this region, where farmers sell their produce locally at low prices instead of selling it in distant markets.

The farmers in the valley areas and more so around the Panchkhal area, have immediate access to the local markets, giving them a platform to sell their produce directly to consumers. New opportunities arise, more so for the growing group of health-conscious buyers, with the increasing demand for organic and locally produced items. In the Panchkhal, Banepa, and Dhulikhel markets, farmers can be found selling organic vegetables and fruits directly to consumers, hotels, and restaurants, especially in the Kathmandu Valley area. The growing demand for organic vegetables has helped increase the income of farmers. For example, a local farmer in Panchkhal saw an increase in demand for his tomatoes, potatoes, and green vegetables after switching from chemical fertilizers to organic fertilizers. While farmers reduce broker costs, establish regular customer relationships, and receive higher prices due to health-conscious consumer preferences by capitalizing on local market trends towards organic and sustainable food.

Value Addition

Value addition is the process of increasing the economic value of agricultural produce through preservation, processing, or packaging. The farmers in Panchkhal

Municipality are now beginning to participate in value addition, especially in pickling and organic jam preparation of the tomato. These activities also help them diversify their streams of income and reduce wastages of excess produce. Value addition not only raises the income opportunities of farmers in the study area but also allows farmers to handle surpluses better, reducing the losses and increasing the profitability of produce. It further empowers small-scale farmers to participate in higher-value economic activities. For example, the women are co-operative of farmers' processes surplus tomatoes into pickles and jams. In the tomato, potato, and cauliflower season, surplus fallen vegetables are collected by these farmers and processed into grading or levelling.

The value-added products are then sold in local markets and supplied to stores in nearby urban areas like Banepa, Dhulikhel, and Kathmandu Valley. By adding value to their products, these farmers can make additional money, specifically during seasons when demand is low, and build a brand synonymous with quality local products. In this context, one of the farmers said," Last year, I successfully graded potatoes to generate a substantial income. The study found that graded potatoes produced superior returns compared to other potatoes." It indicates that the farmers have implemented various strategies to enhance their value.

Human Resources

While studying the human resources in this municipality, the focus of human resources (HR) is the section of an organization responsible for managing and overseeing various aspects related to the organization's employees or workforce. As improved access to educational and training facilities results in increased human resources within the valleys of the study area, for instance, improved skilled labour in agriculture and other market activities related to it. The hill slopes, however, have limited access to education, leading to a workforce reliant on traditional farming knowledge. Valleys have more exposure to modern agricultural techniques and innovations, while hill slopes rely on local knowledge.

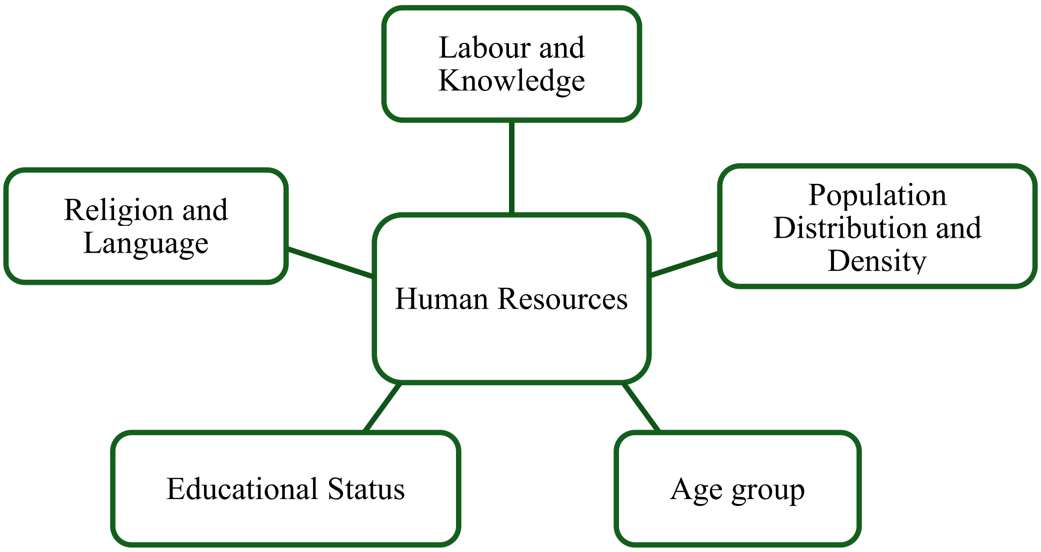
In the context of the study, human resources cover a wide range of tasks and responsibilities, all aimed at the effective utilization and development of human resources within the organization. Recruitment of talent benefits management, labour relations, and employee safety and health are all covered in the process of human resource management (Haslinda, 2009). Productivity, innovation, economic and social development, and the sustainable growth of any organization all largely depend on the effective management of unskilled, semi-skilled, and skilled human resources. The people of this municipality are into agriculture; there are skilled, semiskilled, and unskilled laborers. As migration is one of the common practices in this municipality, it's seasonal; some go to urban areas while others go abroad in search of work. The farming practices are highly traditional, although there is an increasing integration of modern techniques, influenced by traditional knowledge and education, as well as training programs.

In Panchkhal Municipality, it focuses on skilled manpower with special knowledge, training, or expertise in a field or profession. Such persons have acquired the necessary knowledge, skills, competence, and experience to perform the work with a high level of competence and efficiency. For example, skilled manpower in the study area includes those trained in adaptive strategies related to climate change. These persons are responsible for introducing modern farming techniques like water-efficient irrigation systems, the use of drought-resistant crop varieties, and providing training to the local farmers for practicing sustainability. While semi-skilled laborers in Panchkhal Municipality include local farmers who have acquired little modern agricultural knowledge but lack formal educations on climate change adaptive strategies.

Similarly, unskilled laborers contribute mainly to carrying out physical labour required at different levels, such as planting, harvesting, and development at the farm level, like irrigation canal development. They may not have any formal knowledge about climate change adaptation, but their role is very important regarding day-to-day farming. Unskilled manpower in Panchkhal-Municipality does not have special training, qualification, or expertise in a specific job role or field. These individuals lack the knowledge, skills, and competencies required to perform a particular job or task effectively. Such manpower earns less than skilled and semiskilled manpower. In this way, in this municipality, the skilled manpower is living a happy life by earning a good income, while the unskilled manpower is living a miserable life by selling labour at a cheap price. The following schematic diagram of the human resources:

Figure 11

Human Resources



Labour and Knowledge

Human resources involve capacities related to labour and technical knowledge in the implementation of climate-adaptive strategies. Education on climate change builds farmers' capacity, together with laborers at a local scale, in terms of skills and knowledge that are adaptable to new technologies, including sustainable practices. For example, farmers in Panchkhal are now receiving training on sustainable farming practices through local workshops and community programs. Education on climate change has helped them understand the changing pattern of weather and the shifting of planting seasons, and the diversification of crops. Furthermore, qualified agricultural technicians teach how to control pests and diseases that have developed due to climate change. Human resources play an important role in ensuring that all these adaptive strategies are put into practice effectively.

Population Distribution and Density

The total population of Panchkhal Municipality is 35,521, of which the number of males is 17,212 (48.2%) and the number of females is 18,309 (51.8%). Accordingly, the sex ratio is 94.0 males per 100 females (CBS, 2078). Thus, as the ratio of men to women in Nepal is more, the number of women in this municipality is also higher. In my study, Population distribution refers to the distribution of people across geographical areas like cities, regions, or countries. It indicates how people settle in different places or regions. The total population in the Panchkhal Municipality is 35,521 (CBS, 2068). On the other hand, population density is a numerical representation of the number of people per unit area or unit volume. In other words, the group of people living in each area is called the density. The population density in the Panchkhal Municipality is 345.1/km^2 (CBS, 2068).

Age Group

Panchkhal Municipality's working-age population, ranging from 0-65 years, actively participates in agricultural production, contributing to livelihoods, income generation, and food security, with 70.5 percent aged 15-64 actively involved. The majority of the population is independent, with a small percentage of farmers being dependent. 21.7 percent of the population aged 0-14 years is dependent on support from parents or caregivers. The few of the population (0.8%) is over 65 years old, often the elderly, who are no longer part of the workforce and rely on others for support and care (CBS, 2068).

Educational Status

Panchkhal Municipality's farmers, including literate and illiterate individuals, rely heavily on education for their livelihood, with a majority of 70.8 percent being literate. A literate population is the percentage of a community or area that is proficient in reading, communication, and writing. Literacy is a crucial indicator of overall development and is used to assess the status of the population as a whole. Educated individuals are capable of actively participating in economic, social, and political activities, which contribute to the overall development of society. Only *29.2* percent of the population lacks basic reading, communication, and writing skills, causing difficulties in writing, reading, and singing. Illiterate farmers make incorrect decisions, leading to economic hardship due to a decline in agricultural productivity.

Religion and Language

The Panchkhal Municipality is home to a diverse range of religious beliefs, with Hinduism being the dominant faith, influencing the cultural practices, rituals, and traditions of farmers. Buddhist farmers, particularly from the Tamang caste, also have a significant influence on their agricultural practices and community interactions. The majority of farmers (57.7%) speak Nepali (CBS, 2068). Nepali is the official language of the country, widely used in education and official communication. The Tamang language, spoken by 20.9 percent of farmers in the municipality, is crucial for inclusive communication and cultural effectiveness in development activities. The Danuwar language, spoken mainly by the Danuwar castes, is spoken by 11.2 percent of the population (CBS, 2068). The minority language, Newar, holds cultural and linguistic significance among farmers, promoting cultural diversity in communication strategies and agricultural development initiatives. The language usage is influenced by factors such as geographic region, social norms, historical developments, and transfer designs.

Discussion of Findings

The discussion of the findings is on the features and resource use in the study area, setting out how local farmers manage and utilize the natural assets of land, water, and vegetation. The challenges faced by farmers, including water scarcity and diminishing fertile land, which significantly affect agricultural productivity, are discussed which is given below:

Vegetation Gradually Increasing after Farmers Left their Cultivable Land Fallow

Climate change has affected human settlement patterns. Farmers are leaving bare land, especially on steep slopes, where plants and shrubs are now growing. As a result, private forest areas have expanded, but farmers face difficulties due to attacks by wild animals. Following the principles of sustainable development, it is important to balance economic growth with environmental protection when managing natural vegetation in abandoned areas. According to Adams (2009), the article "Environment and Sustainability in a Developing World" explores how development and modernization can cause secondary succession in abandoned agricultural lands. The area is traditional farming practices facilitate gradual vegetation regeneration during fallow periods. The shift from rural to urban areas, the decline of traditional farming, and the economic sustainability of agriculture in specific regions are significant factors to consider (Boserup, 1965; Bryceson, 1996). While vegetation has increased on barren agricultural land in Panchkhal Municipality, this change is largely due to the abandonment of traditional farming practices. Due to climate change and lack of irrigation, when the water sources start to dry up, vegetation starts to grow on the uncultivated land and gradually becomes denser. The people refused to sell the land as it was their ancestral property.

Researcher investigates how environmental factors like type of soil, climate, and topography affect vegetation regrowth post-farming, identifying regions more prone to reforestation or native vegetation return (Chazdon, 2008; Rudel, 2009). It shows that an area's topography, including its slope and elevation, also determines how vegetation grows.

Flat sites show faster regeneration due to improved soil retention and water availability, but steep slopes cause faster soil erosion, making it difficult for vegetation to regenerate. On the other hand, the farmers thought the area was the near side of the Kathmandu valley and it is a valuable property for us. Additionally, land is available at a low price. If you have a lot of land in the study area and sell that land and buy it in the market area or elsewhere, you will get only a small amount of land. Therefore, people migrate to other places without selling their ancestral property. It shows that they did not sell their land to work elsewhere and rest for some time, and to maintain their social existence. On the other hand, not all land in this municipality is equally fertile. The process is particularly noticeable in the hilly regions of Nepal. Many farmers have resorted to leaving their agricultural land for employment elsewhere. As a result, weeds and small plants in those areas help to maintain the soil quality and conservation of soil erosion. The gradual increase of small trees and shrubs eventually leads to the development of a dense forest over time.

The different studies support the phenomenon of vegetation in Nepal's hilly arable land. The researchers, Thapa and Weber (1990), have emphasized the importance of natural vegetation restoration in abandoned agricultural areas. The study showed that the natural vegetation re-established itself after agriculture was abandoned in the hilly areas of Nepal. Similarly, this phenomenon has also been observed in other countries. For example, studies in the Mediterranean region have shown significant increases in vegetation on abandoned agricultural lands. A study by

Kramer et al. (2008) noted that natural vegetation restoration occurred on abandoned lands due to a decline in agriculture. It indicates that these studies consider the increase in ecological restoration and improvement in biodiversity on abandoned land as important. There are positive and negative aspects to the growth of vegetation on land abandoned by farmers. On the positive side, it can increase biodiversity, improve soil quality, and help with carbon sequestration against climate change. In addition, the restoration of forests and grasslands helps restore habitat for wildlife, thereby improving the health of local ecosystems. However, this process also has its challenges. In some cases, foreign plants can take over abandoned agricultural land, which can displace native plants and alter local ecosystems. In addition, the loss of agricultural land can also have an economic impact on rural communities, especially if those lands were once the main source of income.

In this context, Research by Sujakhu et al. (2018) the study demonstrates that uncultivated lands undergo a natural succession process, resulting in the regeneration of forests and the return of biodiversity. The reforestation helps in soil stabilization, reducing the risk of landslides, which are common in Nepal’s hilly terrain. Increased vegetation cover aids in carbon sequestration, thereby reducing climate change. The community forestry program in Nepal is an effort made at the government level to reduce deforestation and improve the livelihood of the community, in addition to sustainable development (Ojha, 2009). It shows that the community forestry in Nepal empowers local communities to manage resources, reduce poverty, and promote sustainable forest management, supported by the government, law, and user groups.

The Fertile Land Gradually Decreasing Due to the Urbanization Process

The connection between fertile land and human habitation has been a significant area of interest in geographical and urban studies for a long time. As urbanization and population increase and fertile land is being used for human settlement. This type of trend is having a significant impact on food security, environmental sustainability, and social development. The tendency of residential areas to encroach on the fertile agricultural land of Panchkhal Municipality of Nepal is happening rapidly. The region has historically been an important agricultural center and is noted for its fertile soil and favourable climate, especially for vegetables. In recent years, many people have migrated from rural areas to urban areas (CBS, 2078). It indicates that people have migrated from rural to urban areas, obtaining more facilities than in their original place.

The study examines how urban proximity influences land conversion into residential areas, focusing on cities tend to attract more land due to higher demand and better service access (Von Thünen, 1826; Alonso, 1964). While growing population and demand for housing is converting fertile agricultural land into residential areas. Due to modernization, productive agricultural land has been converted into residential areas.

As urbanization increases and population demands increase, this often happens. Due to economic development and urbanization, agricultural land is gradually being converted into residential areas. Researchers find out how transitions are driven by factors such as population growth, economic expansion, and housing demand (Satterthwaite, 2007; Angel et al., 2011). Due to internal migration and the expansion of road networks and facilities, the Panchkhal area is becoming a popular destination for those seeking to escape the urban congestion of Kathmandu. The study examines how economic activity, population density, and policy choices influence land use shifts from agriculture to cities (Lambin et al., 2001; Seto et al., 2011). Fertile land is gradually decreasing, and people's residence is gradually increasing. The issue is not exclusive to Panchkhal Municipality but is a global concern. Regarding the urban expansion encroaching on fertile land worldwide, like Nepal. According to the Food and Agriculture Organization (FAO), 12 million hectares of productive land are lost each year due to land degradation. The support of these statements (FAO, 2019) reported that urban sprawl, driven by population growth and economic development, is a major factor contributing to the loss of fertile agricultural land. While the rapid urbanization in countries such as China and India has converted vast tracts of fertile land into residential and industrial areas. China's urban expansion policy has led to the loss of 3.6 million hectares of arable land between 2000 and 2010 (Liu et al., 2015).

Similarly, urban sprawl in India has led to the loss of productive agricultural land, particularly in Punjab and Haryana, the country's "breadbasket" of the country (Gopal, 2017). It shows that the conversion of fertile land into residential areas has a significant impact on agricultural activities. The construction of buildings and infrastructure leads to environmental degradation, loss of ecosystems, reduced biodiversity, and increased carbon emissions. The conversion of agricultural land into urban areas often leads to issues such as soil erosion, water scarcity, and the loss of natural vegetation.

The environmental impacts in Panchkhal Municipality are becoming more apparent, such as agriculture, landslides, and erratic rainfall. The growth of residential areas has fragmented agricultural land, making it challenging for farmers to earn their living. Meanwhile, the decrease in fertile land has resulted in a decrease in agricultural productivity, potentially impacting the region's food security in the long term. The loss of fertile land significantly impacts socio-economic conditions, potentially leading to increased inequality. Regarding the small farmers, due to the scarcity of arable land and rising cost of land, they sell their land to businessmen who invest in big real estate. As a result, the effects are the displacement of rural communities and traditional livelihoods. The farmers of Panchkhal are selling their land for development and changing from an agricultural economy to a real estate and services-based economy. Thus, the lack of fertile land leads to food insecurity, especially in developing countries where agriculture is the main source of income. The United Nations estimates that the world will need 60 percent more food to feed a population of 9.7 billion by 2050 (UN, 2017). However, the continued depletion of fertile land poses a major risk of increasing food prices and increasing poverty.

The conversion of fertile land into residential areas necessitates comprehensive policy responses to tackle the challenges. Panchkhal Municipality's local authorities have recognized the necessity to balance development with the preservation of agricultural land. To reduce the loss of fertile land, the municipality should bring programs of housing promotion and sustainable farming practices. Globally, similar approaches are being implemented.

The European Union has implemented policies like the Common Agricultural Policy (CAP) to limit urban sprawl and protect agricultural land in Europe (European Commission, 2020). It shows that developed countries have implemented agricultural land conservation policies to limit urbanization, prevent land encroachment, and ensure a stable food supply. In summary, the issue of decreasing fertile land and increasing residential areas is a multifaceted problem that necessitates a comprehensive approach. Urbanization is necessary, but it is crucial to ensure it doesn't compromise food security and environmental sustainability.

Panchkhal Municipality's experience illustrates a global challenge necessitating innovative solutions, policy interventions, and a commitment to sustainable development. Balancing urban growth with land conservation can lead to a future that meets both human and environmental needs.

Chapter Summary

Resource characteristics comprise natural, human, and aesthetic resources that provide the base for human adaptation. Natural resources include land, forest, water, climate, and humans available in the Panchkhal Municipality. It is situated at 27° 39' to 28°N and 84° to 85° 37' E latitude and longitude, respectively. The area of Panchkhal represents an intermountain valley in the central hills of Nepal, having several plains, peaks, and slopes. There are two types of temporary rivers (Jhiku Khola and Thokare Khola) flowing in this municipality, which provide seasonal irrigation facilities for crops. The elevation of Panchkhal Municipality is from 450 to 1435 meters. The climate is characterized by summers being warm and moist and winters being cold and dry. The average mean annual rainfall was 1020 mm, and the maximum temperature was 38°C in 2008. The forest has covered 51.5 percent, followed by agriculture 48.0 percent, and the lowest area 0.5 percent (road, urban area, and river), as well as 1.5 percent covered by the pastureland. The prominent species are deciduous forests. The forest-covered areas are managed by different community forest user groups (CFUGs). There are 52 CFUGs in this municipality that manage about 2754.37 ha of the total area. Dhulikhel is one of the reputed tourist destinations of the country, and Panchkhal is also a part of it and is crossed by the Araniko highway.

Palanchok Bhagwati Temple, Anaikot View Tower, Dugdheshwari Temple, Suvarneshwari Temple, and Sunkoshi Riverbanks are known as tourist areas in Panchkhal. It shows that there is potential for the local tourism industry. Similarly, the total population of Panchkhal Municipality is 35,521, of which the number of males is 17,212 and the number of females is 18,309. Most of the population is literate in this area. Climate change education is important for Panchkhal Municipality farmers while promoting the use of sustainable resources. It raises awareness of the local impacts of climate change, helps farmers adapt their practices, and provides knowledge on sustainable agricultural practices such as agroforestry and crop diversification.

Education also teaches farmers about efficient resource management, water-saving irrigation methods, soil conservation, and integrated pest management. By understanding climate risks and adopting sustainable practices, farmers are more resilient to climate-related challenges, ensuring agricultural productivity and livelihoods. Resource characteristics and utilization patterns in Panchkhal Municipality reflect a dynamic interplay between natural resources, agricultural practices, community engagement, and adaptive strategies. Understanding these aspects can guide policymakers, development agencies, and farmers in creating sustainable and adaptive strategies tailored to local needs and conditions. Climate change education promotes responsible practices that balance current needs and environmental concerns.

CHAPTER V

INFORMATION OF CLIMATE CHANGE AND ADAPTIVE STRATEGIES

In this chapter, I have examined the spatial variability of climate change conditions in Panchkhal over the past four decades, focusing on impacts like drought, erratic rainfall, fluctuating temperatures, and flooding. For this purpose, I have used data from the Hydrology and Meteorological Department, household surveys, interviews, and focus group discussions to analyse rainfall patterns of this area. The spatial approach reveals the diverse agricultural practices across regions, highlighting the strategies employed to tackle local climate change challenges.

Causes of Climate Change

The Panchkhal Municipality located in the Kavrepalanchok district has experienced a notable change in climate trends over recent decades. Urban expansion, use of chemical fertizer and pesticides, and overexploitation of natural resources such as land and water are the main drivers of climate change in this region. In addition, constructions of infrastructure and increased greenhouse gas emissions from agricultural machinery have further contributed to local climate change. The following causes of climate change in the study area are given below:

Urbanization and Infrastructure Expansion

Urbanization and infrastructure expansion are having a significant impact on farmers' adaptation strategies to climate change in Panchkhal Municipality. This is because the municipality was only converted from a rural municipality to a municipality in 2074 BS as per the decision of the Government of Nepal. Urbanization and expansion are consequently happening very quickly. As cities and infrastructure such as roads, irrigation systems, and marketplaces expand, farmers are modifying their traditional farming practices. Regarding this, one of the farmers said,

> *Urbanization has reduced land area, but roads and markets have made it easier to produce agricultural products, particularly vegetables, and market them. However, urbanization and market expansion have also contributed to climate change because urbanization is contributing to environmental pollution. This trend is increasing day by day.*

In the same way, the ward member also supported,

> *Pollution is on the rise as a result of rapid infrastructure development and urbanization. Although this municipality was formerly an agricultural municipality, the Nepali government recently decided to make it a municipality. Consequently, the loss of agricultural land due to urbanization is accelerating and causing climate change. Although it hasn't been put into action yet, the municipality has also created a thorough plan for the growth of urbanization. For this, we are providing grants to limited farmers on a priority basis and have emphasized organic farming.*

In summary, the expansion of urban regions and facilities has provided farmers with both opportunities and obstacles. Enhanced roads and markets have enabled the production and marketing of agricultural goods; nevertheless, urbanization has led to diminished arable land and increased pollution, both factors exacerbating climate change. The local government is presently executing its strategies for city growth.To address these issues, local governments are emphasizing organic agriculture and offering farmers minor grants to support their adaptation to climate change. In order to solve these problems, local governments are prioritizing organic farming and providing farmers with small grants to aid in their climate change adaptation. Finding a balance between urban expansion and agricultural preservation requires the use of sustainable urban development strategies.

Vehicle Emissions and Road Traffic

Vehicle emissions and higher road traffic play a major role in climate change, impacting farmers' capacity to adapt to shifting climatic conditions in the Panchkhal Municipality. In particular, at the highway nearside, vehicles release greenhouse gases (GHGs) such as carbon dioxide (CO_2) and nitrogen oxides (NO_x), contributing to air pollution and global warming. It helps to change the impact of local weather conditions, condition of soil, and water availability while climate change education helps the farmers to understand these impacts and implement the solutions. In the same way, one of the farmers stated,

> *The dust and fumes from vehicles are having impacts on my crops and sometimes it becomes difficult to breathe when working in the home or the fields. The municipality's agricultural produce is influenced by the changeable weather and sporadic sudden rains. However, urbanization and road expansion are necessary for economic growth in this municipality, so while urbanization and road expansion; we must also consider the environmental impacts. The local government is encouraging sustainable transport and providing benefits to farmers to embrace organic agriculture methods.*

In this situation, the local representative from Ward No. 2 stated,

> *Urbanization and road expansion are necessary for economic growth because it allows agricultural products to be easily transported to the market and increases economic activities. But we must also consider the environmental impact while developing. Therefore, our municipality is encouraging environmentally friendly transportation and providing incentives to farmers who adopt organic farming.*

In this regards, the agriculture officer of this municipality said,

> *Farmers require education and training on the effects of emissions on the climate and soil. We are pushing low-emission farming methods like organic fertilizers and water-saving irrigation systems in this municipality and offering training on sustainable land management. The impacts of climate change within this municipality will be tackled through such training and education.*

In conclusion, urbanization and infrastructure are necessary to economic growth, but environmental sustainability needs to be addressed. Through such assistance in organic agriculture, sustainable agriculture training, and sustainable transport, the municipality is attempting to reverse this. Through the integration of climate change training, farmers are able to adapt to new environmental conditions while inducing economic growth.

Emissions from Brick and Industrial Kilns

These are the main causes of climate change and influence the water, soil quality, and air of Panchkhal Municipality Carbon dioxide (CO_2), sulphur dioxide (SO_2), and particulate matter (PM) are a few of the pollutants released by brick and industrial kilns. These help in accelerating climate change and influence the economic production of food by farmers. Farmers in this community benefit greatly from climate change education since it helps them comprehend these effects and implement adaption measures. With this, one of the farmers stated,

> *The dust and smoke from the brick kilns also settle on my plants, especially in vegetable fields. It inhibits the vegetables' growth and reduces yield. Similarly, the brick kilns use a lot of water, which evaporates other sources of water around. That is why we are unable to water our fields well. We are reducing these problems by improving the soil with organic manure and utilizing water-saving irrigation methods like drip irrigation and rainwater collection. These measures allow us to continue farming despite water constraint and pollution.*

Similarly, in this municipality, a ward member from Ward No. 3 stated,

> *Industrialisation is needful for economic development, but it has to be sustainable. For this, we are in the process of closing brick industries and opening other industries only after conducting Environmental Impact Assessment. As a result, industrial development prevents environmental imbalance.*

In this regards, an agricultural officer stated,

> *We are helping farmers' combat pollution from industry and brick kilns by encouraging them to protect their soil, use water wisely, and grow crops that are tolerant to pollution. In order to preserve the soil's fertility, we are advocating for soil conservation techniques including mulching and composting. In order to struggle the problem of water shortage, we are also educating farmers on how to use water-saving technology like drip irrigation and rainwater collecting. Furthermore, we are introducing crop types that are tolerant to pollution and climate change. Our main goal is to provide farmers with climate-resilient agriculture so that they can continue farming successfully despite such adversity.*

In conclusion, the direct effects of industrial and brick kiln pollution on agriculture, particularly through air pollution and water scarcity. Farmers are adopting green methods such as pollution-resistant crops, water-saving irrigation, and organic farming with assistance from agricultural officers and local members. We are also working with agroforestry to reduce erosion and maintain soil moisture to reduce agricultural losses and mitigate climate change. In a similar vein, the local representative of ward 9 said,

> *The municipality is expanding swiftly and that agricultural land is progressively being converted into homes and businesses. We are attempting to implement zoning laws to safeguard agricultural land and offer farmers subsidies for climate-smart agriculture in order to guarantee food security and environmental balance in this municipality, but it is insufficient. We are not putting into practice a sustainable land use plan that was created to strike a balance between agricultural sustainability and development.*

In this regards, the agricultural expert said,

> *Soil erosion and a slow reduction in agricultural water supply are the results of land use change. Soil erosion and a slow reduction in agricultural water supply are the results of land use change. Among the sustainable land management practices we are teaching farmers are crop rotation and organic composting. In order to help farmers adapt to changing conditions and maintain agricultural output, we are also promoting climate-smart farming practices, which lessen the consequences of climate change and increase yields.*

In conclusion, traditional farming is avoided by rapid urbanization that reduces the land under farming and causes water scarcity. Agroforestry saves water in the soil and avoids erosion of the soil, while reduced water supply is countered by farmers using alternative means like drip irrigation, boreholes, and drought-resistant plants. Though hard to implement, zoning regulation and climate-smart agriculture subsidies are the result of urbanization's conversion of arable land to residential and commercial use. Experts point out that change in land use lead to soil erosion and reduced water availability. Climate-smart agriculture measures are being encouraged to increase productivity and offset the effects of climate change, and farmers are being supplied with the required machinery to learn sustainable land management practice.

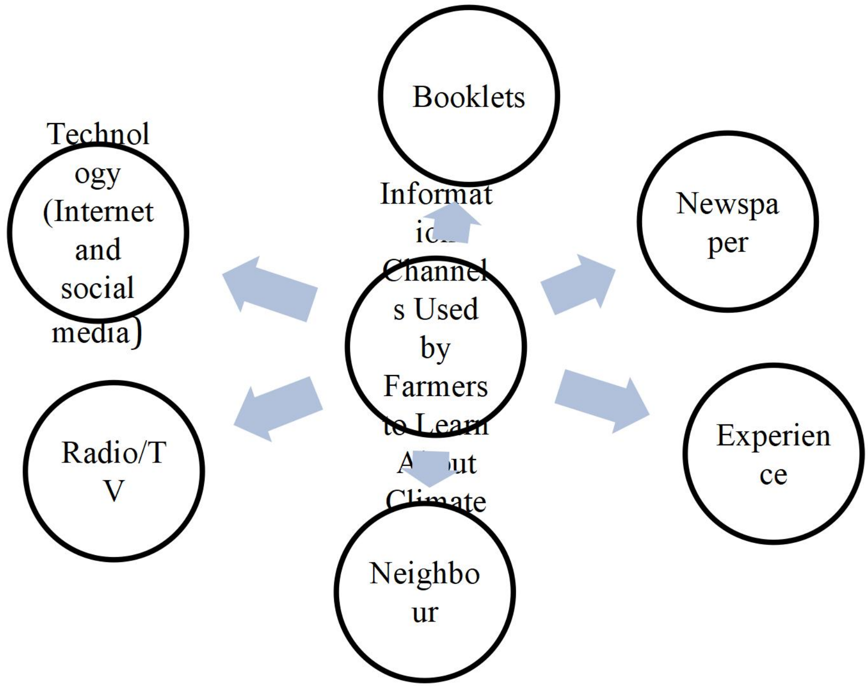
Information Channels Used by Farmers to Learn About Climate Change

Local farmers in Panchkhal Municipality receive climate change information through a blend of traditional knowledge and modern communication methods. Farmers' direct interaction with the land and climate provides valuable insights into climate change, as they observe and adapt to changing weather patterns and crop failures. Elderly farmers transmit their wisdom and adaptive strategies, such as rainwater harvesting and soil conservation techniques, to younger generations, fostering intergenerational knowledge transfer in rural communities. Farmers rely on radio and TV programs for weather forecasts, climate news, and adaptive farming techniques. With increasing mobile phone access, they receive climate information through apps, social media, and SMS services.

Local newspapers and booklets provide information on climate trends and government initiatives. Government agencies and NGOs collaborate on agricultural extension services and development programs to provide climate change information, offering guidance on climate-resilient farming practices and sustainable resource management. Local experts and key informants, such as farmers, leaders, and agricultural experts, provide tailored advice on climate change based on local environmental conditions. The diverse sources of information aid local farmers in comprehending and adjusting to the effects of climate change, enabling them to adjust their agricultural practices to maintain their livelihoods. Farmers engage in peer networks and community sharing, creating a local knowledge pool and fostering informal learning. Local farmer organizations and cooperatives also facilitate climate-related information and adaptive farming strategies. This source of information on climate change is illustrated in the schematic diagram:

Figure 12

Sources of Information on Climate Change



In a spatial perspective, farmers across different locations in Panchkhal Municipality rely on various sources to understand the effects of climate change on agricultural processes and production. These sources include personal experience, neighbours, radio/TV, and newspapers with experience being the primary source. The spatial distribution of knowledge-sharing practices is evident (see Table 16).

Table 16

Information Sources of Climate Change

Sources	Numbers [(Multiple response) n=568]	Percent
Experience	556	97.9
Neighbour	545	96.0
Radio/TV	412	72.5
Internet	137	24.1
Newspaper	105	18.5
Booklets	8	1.4

Source: Field Survey, 2020

Table 16 shows that 97.9 percent of farmers from diverse areas in Panchkhal receive climate change information through direct experience, shaped by their interactions with local weather and climate conditions. Farmers across various microclimates and terrains have shared knowledge and adaptations over generations, adapting to their specific geographic contexts. For instance, in the hill areas, an elderly farmer shared how he taught his grandson to preserve rainwater in deep wells for use during droughts, reflecting localized adaptation strategies. Similarly, in valley regions, indigenous practices such as seed protection, mulching, and seed fertilization are passed down during family gatherings, emphasizing how spatial proximity and community interactions shape knowledge transfer. These practices, adapted to different geographic conditions within Panchkhal, highlight the spatial variations in how climate change information is gained and shared, with personal experience remaining central to learning across diverse agricultural landscapes. Neighbouring farmers are another essential source of information about climate change through informal education systems. Ninety-six percent of farmers have received information about climate change from their neighbours about the agricultural process and production. In my qualitative interview, one of the farmers said, *Last year, I could not grow tomatoes due to lack of rain. But my neighbour X suggested that I use drip irrigation. In 2074, my neighbour took training on drip irrigation, which can be constructed cheaply, from Panchkhal Municipality's agricultural knowledge centre. I also liked this method because I had a water tap and could store the water in a tank and it directly irrigates the roots of the crops, so water is not wasted.*

Afterwards, I asked the neighbour about the need of materials required for making drip irrigation and collected the necessary material from the market and called a technician and connected it. Now I have used drip irrigation to irrigate tomatoes during water shortage, which is helping me to grow tomatoes.

This experience indicates that social networks using informal communication and friend circles are always important for learning. Although farmers have many ways to learn, informal learning from peers is important to climate change strategies. Inspired by the successful implementation by neighbours, the problem of tomato cultivation was solved by adopting drip irrigation. In the process of drip irrigation, technical assistance, including consultation with neighbours and collection of necessary materials, was provided. Even in the absence of rain, drip irrigation systems are proving to be effective in producing tomatoes during the dry season. Farmers who were interested in this method stored water in tanks and used it for irrigation. In this context, another farmer said,

Although I have some knowledge about drought-tolerant crops, I got practical ideas from one of my friends. He has returned from the training of Lob Green Nepal and suggested I plant DY 28 paddy and drought tolerant vegetables like cauliflower, cabbage, bitter gourd, and carrot. According to the suggestion of my neighbour, I planted this paddy in June and cauliflower in November. Those rice and cauliflower varieties need less water and produce better crops than before. I am still planting crops that need less water during water shortages.

This suggests that informal communications and neighbours are always important for learning. While farmers have several ways of learning, informal learning from neighbours is significant for climate change strategies. A trained farmer suggested planting drought-resistant crops due to climate change. Following his suggestion, farmers are now planting these crops for proper water management and effective cultivation. As a result, farmers are achieving good yields by selecting and planting the right seeds at the right time. During my field observation, I interacted with the farmers about climate change information sources through their neighbours. Farmers said that they use drip irrigation in tomato cultivation during the dry season. In the past, drip irrigation was not used, but now, due to climate change, water scarcity is increasing as water resources are drying up. A neighbour provided them with this knowledge after receiving training from Lob Green Nepal in 2075. As a result, some of the farmers are now using drip irrigation in vegetable cultivation. This method helps them manage water more efficiently and maintain crop yields despite the challenges posed by climate change.

Radio/TV is an important source of information about climate change, as farmers are getting information. Local farmers have been implementing adaptive strategies to climate change through radio and TV. About seventy-two percent of the farmers have obtained information on climate change through radio/TV. In this context, some farmers change their crop seeds and plants according to the changing climatic conditions by listening to the radio and watching TV. The qualitative data also supported that the farmers received information regarding climate change from various sources, including newspapers, radio, the internet, and TV. In the context, one of the farmers in Ward No. 3 reported,

Photo 3: Radio, Site: Panchkhal ward No. 12.
Source: Field Survey, 28 Dec. 2020

> *I always listen to the agriculture program from 6:40 to 6:55 pm on Radio Nepal. One day, I was listening to a program on climate change, flexibility about vegetable farming, and suitable soil and climate for cauliflower (khumal jyapu), which struck me. I was thinking of changing the species of cauliflower. So, I brought new cauliflower seeds from the nearest seed store and replaced the hybrid cauliflower that was being planted earlier. The cauliflower planted in November should be watered and weeded periodically, and spray medicine should be applied as needed. The production of cauliflower is better than before. I am still using this cauliflower, which gives a good yield according to climate change, during the time in the dry season*.

This suggests that informal communication and experience are always important for learning. Farmers receive information about climate change through various channels, including radio. Radio programme guides are adapting farming techniques to changing climatic conditions. After listening to the radio, farmers have changed their crop seeds to those better suited for the new climate. These new seeds have produced better yields than local seeds. Farmers especially use mobile phones to listen to radio programs. This easy access allows them to stay informed about agricultural practices and adopt the methods that resonate with them.   In this context, another farmer expressed similar views

> *I usually watch television programs after 7 pm. At the same time, one day I was watching a program on TV, a program was being broadcast on the topic of 'what crops to grow in the dry season'. The program was encouraging heat-tolerant vegetables that require less water, like radish, cauliflower, green vegetables, and kitchen gardens. The program deeply touched my heart, prompting me to consider planting greens. After interacting with friends, I purchased vegetable seeds from Banepa in Kavrepalanchok. I prepared the ground for the leaf vegetable and sowed the seeds of the leaf vegetable as before. Today's leaf vegetable is earning better than before. In this way, agricultural programs broadcast on TV are also helping to select crops according to the time.*

This suggests that television is playing a significant role in the adaptive strategies to climate change. While farmers are utilizing various learning methods, television is a significant tool for both informal and non-formal learning in climate change strategies. Television shows about raising crops during the dry season were viewed by farmers. These initiatives promote the planting of low-water-requiring, heat-tolerant plants. According to the advice, I have prepared the ground and sown the seeds as usual, but more greens were produced than before. It shows how farmers can choose suitable crops according to the changing climate with the help of TV programs, improving the efficiency and sustainability of their farming practices.-During my field observation, I noticed that the farmers used their mobile phones, especially to listen to the radio, to get knowledge about vegetable farming. They have succeeded in modifying their farming methods by listening to the agricultural program. Through the recommendation of crops and practices that are more tolerant of climate change, these programs guide how to decrease the effects of a changing environment. Farmers may increase crop yields and better manage climatic issues by observing this advice.

This emphasizes how crucial easily accessible media is to farmers' efforts to adjust to climate change, providing updates on resources and education to farmers and stakeholders. These days, the internet is gradually increasing the sources of climate change. About twenty-four percent of farmers have accessed information on climate change through technology such as the internet and social media about the agricultural process and production. In this context, farmers are searching for audio and video materials that are used on Facebook and social media. Around 24 percent of farmers have used Google, Bing, and Chat GPT to search for materials on climate change effects, causes of global warming, or climate change statistics. One of the farmers who has a BA degree in Ward No. 2 shared,

> *My daughter is studying Computer Engineering at Kathmandu University, and I asked her to identify drought-tolerant rice varieties. Due to increasing drought and shortage of water, I was thinking of changing to drought tolerant rice varieties. My daughter suggested planting Hardinath-4 paddy according to our soil and environment using the help of Google.*

This suggests that the younger generation is well-informed about the latest technological innovations. They offer the necessary knowledge for agricultural production according to the changing environment. Knowledge helps farmers select the crops based on the climatic conditions. The young generation has used the new technology and taught the old generation. Through technology, the farmers have identified drought-resistant paddy varieties and choose and plant them during water shortages in the dry season. In this context, other farmers said,

> *I interacted with the agricultural expert of the municipality; he also suggested planting the same Hardinath-4 paddy. Then, I went to Dhulikhel Agricultural Materials Institute and brought the seeds and prepared the seeds for the plantation in the first week of June. I planted and the paddy was ready to harvest in the first week of October. The yield of paddy was good, so I am still planting this paddy.*

These experiences suggested that informal communications and social networks using the friend circle are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. The agriculture consultant recommended planting drought-resistant crops.

The farmers have collected the drought-resistant seeds from agrovet shops and got them ready to plant during the changing times. The farmers are using drought-resistant crops such as paddy, maize, and vegetables. During my field observation, I interacted with the farmers about the paddy. They said that hybrid paddy was brought instead of local paddy. Farmers utilize this paddy due to its suitability in changing climatic conditions such as frequent droughts and water scarcity. Despite the obstacles of climate change, farmers have been able to maintain good production by adopting this drought-tolerant crop. It illustrates how farmers are modifying their crop choices in response to environmental changes to maintain food security and sustainable agriculture.

About 27 percent of farmers obtained climate change information from various newspapers such as Kantipur, Annapurna Post, and Rajdhani. In this context, another farmer expressed similar views that were derived from quantitative data,

> *I read about the impact of climate change on access to water in the Kantipur Daily of December 15, 2020, from the local ward office. It was mentioned that due to a lack of irrigation, farmers are attracted to crops that require less water. Farmers are attracted to cash crops in vegetables. According to that, I chose beans, long/snake beans, bitter gourd, and sponge gourd among the wave vegetables that require less water and can be grown even in drought. I discussed with the neighboring agricultural leader about vegetables, and he also suggested that I plant the same crops. The seeds were bought from a nearby seed shop and planted in April, and vegetables were harvested in June. The yield of vegetable crops is better than other crops when compared.*

This experience suggests that informal communications and newspapers are always important for learning about the selection of agricultural seeds in a changing environment. While the farmers have different techniques of learning, informal learning from newspapers is significant for climate change adaptive strategies. Due to the impact of climate change on access to water, farmers plant drought-resistant vegetables. Farmers utilize this paddy due to its suitability in changing climatic conditions such as frequent droughts and water scarcity. In this context, another farmer shared ward no. 13, a similar view that was derived from quantitative data:

> *I read the Annapurna post in January 2021 from the office of the municipality, about the shortage of water in agriculture. It was written, the water sources are gradually decreasing in Nepal. The farmers replaced the local crops and applied the hybrid crops because the local crops required a lot of water than the hybrid crops. The news touched my heart, and I also discussed with my neighbours and planned to grow leafy vegetables in a small area during the dry season. After that, I bought seeds of vegetables from the Dhulikhel Agricultural Material centre and prepared the land and sowed it in March. The crops have been successfully produced, and I am earning sufficient income. Even now, I am planting leafy vegetables that need less water in the dry season.*

This suggests that the newspaper information is a key source of climate change, as farmers get educated. Newspapers are an important source of information on climate change, but their use is declining due to the internet among farmers. Nowadays, some farmers are getting climate change information by connecting their mobile apps and other related information technologies to the Internet. During my observation, I saw leafy vegetables being cultivated in the dry season in the field and interacted with the farmers about this. They said, about three years ago, we did not plant vegetables in the dry season due to a lack of water. After reading a newspaper about vegetables, we have selected and planted drought-tolerant seeds that thrive in the dry season and adapt to environmental changes. Now we are planting drought-tolerant crops for better production.

A booklet is also a source of climate change information, providing farmers with knowledge about effective adaptive strategies and helping them adopt farming practices against environmental challenges. A few of the farmers (1.4%) have obtained knowledge of climate change through booklets. The farmers read booklets such as environment, forests, and climate change in Nepal, Climate change adaptive and disaster risk reduction project, Nepal, Social and environmental transition-Nepal, vegetable crops in Nepal, and probable future directions for improvements related to agriculture, and can choose the seeds and plants according to climatic conditions. One of the farmers shared,

> *I read the booklet of Climate Resilient Agriculture of Cucumber, Vegetable Crops in Nepal, and Possible Future Directions for Improvement on January 10, 2021. The booklet's title was "Dry Tolerance Cucumber," and it caught my attention. I knew little about it, and the booklet provided more information on drought-tolerant cucumbers. I planned to plant cucumbers in the dry season and brought seeds from the seed shop of Panchkhal Municipality. I planted the current cucumbers following the cucumbers I previously planted. However, compared to earlier, the current cucumbers are producing better.*

This practice suggests that informal communications and booklets are significant knowledge for learning. While the farmers have different ways of learning, informal learning from booklets is significant for climate change strategies. Farmers were educated about dry season seeds through booklets to select dry season seeds according to soil and water availability. In this way, even from booklets, farmers have been able to select crops according to time and get high returns. Some of the educated, literate, and trained farmers have adopted this type of knowledge. In this context, another farmer said,

> *I had read a booklet about the importance of off-season farming in Nepal. The booklet discusses the practice of off-season farming, specifically in the case of tomatoes. The title touched my heart, and I discussed it with the agricultural expert of the study area and decided to plant it. Then I collected seeds from the seed shops of Panchkhal Municipality, and the field was prepared for tomato planting in July to ensure a good yield and harvest in October. He said that even though the production of tomatoes was low at that time, I managed to earn a good income due to the festival. Even now, I am planting tomatoes in the off-season.*

This suggests that the booklet is a useful source of climate change information, providing brief and important knowledge that contributes to farmers' awareness. It helps to understand adaptive strategies and their implementation in local contexts. The farmers got knowledge about shifting crop production, like tomatoes. According to the changing climate, the farmers have changed the order of planting and sowing the crop species. Climate change is affecting traditional crop production cycles in the agricultural sector, and farmers are shifting to more flexible crops and producing environmentally friendly agriculture.

Perception of Climate Change

The study reveals that the perception of climate change exists among the farmers, which has a direct impact on the agricultural process. It is, therefore, very important to understand the perception, especially because it has an impact on the decisions of the farmers. In this case, climate change is defined as changes in rainfall, temperature, and extreme weather occurrences, which have a very impact on farmingIn order to find out the perceptions of the farmers, ten variables were created to classify the perceptions of the farmers.

The variables were employed to create the perceptions of the farmers on a Likert scale, which was measured using the scale of Strongly Disagree (SD = 1) to Strongly Agree (SA = 5), with the options being Disagree (D = 2), Undecided (U = 3), and Agree (A = 4). The researcher, therefore, was able to found the perceptions of the respondents by creating the level of agreement and disagreement of the farmers with the statements regarding climate change (see Table 17).

Table 17

Perception of Climate Change (n=568)

Variables	Min.	Max	Mean	SD	Interpretation
The climate has changed over the last four decades	1.00	5.00	3.67	1.07	Moderate to high agreement; participants generally agree that the climate has changed.
Climate change is caused by human activities	1.00	5.00	4.04	.96	High agreement; strong belief in anthropogenic causes
The world issues in climate change	1.00	5.00	3.68	1.04	Moderate agreement; awareness of global climate issues is notable.
Global warming is rising due to climate change	1.00	5.00	3.97	1.03	High agreement; participants perceive a link between global warming and climate change.
Climate change is the change in average weather	1.00	5.00	3.63	.95	Moderate agreement; fair understanding of the climate definition.
Climate change is making a hole in the layer	1.00	5.00	3.68	1.00	Moderate agreement; indicates some misconception about climate change vs. ozone depletion.
Deforestation is the cause of climate change	1.00	5.00	3.86	1.13	High agreement; deforestation is widely perceived as a cause.
More use of organic fertilizers is due to the climate	1.00	5.00	2.75	1.26	Low agreement; weak perception of this linkage.
Pollution from industry causes climate change	1.00	5.00	3.81	1.03	High agreement; strong perception of industrial contribution.
Climate change is the cause of poor waste Management	1.00	5.00	3.92	1.12	High agreement; possibly a confusion of cause and effect

Source: Field Survey, 2020

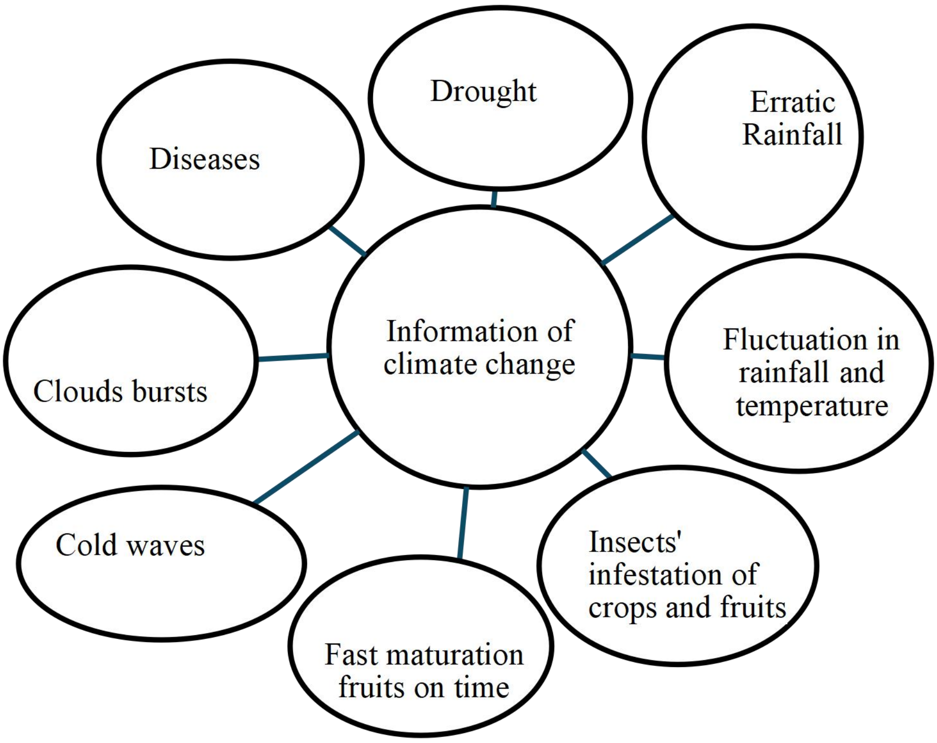
Table 17 shows the farmers' attitudes towards climate change, according to the 5-point Likert scale, indicating that the statements with mean values greater than 3.5 will represent agreement or recognition. Above all, the highest mean value of 4.04 indicates a strong belief that human activities are the significant drivers of climate change. Similarly, there is strong agreement on issues concerning the rise in global warming (mean = 3.97), the impact of industrial pollution (mean = 3.81), deforestation (mean = 3.86), and incorrect waste management (mean = 3.92), indicating a very good awareness of the main causes and implications of climate change. Conversely, the lowest mean score of 2.75 for the increased use of organic fertilizer as a climate change adaptation measure expresses a weak or indefinite perception of such a link. The same pattern is observed in the moderate mean score of 3.63 for the basic definition of climate change, showing only a fair understanding. In addition, moderate agreement that climate change causes a hole in the ozone layer (mean = 3.68) reveals a common misconception among the respondents. In total, while there is moderate to high agreement on most of the topics of climate change—especially anthropogenic causes—there is still some misunderstanding of concepts like the utilization of organic fertilizer and the distinction between climate change and ozone depletion. Standard deviations around 1 for all the statements illustrate moderate variation in the responses, which indicates partial knowledge with some misinterpretations but no polarization. Farmers tend to be high on climate change awareness and its main human causes, with some misconceptions and science knowledge gaps (see Table annex G).

Information of Climate Change on Agricultural Production

Climate change significantly impacts agricultural production, influencing crop yields and farming practices. Unpredictable weather patterns and extreme climatic conditions significantly reduce agricultural productivity and increase crop vulnerability. The various impacts of climate change on agricultural production and its impact on various agricultural processes and production. The impact of climate change includes drought, erratic rainfall, fluctuation in rainfall and temperature, insect infestation of crops and fruits, unripe crops and fruits on time, cold waves, cloudbursts, and wind blows as cyclonic winds. The following schematic diagram is given below:

Figure 13

Information of Climate Change



Drought-induced climate change increases water access, crop production, food insecurity, and economic hardship due to reduced crop production and food insecurity (see Table 18).

Table 18

Information of Climate Change

Variables	Numbers [Multiple response](n=568)	Percent
Drought	464	81.7
Erratic rainfall	412	72.5
Increase in temperature	398	70.1
Increase disease in crops and fruits	265	46.7
Not ripening crops and fruits on time	232	40.8
Cloudburst	25	4.4
The wind blows as a cyclone	14	2.5

Source: Field Survey, 2020

Table 18 shows that the impact of climate change due to drought is felt by about eighty-two percent of farmers. Drought is a period of low rainfall that leads to water scarcity, which poses significant challenges to farmers in Panchkhal Municipality. For example, one of the farmers shared,

Photo 4: Drought, Site: Panchkhal ward: No.12, Source: Field Survey, 2020, 27,Dec.2020

> *This leads to a shortage of water, delay in planting, hence financial problems and no food for the farmer. Last year, farmers planted paddy in July instead of June because there was not enough water. Drought, caused by climate change, is the main problem, forcing some farmers to move temporarily and permanently.*

This suggests that informal communications and experience are always important for learning. While the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. The farmers have changed the cropping time due to climate change.

Droughts led to water shortages, delayed planting, economic hardship, food insecurity, climate change, and imposed migration for farmers, which was worsened by delayed paddy planting and adverse conditions. In the context of other farmers' shared,

> *Due to the drought, I had chatted with the family about the drought in the evening time for dinner. The father said, due to lack of crop production to fulfil the shortage of food the son went to Qatar to earn money. As a result, due to the drought, the farmers are not able to harvest the crop during the season and the agricultural produce had suffered a great loss in 2068.*

This suggests that the informal communications and experiences of the farmers are facing different problems in cultivation. Farmers are transferring intergenerational knowledge to their younger generations, which is crucial for climate change strategies. The knowledge of old people is crucial for adaptive strategies in the context of agricultural planting in the face of climate change. Climate change has led to food shortages, prompting farmers to adopt alternative adaptive strategies. During my field observation, I saw the dried up crops that were not planted, and I interacted about the water sources. The farmers said that, due to a lack of permanent irrigation, especially in the dry season, we are dependent on the rainfall for cultivation. The farmers added that without timely rain, the crop could not be planted, and the land would become barren.

The impact of climate change due to erratic rainfall patterns poses significant threats to agricultural challenges such as soil erosion, crop loss, and disrupted planting schemes, food production, and livelihoods. About seventy-two percent of farmers are affected by climate change, mainly due to erratic rainfall. Erratic rainfall patterns have disrupted traditional agricultural practices, impacting crop growth cycles, soil moisture content, and overall agricultural productivity. Erratic rainfall complicates water resource management, affecting communities, on rain-fed agriculture, leading to food insecurity, economic distress, and increased external resource dependency in the study area. For example, one of the farmers reported,

> *I am changing the schedule of planting and harvesting according to the rain as it depends on the rain. Plants that require constant moisture suffer from water shortages during dry periods. Low rainfall sometimes results in loss of crops, lack of rain on time and sometimes the land remains barren. While last year, paddy was planted in the beginning of June, this year, due to lack of rain, paddy was planted at the end of June.*

This suggests that informal communication and experience always provide important knowledge of changing planting dates. Due to erratic rains, some farmers have left their land barren, which has reduced crop production. Although farmers have many ways to learn, informal learning from peers is important for climate change strategies. Keeping in mind the effects of climate change, farmers have started adjusting their harvesting and planting times. As most of the arable land is dependent on rain, some land has not been able to be planted due to a lack of rain. If there is no rain on time, there will be a huge impact on planting and harvesting dates in agriculture. In this context, another farmer said, "*Last year, due to a lack of rain, I could not sow corn on time. I used to sow corn in March, but now they have to sow it in April*." This suggests that informal communication and experiences are always important sources of knowledge acquisition for learning. Farmers rely on rainfall for planting crops. Due to the erratic rainfall, the farmers could not plant the crops in time. While the farmers have several ways of learning, experience is significant for climate change strategies. During my field observation, I observed that the farmers have altered the sowing date.

Farmers are adapting their sowing and planting dates due to changes in rainfall, as climate change impacts rainfall, necessitating adaptation.

Due to an increase in temperature is evident in various phenomena such as rapid melting of glaciers, changes in rainfall patterns, and increased risk of heat illnesses in both humans and livestock. Around seventy percent of farmers have felt the increase in temperature. One of the farmers said,

> *Compared to ten years ago, I have experienced that the winters are getting shorter, and the summers are gradually getting longer. Because earlier I saw frost in the winter season, but now I don't see frost in winter season. This indicates that winter is gradually decreasing, and summer is increasing day by day.*

This suggests that informal communication and experience are always important for learning. While the farmers have several ways of learning, informal learning from experience is significant for understanding the impact of climate change. Climate change is likely causing a change in seasonal patterns, affecting the length and intensity of different seasons. During my field observation, I interacted with the farmers about the temperature. The farmers reported that, in the past, we could not feel the high temperature in this area, but now we have been feeling the high temperature over the past ten years due to climate change.   The increasing incidence of plant diseases, influenced by climate change, poor pest management, and soil health issues, poses significant challenges to agricultural productivity and food security.

Rising temperatures and changing rainfall patterns increase crop vulnerability to pests and diseases. Ineffective pest management and soil erosion have increased with chemical fertilizers and agricultural techniques, emphasizing the need for integrated pest management and climate change adaptation. About forty-seven percent of farmers felt that the disease was in crops and fruits. One of the farmers reported, “I observed that the increase in diseases like fungus, late blight, and root cutter insects is due to excessive use of fertilizer and pesticides in crops. Last year, the crop borer was attracted to the crop field and caused a large amount of damage to the maize." This suggests that informal communication and experience always provide important knowledge for learning. While there are many ways to educate farmers, informal education is an important means of gaining knowledge about the impact of diseases on agriculture through the experience of learning.

The study area is experiencing an increase in crop diseases due to the improper use of chemical fertilizers and pesticides. In this context, another farmer in Ward No. 11 shared, "*Due to climate change, an unknown disease occurred in tomatoes in 2072. There was a huge loss of tomatoes because of the lack of timely treatment. My friends were also unable to provide me with appropriate suggestions*." This experience suggests that informal communications and friends are always providing significant knowledge for learning. While the farmers have several ways of learning, informal learning from friends is significant for the impact of climate change, and has attracted different unidentified diseases that appeared in the study area in which impact on agricultural production. Climate change has caused new diseases and led to significant crop loss due to a lack of timely treatment and the lack of the right advice. During my field observation, I interacted with the farmers about diseases; they said in the past, we could see some types of diseases in this area, but now, due to climate change lot of different types of diseases have appeared, and some of them have not been identified, and they caused loss of crop production.

Climate change, erratic rainfall, temperature variation, and prolonged cloud cover cause untimely crop harvesting and planting, leading to decreased yield and quality in crops. As a result, agricultural crop output and quality are reduced. Unusual weather patterns make crops more vulnerable to disease, which diminishes productivity even further and affects food security. This situation has emphasized the need for disease management strategies and adaptive farming approaches to meet the challenges presented by climate change. About forty-one percent of farmers observed that the crops do not ripen and fruits on time, as which the farmers have observed fast maturing of crops and natural products due to climate change. One of the agriculture experts shared,

> *Earlier, the paddy crop used to ripen in the month of November, but now due to climate change, it has started ripening in the month of October. The effect of climate change has been seen in mango, banana and other crops like tomato, cauliflower, and bitter gourd.*

This suggests that informal communication and experiences are always important for learning. While the farmers have several ways of learning, informal learning from an expert in agriculture is significant for the impact of climate change on crops. They changed the planting and harvesting times due to climate change. In the past, farmers planted and harvested crops later than they do at present. In this context, another farmer said, “In the past, Bombay mangoes bloomed at the end of April and ripened at the end of June, but now Bombay mangoes bloom at the beginning of April and ripen at the first of June.” This suggests that informal communication and experiences always provide important knowledge for learning. Farmers have experienced that the weather is changing in the study area, and the planting and harvesting times are also changing. Today, the ripening time of mangoes has shifted earlier than in the past. During my field observation, after seeing mango blossoming in the first week of April in the garden, I talked to the farmers about mangoes; they said,

> *About 15 years ago, mangoes used to bloom towards the end of April. However, due to climate change, mangoes bloom from the first week of April, and fruits like lychee and avocado also bloom sooner than in the past, according to farmers.*

The effects of climate change due to cloudbursts show damage to foundations, which pose significant threats to public security, agricultural efficiency, and greater community flexibility.

Cloud bursts and intense downpours cause severe floods, soil erosion, and agricultural output in the study area. Extreme weather events strain infrastructure, reduce agricultural output, and burden community resilience. Local farmers to mitigate climate change effects, enhanced infrastructure, improved water management, and comprehensive disaster preparedness strategies are crucial. A small number of farmers (4.4%) have felt the cloudburst due to climate change, in which they reported experiencing cloudbursts, a strong and sudden precipitation occasion. One of the farmers reported,

> *Ten years ago, due to bursting clouds and heavy rains; the Jhikhu River flooded and drowned the planted paddy and caused huge loss in agriculture production. Impact of climate change due to cloud bursts present significant challenges, including increased threats of streak surges, avalanches, and framework damage.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from experiences is significant for understanding the impact of climate change. River floods caused by climate change destroyed many crops in the study area. During my field observation, I discussed with the farmers about cloudburst; they informed me that some parts of the study area were flooded after heavy rains in the past. However, due to climate change, sometimes droughts cause huge losses in agricultural production.

The impact of climate change is significant due to cyclonic activity, which increases the risk of large storms, high winds, and floods. These events pose significant threats to infrastructure, agriculture, and public safety, emphasizing the need for robust disaster preparedness measures, strong infrastructure development, and community-based adaptive strategies to mitigate the adverse impacts of cyclone events and increase overall flexibility to climate change. A few farmers (2.5%) are affected by climate change, mainly due to the wind blowing as cyclonic winds. The cyclonic wind pattern, characterized by rotation of the atmospheric system, poses significant problems to the Panchkhal Municipality from a climate change perspective. Sometimes, cyclones produce devastating effects such as strong winds and heavy rains in the study area. For example, one of the farmers shared, "*In 2065, the cyclone came and destroyed the maize and caused huge economic losses. However, such a type of cyclone sometimes occurs in the study area.* "This suggests that informal communication and experience are always providing important knowledge for learning. While the farmers have several ways of learning, informal learning from experience is significant for understanding the impact of climate change. Sometimes cyclones in the study area cause severe agricultural devastation and financial hardship, highlighting the region's vulnerability to extreme weather events and their potential impact on the local economy. During my study, I interacted with the farmers about cyclones. In the past, cyclones caused significant crop production losses, but small cyclones occasionally could not significantly impact agricultural production.

Disease in Agricultural Crops

Due to climate change, the temperature and humidity in Panchkhal Municipality have increased, and the way for fungal diseases in crops has opened. Hill slopes are susceptible to various diseases, including root rot and waterborne diseases. Dry conditions develop susceptibility to drought-tolerant insects and diseases. Although there is quick access to disease control measures in the valleys, there is limited access in the hilly areas. Low soil fertility makes crops weak and, therefore, more vulnerable to diseases. While farmers reveal that pests and diseases in crops also adversely affect agricultural practices. Trends of crop diseases have evolved depending on local agricultural practices and environmental factors (see Table 19).

Table 19

Disease in Crops

Statements	Response	Numbers (n=568)	Percent
New diseases in crops	Appeared	498	87.7
	Not appeared	70	12.3
Name of diseases	Late blight (Daduwa)	144	25.3
	Army insects	64	11.3
	Borer (Cutworm)	33	5.8
	Salah insect	22	3.9
	Black field cricket	9	1.7

Source: Field Survey, 2020

Table 19 shows that approximately 87 percent of farmers believe a new disease has emerged in their crops. The farmers believe that the various crops that appear in agriculture crops include late blight diseases, salah insects, borer, black field cricket, and fall armyworm. Crops affected by late blight disease develop conditions that encourage the establishment of infesting insects, which are attracted to cold, moist surroundings.

Climate change is increasing humidity and precipitation, making it easier to spread, and may extend crop infestations, potentially affecting the geographic distribution of late blight. About 25 percent of farmers believed that the crops were destroyed by the late blight insects. Due to this disease, the leaves of crops dry up, and the crops do not bear fruit. It is found in abundance in crops such as rice, corn, and potatoes. As a result, if not treated in time, this disease causes great damage. For example, one of the farmers shared, "*In 2076, the late blight disease caused major economic losses to the paddy. The delay in detecting the disease had a major impact on farmers' livelihoods and the overall food supply*." This suggests that informal communications and experiences are always important for learning. Although the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Due to the increase in temperature, various diseases have appeared in crops, and it causes damage to many crops. One of the farmers reported, "*In October 2071, a kind of disease appeared in cattle. But even the veterinarian could not identify the disease. As a result, due to a lack of proper treatment, some cows have died*." This suggests that informal communications and experiences are always important for learning. Although the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. An unknown disease appeared in the animals, and even the veterinarians could not identify it in time. As a result, many animals died and causing a lot of financial loss.

During my field survey, I discussed the disease with the farmers. They said that various insects/ diseases appeared in the study area due to climate change. Some diseases could be identified in time, and some could not. If I could not identify the disease in time has been severely damaged.

Climate change is affecting the distribution and activity of armyworms, which are significant agricultural pests. Climate change, including warmer temperatures, changed precipitation patterns, and increased extreme weather events. It can enhance the survival and spread of army insects, expanding their geographical range, and influencing their food sources and habitats.

Armyworms are a serious threat to crops like maize and rice, and local farmers are facing them. Effective pest management techniques, including early detection and integrated approaches, are crucial for preserving agricultural productivity. About eleven percent of farmers believed that the crops had been destroyed by armyworms. Due to the disease, a leaf of the crop dries and becomes fruitless, affecting the crop production and overall food supply. It is an impact of changing climatic conditions in the study area. One of the farmers shared the experience of the diseases, "*In 2074, the army worm first appeared in ward no. 2 after it was attracted to the paddy crops and destroyed a large amount of agricultural production, and other wards were also attacked.*" This suggests that informal communications and experiences are always important knowledge for learning about diseases. Although the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Due to climate change, various diseases have affected the crops, and the economic condition of each ward has suffered. During my observation, I talked with the farmers. They reported that in the past five years, we did not see the army of insects in this area, but now such types of disease have appeared and destroyed the paddy. During the ripening of paddy, many of these insect species appear, leading to the destruction of the crop.

Climate change contributes to the spread of blight disease by fostering supportive environments. Climate change-related increases in humidity and warmer temperatures create the perfect setting for blight germs. The frequency and severity of blight disease outbreaks are increasing due to these shifting weather patterns, which influence agricultural productivity. About six percent of farmers believed that the crops had been destroyed by the late blight disease, which cuts the hollow of the root, and the crop dries up without bearing fruit. It appears in the paddy crop through pollination. As a result, there is a big loss in paddy production. In this context, a farmer reported,

> *In 2075, the main part of the paddy was cut and dried due to late blight disease. As a result, the entire crop died without bearing fruit. Due to the failure to treat the disease in time, the overall agricultural production of this area has decreased. In the evening, after eating, my father used to watch TV and inform the family about the disease. For many years, certain diseases have emerged in the study area, causing significant crop loss, while unidentified diseases have also emerged due to climate change.*

This suggests that informal communication and inter-generational chatting always provide important knowledge for learning. While inter-generational chatting has several ways of learning, it is significant for climate change strategies. The disease is attracted to the crops, but in the past, many diseases did not appear in crops. In the past, few diseases attracted but now, due to climate change, many diseases are affecting the crops. In this context, another farmer said, "*Five years ago in ward no. 5, the late blight disease cut off the leaves, stems, and other parts of the greens in maize, which resulted in the loss of the entire crop and huge economic losses."* This suggests that informal communications and experiences are important knowledge for learning. While the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Climate change has led to significant economic losses due to diseases, resulting in the complete loss of agricultural production. During my observation, I discussed with the farmers about the late blight disease. They said, this disease cuts the soft part of the crop, so if it is not treated in time, the whole crop will dry up and cause significant crop damage.

Other Diseases and Pesticides

Due to the climate change, pesticide use is increased in insect-borne diseases, drought-resistant pests, and difficulties in timely pest control, which are exacerbated by increased temperature, fragmentation of land, and deforestation arising from climate change in Panchkhal Municipality. Other crops, diseases and pesticides are included (see Appendix J)

Adaptive Strategies to Mitigate Climate Change

In Panchkhal Municipality, adaptation strategies in response to climate change include valleys on hill slopes. Farmers in valleys use intensive irrigation systems and techniques for water conservation, while farmers on hill slopes practice terracing to prevent soil erosion. They diversify sources of income and adjust planting and harvesting times. Rising temperatures and unpredictable rainfall are considered impacts of climate change that cause issues of pests and disease, water scarcity, drought, cloud outbursts, flooding, and soil erosion. In the study area, extreme weather events related to storms, hurricanes, and floods have massively damaged crops, infrastructure, and the well-being of farmers. In addition, the increase in atmospheric CO_2 levels can increase plant growth but also decrease crop nutritional value and increase climate stress in the study area. The local farmers have implemented indigenous adaptive strategies and new adaptive strategies to mitigate the effects of climate change on their agricultural practices in Panchkhal Municipality.

Indigenous Adaptive Strategies

Local farmers have used various indigenous adaptive strategies such as the use of local seeds and fertilizer, agroforestry and biodiversity, Traditional pest and disease Management, and Community-Based Adaptation. These strategies are used to minimize the impact of climate change, which are rooted in local ecological knowledge within communities. The ecological knowledge is different from one place to another. The indigenous strategies are derived from the social systems, like community labour sharing, equitable resource distribution, seed banks, and disaster risk management, enabling communities to jointly implement adaptations, with local institutions playing a crucial role.

This strategy has used local resources, knowledge, and skills, and aims to reduce external inputs such as crop varieties, farm fertilizers, pesticides, and modern adaptive tools. Adaptation strategies focus on vulnerability reduction and sustainable resource management, considering long-term environmental changes. Indigenous knowledge and belief systems inform practices, promoting stewardship, equity, self-reliance, and respect. Farmers' adaptations are dynamic, evolving, and influenced by observations, experiments, and innovations in response to climatic, economic, and social changes. Their strategies aim to ensure agro-ecosystems and food security among climate risks like droughts, floods, and landslides (see Table 20).

Table 20

Indigenous Adaptation Strategies

Statements	Response	Numbers (n=568)	Percent
Methods of Indigenous agriculture practice	Application of indigenous knowledge	443	78.0
	Use of local seeds and fertilizer	156	27.5
	Agroforestry and biodiversity	113	19.8
	Traditional pest and disease Management	91	16.2
	Community-Based Adaptation	83	14.5

Source: Field Survey, 2020

Table 20 shows how farmers adapt diverse indigenous adaptive strategies to mitigate the impact of climate change on their agricultural practices in my study area. The schematic diagram of indigenous adaptation strategies is given below:

Figure 14

Indigenous Adaptation Strategies

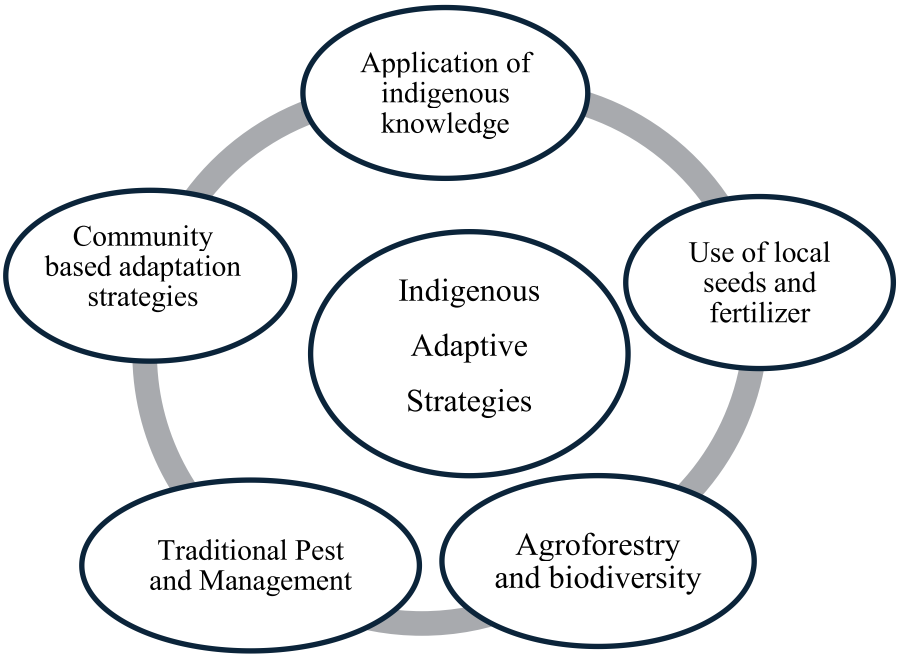


Figure 14 indicates that seventy-eight percent of farmers are utilizing indigenous adaptive strategies like crop varieties, farmyard manure, rainwater harvesting, and indigenous tools. Utilizing local seeds and fertilizers promotes biodiversity and adaptability to local conditions. These seeds are better suited for development and stronger against diseases. Increasing agricultural flexibility using indigenous seeds and fertilizers is a successful indigenous adaptive method. Local fertilizers, like compost manure, improve soil health and reduce chemical inputs, improving agrarian efficiency and community adaptability. However, only about twenty-eight percent of farmers in Panchkhal Municipality are utilizing local seeds and fertilizer. The use of indigenous adaptive strategies by local farmers, which considers local seeds and fertilizers beneficial, aims to improve farmers' adaptability, cost-effectiveness, and cultural knowledge. Farmers use cheap seeds and compost fertilizers, which help reduce costs and conserve soil moisture, as well as minimize the impact of climate change.

The farmers have used traditional seeds and homemade fertilizer in the study area. However, the use of these fertilizers and pesticides does not produce well due to a lack of chemical fertilizers and the prevalence of various crop diseases. In this context, one of the farmers shared, "*I have received the training on organic fertilizer through the Lob Green Nepal and utilized it in cauliflower, but it did not produce good results. But I am trying to produce better agriculture*." This suggests that non-formal communications and experiences always provide important knowledge for learning. Although the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. Farmers were trained to use organic fertilizers on vegetables. But due to the lack of use of modern fertilizers, good production has not been achieved. During my observation, I discussed with the farmers about the Lob Green Nepal. They said, the Lob Green Nepal is a leading INGO in this Municipality, organized ongoing workshops, training, and knowledge of climate change education to enhance local adaptive strategies, promoting the incorporation of local seeds and fertilizer into farming practices to mitigate the impact of climate change.

Photo 5: *Avocado Site: Panchkhal ward No.12, Source: Field Survey, 27 August, 2020*

The use of agroforestry and biodiversity is an important Indigenous adaptive method to improve flexibility and sustainability in agriculture. This method enhances sustainable agricultural practices, natural preservation, biodiversity, and climate protection by integrating trees and shrubs, improving resource management, and ensuring food security in Panchkhal Municipality. Only about twenty percent of farmers are utilizing agroforestry and biodiversity to promote sustainable practices for soil conservation, carbon sequestration, and biodiversity. One of the farmers in Ward No. 5 shared,

> *In 2072, the Lob Green Nepal had provided the training of agroforestry and biodiversity practice in agriculture. The training touched my heart and I also applied it. Through training, I have also succeeded in increasing income through biodiversity, improving climate flexibility, diverse land use, selection of tree species, soil health improvement, community participation and tree care.*

Photo 6: *Asuro Plant, Site: Panchkhal ward No.3, Source: Field work, 27 July,.2020*

This statement suggests that non-formal communications and experiences always provide important knowledge for learning. Although the farmer has several ways of learning, non-formal learning from training is significant for climate change strategies. For example, the local farmers used agroforestry and biodiversity practices over the centuries. They have still applied indigenous agricultural adaptive strategies to increase agricultural productivity in food crops, cash crops, timber, or

Photo 7: *Insects Trap, Site: Panchkhal ward No.3, Source: Field work, , 27 Dec. 2020*

fruits against climate-related uncertainties. In addition, another farmer adopts new farming methods within indigenous practices for mitigating the adverse effects of climate change. For example,

> *Since 2068, I have been planting 25 grafted avocado plants, thanks to agriculture training provided by Lob Green Nepal. The avocado plant began to bear fruit after 4 years. In the initial year the production was about 25 kg per plant, nowadays it is about 250 kg per plant. I sold this product in the local market for 200 to 250 rupees per kg. It helps to increase my income for supplementing income from crop production. It also conserves soil moisture content during the dry season.*

This statement suggests that informal communications and training always provide important knowledge for learning. Among the various ways of learning, non-formal learning from training has been found as a significant factor for learning strategies of climate change. Farmers have benefited from agriculture by being trained to adopt climate change adaptive strategies. Due to climate change, these days, farmers are getting better crops by farming. During my fieldwork, I interacted with farmers about the agroforestry program, which helped them learn strategies to deal with climate change in farming. In this context, during the interaction time, farmers said an agriculture adaptive strategy helps to initiate an agroforestry program to encourage farmers to plant fruits and nitrogen-producing crops, thereby maintaining soil humus and enhancing soil fertility as well as increase in agricultural productivity.

Traditional pest and disease management practices are crucial indigenous adaptive strategies for preserving agricultural health and productivity. Farmers have also been using intercropping, familiar planting, and traditional pest and disease management practices in vegetable crops. The target is to enhance agriculture, preserve biodiversity, and adapt to the effects of climate change. Table 20 indicates that about sixteen percent of are utilizing traditional pest, insect trap, and disease management practices as indigenous adaptive strategies due to their effectiveness, low cost, and compatibility with local ecosystems.

One of the farmers shared,

> *I have used farming practices like crop rotation; diversification, traditional breeding, Seed saving and timing crops to break pest and disease cycles help protect plant species and reduce the need for chemical pesticides. I used natural pest management practices based on local plants, like the green leaves of Neem, Ashuro (Adhatoda vasica), and Titepati (Artemisia vulgaris) in vegetable farming in small areas. Due to lack of market, I have only planted these health-promoting crops in a few areas.*

Photo 8: *Titepati Plant, Site: Panchkhal ward No.3, Source: Field work, 27 July,.2020*

This suggests that training and experiences are always important for learning. Although the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. Farmers in the study area have utilized organic pesticides, which are readily available in the local area. Due to the increased immunity of insects, chemical pesticides have become mandatory in disease control. Because of the lack of a suitable market for selling the agricultural produce, farmers practice organic farming in small areas. In this context, another farmer said, "I have used indigenous knowledge in my agricultural practices, such as the use of organic compost, domestic pesticides, and drought-resistant seeds of paddy, maize, and vegetables." This suggests that informal communication and experiences always provide important knowledge for learning. Although the farmers have several ways of learning, informal learning from experience is significant for climate change strategies.

The farmers have used drought-tolerant seeds and organic pesticides, and fertilizer according to climate change while producing well. In this context, another farmer reported, "*I have used only compost manure and pesticides of the Neem, Titepati (Artemisia vulgaris) juice, and cattle urine in the green leaf. However, the production processes were not being carried out effectively without the use of chemical fertilizers and pesticides*." This suggests that informal communications and experiences are always important for learning. Although the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. Farmers have been using traditional fertilizers and pesticides on their crops. The use of modern chemical fertilizers and pesticides is crucial for the successful production of crops. During the observation, I saw the organic farm of leafy vegetables and interacted with the farmers about organic farming. Farmers reported that we have received the training on IPM from the Lob Green Nepal and planted the leaf vegetable through the IPM method. According to this method, the farmers had used the local seeds and disease management for improving soil fertility and moisture in adverse conditions of climatic variability. However, the crop does not do well in production because of a lack of chemical fertilizers and pesticides. Community-based adjustment practice is important for developing effective adaptive strategies to climate change.

Community-based adjustment practice is important for developing effective adaptive strategies to climate change. It is an effective adaptive strategy to tackle the environmental challenges that involve local communities in identifying, organizing, and implementing activities. Community-based adjustment is to enhance climate change flexibility by leveraging collective information, assets, and social systems. Table 20 indicates that 14.5 percent of Panchkhal Municipality farmers use community-based adaptive strategies. One of the farmers shared, *Community-Based Adaptive (CBA) promotes farmer collaboration, resource combining, and ecosystem-based approaches, preserving biodiversity and ecosystems. It develops early warning systems, risk reduction measures, and empowers farmers with adaptive practices. Farmers shared knowledge of community-based adaptation; I have selected climate-friendly seeds and irrigation systems for crops such as potatoes, tomatoes, cauliflower, and cabbage based on local climate and water availability.*

This experience suggests that informal communications and experiences always provide important knowledge for learning. Although the farmers have several ways of learning, informal learning from training is significant for climate change strategies. Community-based adaptation includes the cooperation of farmers, sharing of resources, and ecosystem-based practices to protect biodiversity and ecosystems. It helps choose climate-friendly crop irrigation methods and seeds.

During my observation, I interacted with farmers about the CBA. They said, we have chosen eco-friendly crops according to the availability of water resources. In the past there was availability of water resources in the winter season but now due to increase of the temperature the water sources have dried up and the cropping system depends on the rainfall. The Community-Based Adaptive (CBA) is the best indigenous approach to mitigate the impact of adaptive strategies in my study area.

New Adaptive Strategies

Local farmers adopt new adaptive strategies to address the challenges caused by climate change such as changing planting date, changing plant species and use of chemical fertilizer and pesticides. They emphasize the significance of climate-tolerance crops, empowering Panchkhal farmers to sustain sustainable growth and cultivate them and implementing adaptive strategies. New agricultural strategies and adaptive methods are used to improve productivity and reduce greenhouse gas emissions under adverse conditions of climate variability (see Table 21).

Table 21

New Adaptation Strategies

Variables	Multiple responses, Numbers (n=568)	Percent
Changing planting date	512	90.6
Changing plant species	501	88.2
Use of chemical fertilizers and pesticides	498	87.7

Source: Field Survey, 2020

Table 21shows the new adaptation strategies of the study area. The table reveals that about ninety-one percent of farmers change their planting dates to await a suitable climate for planting their crops. In my Field Survey, I observed that local farmers delayed planting paddy until July or August due to rivers drying up from drought. As a result, they were forced to delay their planting dates until sufficient rainfall was available. Planting dates have been rescheduled to May due to earlier rainfall patterns to improve plant growth and increase yield by adapting cultivation methods to changing climatic conditions. In this context, a farmer said,

> *The effects of climate change have led to droughts, floods, and landslides. I have been learning to respond to climate change through my experience, and I have been changing the planting time to adapt to climate change for a long time. This has changed the planting time of rice, like other crops, to be earlier than in the past. As a result, the planting and harvesting times have also changed.*

This statement suggests that by changing the timing of plantings to adapt to climate change. Climate change has changed the timing of planting and harvesting crops, resulting in earlier and later planting times. While the farmers have several ways of learning, experience is significant for climate change strategies. In this context, another farmer said, *In the past, I had sowed the local seeds of maize in March but now I am sowing the seeds of Maize in April due to a lack of sufficient rainfall and waiting for it. Planting crops depends on rain, and if it doesn't rain on time, fields sometimes will remain barren.*

Photo 9: *Cauliflower Farming, Site: Panchkhal ward No.3, Source: Field work, 27 July,2020*

This suggests that informal communication and experiences are always important for learning. While the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Climate change is the major cause of changing planting dates in the Panchkhal area. During my field observations, due to late rains, farmers had to adjust their maize planting schedule. Instead of sowing maize seed first, they sow seeds in alternate periods. This adaptive strategy agrees with them to work during the late rains.

An essential adaptive strategy to adapting to climate change is to change the plant species. Local farmers have adopted adaptive strategies to adapt to climate change by selecting durable crop varieties. This strategy enhances food security and agricultural sustainability in response to climate change.

Most of the farmers have replaced the local seeds with hybrid seeds due to the mitigation of climate change. Table 5.6 shows that about eighty-eight percent of farmers have altered plant species to mitigate the impact of climatic variability.

Chemical fertilizers and pesticides are a crucial adaptive strategy for mitigating the effects of climate change. These inputs enhance crop flexibility and productivity in response to evolving environmental conditions. Due to climate change, farmers have increased the use of chemical fertilizers and pesticides to grow crops, which over time helps to increase agricultural production. In this way, the farmers have increased their usage of fertilizer to offset unfavourable climatic circumstances in response to the reduction in crop output caused by climate change. Most farmers (87.7%) are using chemical fertilizers and pesticides to increase agricultural production, which has been reduced due to the withered/ drought, with a three-fold increase in paddy production and maize, wheat, and vegetable production. A farmer in Ward No. 1 shared,

> *I have used compost manure and could not produce sufficient crops due to climate change. Therefore, I started using chemical fertilizer too. Regarding helping this process, CEPRED, since 2035, has supported farmers with chemical fertilizers and pesticides in agriculture. When I used this, the production increased, and the use of compost manure decreased in crop production.*

This suggests that, due to climate change, the dependence of farmers on chemical fertilizers has increased, while the dependence on compost fertilizers has decreased. This move reflects the need to increase crop productivity, which has been negatively affected by climate change. During my field observation, I have seen farmers using chemical fertilizers and pesticides on their crops. Farmers said that chemical fertilizers like DAP (Diammonium Phosphate), Urea, Potash (Potassium Chloride), Nitrogen, Triple Superphosphate (TSP), Ammonium Sulphate, and pesticides like Dythin, Beauveria Bassiana EC, Cypermethrin, Peston, and Nuvan are used in the crops. Agricultural production cannot be good if chemical fertilizers and pesticides are not used properly. Proper use of chemical fertilizers and pesticides is important for successful agricultural production.

Water Management Practices

Effective water management techniques are being implemented to adapt to climate change. These strategies ensure efficient water usage and enhance crop flexibility during drought or erratic rainfall. Farmers are preserving agricultural productivity by conserving water and managing irrigation to adapt to changing climate conditions. Local farmers have used different water management practices such as the selection of early-growing crops and vegetables, drip irrigation, water harvesting from the river, and water collection in a plastic pond. Panchkhal Municipality is implementing sustainable water management strategies, enhancing crop production, and enhancing agricultural adaptability to mitigate the impact of climate change. Early growing crops and vegetables planting enhances crop yields, reduces climate hazards, prevents pests and diseases, reduces chemical inputs, and increases crop adaptability for farmers (see Table 22).

Table 22

Water Management Practices

Variables	Number (n=568)	Percent
Selection of early-growing crops and vegetables	530	93.3
Drip irrigation	89	15.6
Water harvesting in the river	87	15.3
Water collection in the plastic pond	50	8.8

Source: Field Survey, 2020

Table 22 shows that the majority of farmers (93.3%) have adopted the practice of planting early-growing crops and vegetables. The early-growing crops and vegetables, such as lettuce, radishes, spinach, tomatoes, and cucumbers, are beneficial for water management. The farmers have planted a short growth cycle, which requires less water, and reach the harvest stage quickly, reducing irrigation cycles. Early growing crop plants have shallower root systems, reducing water requirements.

Growing these crops in areas with limited water availability or during droughts allows for more efficient water resource management, conserving water, and strengthening agricultural capacity. The qualitative data also supported the water management practices experienced by farmers. A farmer reported

Photo 10: *Canal for Irrigation Site: Panchkhal ward no. 12 Source: Field work, 25, Jan.2021*

> *I have experience in vegetable farming as I have been in this field for a long time. Based on the experience, the water sources are slowly drying up in Panchkhal ward no. 7, so I began cultivating vegetables instead of paddy. Crop production has been replaced by vegetables such as cabbage, tomatoes, and potatoes that require less water. As resources are drying up, they have switched from crops that need more water to crops that need less water. Such a type of training is provided by Lob Green Nepal in the study area.*

This suggests that non-formal communication and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. The farmers have been shifting from crops that need more water to crops that need less water. Farmers have advanced in vegetable cultivation by specializing in crops that require little water. Because the water sources have dried up due to climate change and the crops have changed to suit the environment.

In this context, another farmer said,

> *Due to a lack of water, I*

Photo 11: *Drip Irrigation Site: Panchkhal ward No.12, Source: Field work, 25, Jan.2021*

have replaced paddy production and used it in precision agriculture (vegetable) production. The water resources of the Panchkhal Municipality are gradually declining. However, after the massive earthquake of 2072, the experience of *farmers has shown that the water source is gradually increasing in some of the wards of this municipality. My friend also said that before the massive earthquake, there was a flow of water in the small river in the dry season, but now it does not flow in that season.*

This suggests that informal communications are always important for learning. Whereas the farmers have some ways of learning, informal learning from experience is significant for climate change strategies. The farmers shared that before the massive earthquake, there was a lack of water, but after the earthquake, there was an increase in the water sources. Therefore, they have experienced that it is easier to farm now than before the earthquake. During my observation, I discussed with farmers about vegetable farming. They said, due to a shortage of water, we are planting vegetables that need little water. Therefore, the farmers are now utilizing early-season vegetable crops to enhance crop yields and mitigate the impacts of climate change.

Photo 12: *Dig Holes for Irrigation Site: Panchkhal Ward No.03, Source: Field work, 25, Jan. 2021*

Drip irrigation enhances efficiency and reduces water waste by directly supplying water to plant roots, promoting crop growth during the dry season and erratic rainfall. This method ensures sustainable water management, crucial for maintaining

Agricultural productivity is increasingly affected by unpredictable climate patterns, leading to reduced yields and heightened uncertainty for farmers. Only about sixteen percent of farmers in Panchkhal Municipality have adopted drip irrigation to maximizing utilization. It's beneficial in drought-prone areas and can be customized for different crops. This method also contains soil moisture levels to ensure optimum growing conditions. In this context, one of the farmers reported, *I have utilized drip irrigation in tomato cultivation in the dry season. During the time of the water shortage, the Jhikhu River was used for irrigation through drip irrigatio*n. This method simplifies irrigation with minimal water, preventing water damage and ensuring efficient use. I took this training from Lab Green Nepal in 2075. These suggest that non-formal communication is always important for learning. Although the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. Drip irrigation, a conservation method that delivers water directly to plant roots, is widely used in tomato farming, helping to reduce water wastage and optimize water use. During my observation, I saw drip irrigation, and the farmers were irrigating tomato farms. Therefore, I discussed it with the farmers.

The farmers said, the shortage of water, we are utilizing drip irrigation because a lack of water also helps to irrigate the vegetables. Drip irrigation reduces evaporation and runoff, ensuring water reaches roots and resulting in higher yields over time. River water harvesting is a crucial adaptive strategy for addressing climate change. This practice involves capturing and storing water for use during dry periods, ensuring a reliable water supply. River water harvesting enhances community management of water resources and agricultural productivity, despite alterations in climate conditions.

The local farmers have used water harvesting in waterways to aid farmers in supplying water for irrigation. Water harvesting irrigation method effectively mitigates climate change-induced water scarcity, conserves common assets, and enhances agricultural flexibility. About fifteen percent of farmers have adopted water harvesting in the river for the adaptation of agricultural production. Farmers in the study area are implementing climate change adaptive strategies by creating water holes in rivers, irrigating fields through canals and borings, and utilizing river water for water collection. In this context, one of the farmers reported, *"During the dry season, there is no water in the Jhiku River and Thokare River. At that time, farmers made holes in the river to collect water and used water pumping machines to irrigate vegetable crops in the area around the river*." This suggests that informal communications and experiences are always important for learning. Although the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Farmers create holes in rivers during the dry season, collect water, and use a pump set or water motor to irrigate vegetables. During my observation, in the dry season, rivers dried up, leading to reduced water availability. As a result, farmers collect water by making holes in the river and use water pumping machines to irrigate the crops, especially for vegetable cultivation. Plastic ponds are an effective method for mitigating the effects of climate change. They offer farmers a dependable means of storing water during dry seasons and erratic rainfall.

Plastic ponds provide a reliable water supply, enhancing agricultural flexibility and productivity in communities. Local farmers have made plastic ponds to capture and retain rainwater, tap

Photo 13: *Plastic Pond Site: Panchkhal Ward No.9, Source: Field work, 22, Jan. 2021*

water, as well as sometimes canal water for agricultural purposes, particularly during drought or climate change, serving as reservoirs for irrigation and agricultural activities. Few (8.8%) farmers have used plastic pond water collection as a climate change adaptive strategy for water management. One of the farmers shared,

> *I have made a plastic pond in ward no. 9, especially for water collection in the dry season. Lob Green Nepal provided training for making the plastic pond in 2065. The collected water is utilized for irrigation of crops and drinking for animals.*

This suggests that non-formal communication is always important for learning. While farmers have many ways to learn, training provides important education for climate change strategies. Climate change is causing a decrease in water sources, leading farmers to use plastic ponds to protect themselves from leaching water. The study area effectively utilizes this method for water collection. During my observation, I saw the shortage of water and interacted with farmers about it. The farmer said there is a lack of water, especially in the dry season. At that time, the farmers were making plastic ponds that provided both for crop irrigation and livestock drinking.

Improved Soil Fertility

Photo 14: *Compost/Organic Manure, Site: Panchkhal ward No.13, Source: Field work, Source: Field work, 22, Jan. 2021*

Soil fertility improvement is a crucial strategy for addressing climate change adaptation. Healthy soils improve water retention and nutrient availability, thereby facilitating crop growth in adapting to changing climates. Soil health is crucial for farmers to enhance flexibility and maintain agricultural productivity. Local farmers are enhancing soil health, promoting climate flexibility, and involving agriculturists in innovative soil methods. The farmers have adopted different soil health conservation practices. The adaptive change includes mulching, soil health awareness, and soil testing management (see Table 23).

Table 23

Soil Health Conservation Practice

Variables	Multiple response number (n=568)	Percent
Use of compost/organic manure	205	36.1
Crop rotation	191	33.6
Mulching	179	31.5
Soil health awareness	94	16.5
Soil testing management	78	13.7

Source: Field Survey, 2020

Table 23 shows that a few farmers apply different soil health conservation practices. Farmers of Panchkhal Municipality use compost and organic fertilizer made from leaves, animal manure, and kitchen scraps to improve soil fertility, increase crop yields, and promote natural sustainability. Among them, a large number of farmers (36.1%) have adopted the use of compost/organic manure for soil health conservation in which explains to the community the importance of economic agricultural practices to mitigate the effects of climate change. For example, one of the farmers shared in Ward No. 9,

> *I have used compost manure to increase soil fertility and reduce the dependency on chemical fertilizers in a few areas in the vegetable's cultivation. Organic farming practices enhance soil health, mitigate climate change, and decrease greenhouse gas emissions.*

This suggests that informal communication and experiences are always important for learning. Although farmers have many ways to learn, non-formal education is important for climate change strategies. Compost fertilizers increase soil fertility and help mitigate climate change. This method contributes to environmental sustainability. During my observation, I have seen the use of organic fertilizer in a small area of the cauliflower. I interacted with the farmers about compost or organic fertilizers. Although the farmers informed us that we are using compost or organic fertilizers for healthy crop production, they argue that these methods are more expensive than chemical fertilizers. Due to increased investment in agricultural produce, market demand is decreasing, leading to a limited use of compost manure in farming.

Crop rotation is an effective method for addressing climate change adaptation. This method effectively mitigates soil depletion, manages pests, and promotes healthier crops. Rotating crops improves soil fertility and maintains agricultural productivity despite alterations in climatic conditions. Local farmers are utilizing crop rotation strategies to enhance soil health, reduce pest infection, and improve crop yields by rotating cereals, vegetables, and oilseeds. Only about thirty-four percent of farmers have used the crop rotation strategy, which reveals a positive effort towards sustainable farming. The farmers recognize the importance of crop differentiation in preserving soil fertility, preventing erosion, and adapting to changing climatic conditions in Panchkhal Municipality. In this context, one of the farmers shared,

> *I have used crop rotation between vegetables, grains, and grains to naturally renew soil nutrients and reduce the potential for pest and infection build-up. My neighbour recommended me to plant rotation crops. These cropping methods that improve soil fertility also aid in retaining humus in the soil. My friends advised me to maintain soil humus by planting different crops in different seasons.*

This suggests that informal communication and friends are always important for learning. While the farmers have several

Photo 15: *Plastic Mulching, Site: Panchkhal ward No.3, Source: Field work, 20th, Jan.2021*

ways of learning, informal learning from friends is significant for climate change strategies. Crop rotation between vegetables, grains, and fruits maintains soil nutrients, reduces pest infestation, and contributes to climate-smart agricultural practices, reduces chemical inputs, and mitigates the effects of climate change. In this context, another farmer said, "*I have planted paddy in the first season, second season vegetables such as cauliflower, potato, tomato, and third season maize. It is helping to enhance soil health, reduce pest infection*, *and boost crop yields."* This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. Crop rotation increases crop yields, reduces pest infestation, and improves soil health. During my field observation, I interacted with the farmers about crop rotation. Farmers said that in the past, crops were sown and planted indiscriminately, so there was no good yield. However, now we are using the crop rotation method, which improves the protection of soil health, and is helping to mitigate the effects of climate change as well as maintain sustainable farming systems.

Mulching is a crucial strategy for addressing climate change adaptation. It helps in conserving soil moisture, regulating temperature, and reducing erosion. Farmers improve crop resistance to changing climate conditions and protect their harvests by applying mulching. Local farmers are utilizing dry and green weeds and plastic to mulch the plants to increase soil fertility and maintain moisture. Mulch covers the soil surface with natural materials, preventing erosion and regulating temperature, thus enhancing soil health and efficiency. Mulching is one such strategy for adapting to climate change. Around thirty-two percent of farmers have adopted mulching for soil health conservation. Mulching helps conserve moisture, suppress weeds, and enhance soil fertility. Farmers utilize this method to safeguard both new and old plants from drought-induced death, while also ensuring soil fertility and moisture.

Soil health awareness is significant for climate change adaptation. The education of farmers on soil care significantly enhances water retention and nutrient levels. Promoting soil health awareness is important for communities to enhance agricultural flexibility and productivity. Farmers are utilizing sustainable agriculture by raising soil health awareness, providing conservation education, and facilitating access to resources for soil testing and research. About seventeen percent of farmers have used soil health awareness techniques for adaptive strategies. The study area is implementing a plan to conduct a comprehensive soil health awareness campaign, to promote sustainable practices in collaboration with seminars, community gatherings, school programs, and agricultural extension services. For example, one of the farmers shared,

> *In 2072, the Agriculture Branch of Panchkhal Municipality prepared a booklet on local farming and soil health for the environmental conditions of this area. They distributed these booklets at community gatherings and to farmer groups. The booklet mainly discussed both seasonal and off-season vegetable cultivation. It encouraged people to engage in vegetable farming. After reading the booklet, I decided to start off-season cultivation due to the high demand of these vegetables in the market. This decision is giving me good returns.*

This suggests that formal communications and experiences are always important for learning. While the farmers have several ways of learning, formal learning from the municipality is significant for climate change strategies. The booklets provide knowledge on local farming and soil health that generated my interest in off-season vegetable cultivation, leading to positive outcomes. Qualitative information also supported what one of the farmers said,

> *Lob Green Nepal provided training in 2072 about how to maintain soil health for agriculture production. I have also taken this training and emphasized creating awareness among farmers to keep the soil healthy. This includes planting pulses along with maize, which gives nitrogen to the roots and increases soil fertility. My experience has also played an important role in promoting soil fertility farming.*

This suggests that informal communications and experiences always provide important knowledge for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. The INGO conducted training on soil health for agricultural production, promoting soil-friendly farming methods in planting pulses alongside maize. During my field observation, I interacted with the farmers about soil health. The farmers' respondents stated that, to maintain soil health, they planted different types of crops, vegetables, pulses, and crops. Such types of knowledge are provided from the training and experience. This kind of knowledge is conveyed to us through training and experience.

Soil tests are essential for climate change adaptation. This aids farmers in understanding the soil conditions and nutrient requirements. Soil tests enable farmers to make informed decisions to improve soil health and agricultural productivity. Local farmers are utilizing soil test administration to adapt to climate change, protect soil health, and follow guidelines for fertilizer use, crop selection, and management practices. About fourteen percent of farmers used soil testing management for the conservation of soil health, an adaptive strategy to climate change. The study area has conducted soil testing workshops to inform farmers and residents about soil health and climate change mitigation, and to promote dissemination and continuous management. In this context, one of the farmers reported,

> *In 2074, the agriculture branch of Panchkhal Municipality advised to apply agricultural lime to maintain the fertility of soil. I applied this method in my*

> *field in 2074. It is helping to increase the agricultural productivity such as cauliflower, brinjal, tomato, potato, paddy maize.*

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from government organizations is significant for climate change strategies and nutrients of the soil, and the improvement of soil health. The government office provides important knowledge about soil testing methods to farmers, while some of the farmers also apply it. During my field observation, I talked to the farmer about agricultural lime. The farmer said,

> *Earlier, after planting one crop, the land remained barren, and only then was another crop planted, so that lime is not required for agriculture in the soil. But now we are planting crops without keeping the land barren, so we are using agricultural lime in the soil to increase the productivity of the land and to kill the insects in the soil.*

It indicates that the fallow land can enhance fertility if properly preserved. By resting the land without cultivation, nutrients in the soil will get a chance to regenerate over time. Additionally, good farming practices-such as covering the soil with crops and applications of organic matter-can enrich the soil even more. This rejuvenated soil can eventually help in providing healthier crops and increasing agricultural output in the long run.

Use of Climate-Smart Technologies

Climate-smart technologies are crucial for addressing and mitigating the effects of climate change. These technologies enhance soil health and agricultural flexibility. The use of climate-smart tools is being increasingly adopted by farmers to enhance their resource management capabilities. Local farmers have utilized climate-smart innovations for managed farming, focusing on farmer-centered adaptive strategies**.** The farmers have adopted various adaptive strategies, including agroforestry and conservation agriculture, energy-efficient equipment, and smart farming apps and software. Local farmers are integrating agroforestry to improve land management, reduce climate change risks, and diversify income sources through benefits like soil conservation and biodiversity (see Table 24)

Table 24

Climate-Smart Technology

Variables	Number (n=568)	Percent
Agroforestry	225	39.5
Energy-efficient equipment	159	27.9
Smart farming apps and software	90	15.8

Source: Field Survey, 2020

Table 24 shows that many farmers (39.5%) utilize climate-smart technologies, in which the integration of trees and shrubs into agricultural landscapes can enhance biodiversity, improve soil structure, and provide shade and shelter. Agroforestry is a sustainable practice that promotes soil conservation, carbon sequestration, and biodiversity. As a result, the humus of the soil is maintained, and the land becomes fertile. The farmers have implemented an agroforestry approach, combining trees with crops like pulses, to enhance agricultural output and reduce the impact of climate change. The INGO provided training to farmers about agroforestry methods, an important adaptive strategy for climate change.

Energy-efficient equipment is a critical component in addressing climate change adaptation. This method not only reduces greenhouse gas emissions but also conserves resources. Energy-efficient tools enhance soil health and promote sustainable agriculture by being used by farmers. Local farmers are using electrified groundwater systems to mitigate climate change, reduce dependence on fossil energy, labour costs, and environmental impacts, and provide reliable water supplies during droughts. Around thirty percent of farmers utilize energy-efficient equipment to adapt to climate change. Local farmers are promoting the use of energy-efficient equipment through awareness campaigns, incentives, exhibition projects, collaboration with local farmers, and continuous monitoring of energy consumption. For example, one of the farmers shared,

> *In 2068, the electricity office of Panchkhal Municipality organized workshops on the importance of energy efficiency and reducing operating costs over time. I have used the water boring for irrigation in the dry season, which is helping to increase agricultural production and mitigate the impact of climate change. The workshops were centred on cost- and energy-saving strategies.*

This suggests that formal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from government organizations is significant for climate change strategies. The water boring as a technique to improve agricultural productivity and mitigate the effects of climate change during the dry season was emphasized. During my field observation, I saw that the farmers are using electricity for irrigation through the boring, especially in the dry season. Irrigation is primarily carried out through boring in vegetable cultivation. Farmers have been purchasing subsidized borings from GO and I/NGOs, with 50 percent and 75 percent subsidies for agricultural groups. The supply according to their demand has not yet been completed.

Smart farming apps are crucial tools for addressing climate change adaptation. They provide valuable insights and recommendations for enhancing agricultural practices. Farmers are improving their flexibility and productivity by utilizing these apps in response to evolving environmental conditions. Local farmers are utilizing smart farming apps and programs to adapt to climate change, utilizing smartphones, sensors, and analytics for real-time data and informed decision-making. About sixteen percent of farmers are utilizing smart farming apps and software for an adaptive strategy to climate change. Smart agriculture apps and software are crucial for farmers to optimize farming practices, address climate change, and adapt to changing market demands. However, widespread adoption requires training, technology access, and affordability. For example, climate visualization software provides data analysis and insights that help farmers make informed decisions. It provides tools to monitor crop performance, analyze weather trends, and adapt agricultural practices to climate change conditions. One of the farmers reported,

> *Experience of climate-smart technology is quite well-known. I have been using a weather app for planting and harvesting time for the last three years. The apps are simplifying the process of planting and harvesting agricultural crops. The information provided by the apps is mostly correct but sometimes it gives wrong information. If wrong information is provided by weather apps, there is a possibility of huge financial loss.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Weather apps simplify agricultural processes, but occasionally provide incorrect information, posing financial risks if not used correctly. During my field observation, I saw that farmers are utilizing climate-smart technologies to mitigate climate change risks, enhance agricultural productivity, and make informed

Photo 16: *Smart Farming Apps*, *Adopted Google*


Photo 17: *Seeds of DY 28 Paddy, Site: Panchkhal ward No.1, 20th, Dec.2020*

decisions to adapt to changing weather conditions. It helps the farmers to make timely decisions on planting and harvesting crops according to the time.

Crop Diversification

Crop diversification is an important strategy for addressing climate change adaptation. Farmers who grow a variety of crops help spread risk and mitigate the effects of climate variability. Diversification enhances flexibility and ensures food security in the face of changing weather patterns. Local farmers have used various crop diversification adaptive strategies that ensure a balance with diverse crops and a creative approach. Farmers have grown several crops: maize, paddy, wheat, barley, including other vegetables such as cauliflower, carrot, leaf vegetables, and radish in Panchkhal Municipality (see Table 25).

Table 25

Crop Diversified

	Strategies for the diversification of crops	Numbers (n=568)	Percent
Methods of crop diversification	Adopted	495	87.1
	Crop Selection	465	81.7
	Crop Rotation	215	37.9
	Climate-Mitigation Varieties of Crops	195	34.3
	Inter-cropping	186	32.7

Source: Field survey, 2020

Table 25 shows that most of the farmers (87.1%) have adopted crops that are resistant to maturity time, nutritional requirements, and diseases and pests. One of the farmers said,

> *I have adopted the strategy of crop diversification, which involves cultivating paddy in the first season, pulses in the second season, and third season. My grandfather taught me the crop diversification method, which is an effective adaptive strategy for climate change.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from intergenerational interactions is significant for climate change strategies. Farmers are implementing a crop diversification strategy across different seasons to reduce climate change and improve crop production. In this context, another farmer of Ward No. 12 said, *"I have grown crops and vegetables for four seasons on my farm. I have cultivated potatoes for the first time, rice for the second time, cauliflower, cabbage, tomatoes for the third time, and four-leaf vegetables*." This suggests that the dynamic approach reduces climate-related risks, improves soil health, and promotes sustainable agriculture. Farmers in the study area are adopting a strategy of selecting crops resistant to extreme weather conditions and insects to adapt to climate change. During my field observation, I interacted with farmers about crop rotation. The farmers explained that they cultivate crops and vegetables throughout the four seasons to increase productivity, preserve soil fertility, and lessen the impact of climate change. Rainfall affects grain crops and vegetable production. If there is not enough rain, only two or three seasons are cultivated. However, if there is enough rain, agricultural production can be done for four seasons.

Crop selection is a crucial strategy for addressing climate change adaptation. Farmers reduce risk and increase yield by selecting crops suited to their local climate. It helps in selecting resilient crop varieties to increase the flexibility of agriculture in a changing climate and ensure food security. Local farmers are utilizing a crop selection strategy to increase crop yields, mitigate climate change risks, and enhance adaptability to changing conditions. Farmers of Panchkhal Municipality are focusing on the importance of an adaptive agriculture strategy for sustainable food production. Among the adopted crop diversification methods, about eighty-two percent of farmers are utilizing the crop selection method. Regarding, farmers have selected the paddy, maize, barley, wheat, pulses, and vegetables such as cauliflower, cabbage, potato, tomato, carrot, and radish.

Crop rotation is a highly effective method for coping with the effects of climate change. Rotating crops enhances soil health, reduces pests and diseases, and increases overall flexibility for farmers. This practice ensures sustainability agriculture and maintains productivity in chainging environmental condition.

Farmers are utilizing crop rotation strategies to adapt to the challenges of climate change improving soil fertility, updating flexibility, and mitigating climate planning risks. About thirty-eight percent of farmers have utilized crop rotation in the study area. The farmers emphasize that crop rotation is crucial for sustainable agriculture. It involves systematically changing crop types over different seasons or years. For example, one of the farmers said, *"I planted the paddy of DY 28 in the first year, DY 27 in the second year, and vegetables in the third year. This method helps to increase crop productivity and retain soil moisture."* These suggest that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies.

Photo 18: *Cauliflower Jyapu, Site: Panchkhal ward No.13 Source: Field work, 17th, Feb.2021*

Farmers plant diverse crops annually, enhancing crop productivity, conserving soil moisture, and mitigating climate change. Due to climate change, farmers change crop varieties to preserve soil humus and increase crop productivity. During my field observation, I interacted with the farmers. The farmers have utilized crop rotation in which they produce agriculture according to the climate change for good production.

The use of climate-mitigation crops is crucial for ensuring adaptation to climate change. These crop varieties are designed to withstand harsh weather conditions and reduce greenhouse gas emissions. Implementing these crops aids farmers in sustaining productivity and sustainability in the face of evolving climates. Local farmers are adapting to climate change by developing cultivars with traits like drought resistance, heat resistance, disease resistance, and flexibility. Only about thirty-four percent of farmers have utilized climatic varieties for the adaptive strategy to climate change. To reduce emissions, the farmers of Panchkhal Municipality have been promoted and educated about climate change. One of the farmers shared,

> *Earlier, I planted cauliflower with the local name of cauliflower Jyapu, Kathmandu, which ripens in 90-110 days, but today, due to climate change, I have planted cauliflower of the Pusa Dipali, snow queen, and snow king varieties, which ripen in 60-70 days.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. To meet the demand of the market or the Kathmandu Valley due to water scarcity and increasing demand for food, farmers are planting cauliflower that ripens in a short time instead of cauliflower that ripens over a long time. During my observation, I discussed with the farmers about crops. Earlier, they used to plant local seeds that ripen for a long time, but now they have planted rice, wheat, maize, and vegetables that ripen in a short time, and this is also helping to minimize the impact of climate change.

Inter-cropping is an important strategy for addressing climate change adaptation. The process involves mixing various crops to improve soil health and enhance flexibility in extreme weather conditions. This method aids farmers in sustaining productivity and mitigating the likelihood of crop failure in response to alterations in the climate. Local farmers are utilizing inter-cropping to adapt to climate change by growing multiple crops simultaneously, diversifying production, optimizing the use of resources, and enhancing soil fertility and water maintenance. Only about thirty-three percent of farmers are using inter-cropping strategies to adapt to climate change.

Inter-cropping is the practice of growing multiple crops simultaneously in the same field. Regarding the climate change education of farmers in the study area, they have been promoting inter-cropping as a valuable adaptive strategy. One of the farmers shared, "*I have planted the pulses along with maize in my field because they help each other for the crop production. The method is chosen due to its effectiveness in addressing one crop failure and providing support for other crops*." These suggest that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from experience is significant for climate change strategies. Pulses and maize are planted in fields for mutual benefit in crop production, addressing failures and providing support amid climate change challenges. During my field observation, I interacted with the farmers about the inter-cropping agriculture system. The farmers said, we have used the intercropping system in agriculture, while being able to obtain high quantity and quality agricultural products.

Selection of Market-Oriented Crops

The selection of market-oriented crops is a vital aspect in preparing for the challenges posed by climate change. Farmers maintain economic stability by selecting high-demand crops, despite alterations in environmental conditions. This strategy aids farmers in sustaining their flexibility and profitability amidst a fluctuating climate. Market-oriented crop cultivation and sustainability have improved farmers' adaptability, promoting informed, market-driven practices. The farmers have adopted various market-oriented crop methods such as tunnel, organic, and off-season farming in the study area.

The farmers are trying to identify marketable crops, increase value through processing, and diversify their production. The farmers are driven to produce crops that meet market consumers. Local farmers are increasing market access and bargaining power by forming agricultural groups for joint marketing, resulting in improved crop production and supply. Local farmers are implementing tunnel, organic, and off-season farming to improve economic conditions and mitigate changing environmental conditions. Farmers are trying to meet market demand on time and reduce the impact of climate change. The market-oriented agriculture production in the study area is explained below: Tunnel, organic, and off-season farming

Tunnel Farming, Organic and Off-Season Farming

Tunnel farming is a sustainable adaptation strategy that safeguards crops from extreme weather conditions, ensuring consistent crop yields throughout the year. This method aids farmers in maintaining consistent production despite the unpredictable nature of climate conditions. It has been used by local farmers to provide a controlled environment for farming that will respond to a changing climate. Tunnel farming emphasizes the need for improvement, development, and support for the changing climate. This aids in the growth of crops, particularly those that are grown out of season. The tunnel cultivation done by farmers prevents the heat temperatures and controls the winter, and makes the environment favourable (see Table 26).

Table 26

Tunnel, Organic and Off-Season Farming

Statements	Response	Numbers (n=568)	Percent
Tunnel	Adopted	166	29.2
	Not adopted	402	70.8
Organic farming	Adopted	327	57.6
	Not adopted	241	42.4
Off-season vegetables	Adopted	333	58.7
	Not adopted	235	41.3
Total			100.0

Source: Field survey, 2020

Table 26 displays market-oriented crops such as tunnel, organic, and off-season farming in the study area. Most of the farmers (70.8%) did not utilize tunnel farming, while around twenty-nine percent of farmers have adopted it. Tunnel farming is environmentally friendly and promotes vegetable cultivation despite climate change. It safeguards crops from unpredictable weather and fosters.

Climate change mitigation through education and innovative farming practices. In the context of tunnel farming, the pattern is well-practiced by a few farmers. One of the farmers reported in Ward No. 7,

> *I have adopted the tunnel farming method in cauliflower and tomato cultivation to adapt to climate change. This technique was introduced to us by LobGreen Nepal through training in 2071. The training deeply touched my heart and was applied to vegetable farming.*

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from training is significant for climate change strategies. Farmers are using tunnels for off-season farming to control the environment and ensure the production of high-quality crops. In this context, another farmer said, *I have utilized the tunnel, especially in the winter season, for tomato cultivation. The temperature inside the tunnel is higher than the temperature of the outside environment, and the plants grow well without being affected by the winter, and the yield is also good.*

Photo 19: *Tunnel Farming of Tomato vegetable Site: Panchkhal ward No.2, Source: Field work, 27th, Jan. 2021*

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. Tunnels offer protection from cold and summer conditions, promoting better growth and higher yields of the crops. In this context, another farmer said,

A few farmers adopted tunnel farming to adapt to climate change, especially for vegetables such as tomatoes. During the winter season, farmers, particularly in vegetable farming, utilize tunnels for the best efficiency. It maintains a suitable environment for vegetable production and adapts to climate change by ensuring the production of high-quality produce. In addition, my friends also used tunnels in tomato farming. I observed such farming, and it touched my heart, so I have adopted the same method in tomato farming.

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from friends is significant for climate change strategies. Tunnel farming is being adopted by farmers as an adaptation to climate change, providing suitable conditions for high-quality produce during winter. During my field observation, I saw tunnel farming and had the opportunity to interact with the farmers. Farmers said that they did not cultivate tunnels in the past. However, now some farmers are adopting tunnel farming to maintain environmental sustainability, maintain moisture, and increase vegetable cultivation.

Organic Farming

Organic farming is an important climate change adaptive strategy, enhancing soil health and biodiversity, thus enhancing farms' flexibility to climate impacts. Organic farming promotes sustainable agriculture and environmental protection by reducing reliance on fertilizers and pesticides. Local farmers are utilizing organic farming to enhance nature and promote sustainable practices, thereby promoting climate mitigation in the study area. 26 presents that about fifty-eight percent of farmers are utilizing organic farming, which involves growing crops and raising livestock using natural processes and materials without the use of synthetic additives such as chemical fertilizers, pesticides, or genetically modified organisms. A part of climate change education for Panchkhal farmers, the promotion of organic farming is an adaptive strategy. For example, one of the farmers shared,

Photo 20: *Ashuro Plant, Site: Panchkhal ward No.5, Source: Field work, 27th, June. 2020*

> *Lob Green Nepal provides training related to organic farming and the farmers apply this training in a limited area and utilize the natural pest control methods. The pest control insecticides include urine of animals and juice of green leaves of Ashuro (Adhatodavasica), and Titepati (Artmesia vulgaris) especially in vegetable farming such as cauliflower, cabbage, carrot, potato and tomato.*

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, nonformal learning from training is significant for strategies of climate change. Lob Green Nepal offers organic farming training to farmers, utilizing natural pest control methods like animal urine and green leaf juice for vegetables like cauliflower, cabbage, carrot, potato, and tomato. One of the farmers reported,

Photo 21: *Organic Farming of Cauliflower, Site: Panchkhal ward No.5, Source: Field work, 2021*

.

> *For domestic use, I have used organic farming methods in small areas for vegetable cultivation in leaf vegetables, cauliflower, and tomatoes. However, I do not plant organic crops and vegetables in the entire area. In 2068, I took organic farming training from the Agriculture Knowledge Center. However, I do not plant organic crops and vegetables in the entire area. The main reason for the lack of organic farming in all areas is the market problem*.

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. The organic farming techniques are used in a small area for household use, but not in the entire area due to a lack of market. During my field observation, I discussed with farmers about the organic farming that is being implemented in agricultural practices to combat climate change and ensure the production of healthy crops. Organic farming helps to mitigate climate change in the study area.

Off-season farming is an important strategy for climate change adaptation, enabling farmers to grow crops outside traditional seasons, thereby increasing food availability and income. Off-season farming, utilizing techniques like greenhouses and improved irrigation, helps mitigate the effects of unpredictable weather patterns. Local farmers have used the off-season farming strategy to adapt to climate change, enhancing year-round productivity and crop continuity. Table 26 displays that the majority (58.7%) of the farmers are using off-season crop farming, in which they grow vegetables outside their normal growing season to mitigate climate change. In this context, Lob Green Nepal provides training in off-season farming techniques, especially in vegetables, including greenhouse structures, water-efficient irrigation, and crop thrives, which helps to diversify produce and mitigate climate-related risks. Some of the farmers utilize the tunnel for off-season farming in vegetables such as cauliflower, cabbage, tomato, potato, bitter gourd, bean, asparagus, broccoli, green onion, turnip, and cucumber. This farming helps the farmers to increase agricultural productivity and meet market demand for fresh produce year-round. The pattern of off-season farming is well-practiced by the farmer. As one farmer reported,

> *Off-season farming is quite prominent. He emphasizes, I have taken training in off-season vegetable farming from Lob Green Nepal. After that, I used this method on two ropanies of cauliflower, cabbage, tomato, and leaf vegetables. However, off-season cultivation requires large amounts of chemical fertilizers and pesticides. Due to excessive use of chemical fertilizers and pesticides, off-season farming is not beneficial for health as compared to seasonal vegetable farming.*

This suggests that non-formal communications and experiences are always important for learning. While the farmers have several ways of learning, non-formal learning from training is significant for climate change strategies. Off-season farming, a popular method for growing vegetables, but it heavily relies on chemical fertilizers and pesticides, potentially causing health issues. In this context, another farmer said,

> *I have been doing organic farming for household purposes. In the past, I used to produce a lot of organic vegetables, but due to climate change and a lack of markets, now I only produce household food. In the evening, during dinner, my grandfather and father often chat about organic farming, sharing their knowledge and experiences with us. For example, the discussion focuses on the use of natural pest control techniques that control soil fertility and are passed down from one generation to the next.*

This suggests that informal communications and experiences are always important for learning. While the farmers have several ways of learning, informal learning from intergenerational communication is significant for climate change strategies. Farmers have now focused on organic farming for domestic consumption, but due to a lack of market, farmers have not produced in large quantities. During my observation, I interacted with farmers about organic farming. The farmers said that Lob Green Nepal provides the training of off-season farming, and we also planted off-season vegetable farming. However, the off-season farming required a lot of chemical fertilizers and pesticides to protect from diseases and to promote good crop production. Therefore, such types of vegetables are healthier than seasonal vegetables. But also, the farmers are planting off-season crops for a good income.

Agriculture Adaptation Strategies

Farmers are focusing on increasing agricultural production to adapt to climate change. The farmers have utilized climate-flexibility crops and modern farming methods to enhance their crop yields. These strategies ensure food security despite changing weather patterns. Local farmers are utilizing the mitigation of climate change in farming strategies to ensure sustainable food production and livelihoods. Farmers are utilizing a combination of scientific and traditional knowledge to mitigate climatic hazards.

The farmers use various practices of agricultural production as an adaptive strategy to mitigate the effects of climate change on agricultural processes and production. The study categorizes farmers' perceptions of climate change into thirteen variables, assessed on five Likert scales, such as SD= strongly disagree, D= disagree, U= undecided, A= agree and SA= strongly agree with numeral value from 5 (SA) to 1 (SD) (see Table 27).

Table 27

Agriculture Adaptation Strategies (n=568)

Variable	Minimum	Maximum	Mean	Std.D.
Use of multiple crops	1.00	5.00	3.12	0.95
Land fragmentation	1.00	5.00	3.23	1.13
The practice of alternative crops	1.00	5.00	3.58	1.06
Use of irrigation facilities	1.00	5.00	4.04	.95
Engage in non-farm employment	1.00	5.00	3.76	1.20
Increase in productivity	1.00	5.00	3.85	1.01
Use of chemical fertilizers	1.00	5.00	3.09	1.28
Use of compost	1.00	5.00	3.77	1.00
Use organic crops	1.00	5.00	3.90	1.01
Use of agroforestry	1.00	5.00	3.85	1.10
Shading the plants	1.00	5.00	3.26	1.08
Use of mulching	1.00	5.00	3.15	1.05
Change in land use patterns	1.00	5.00	3.33	1.27

Source: Field Survey, 2020

Table 27 shows the adaptation strategies of agriculture in the study area. The first practice of agriculture production is the use of multiple crops (mean 3.12 and SD.95). The use of different crops in agriculture, known as diversified farming, is a valuable technique with certain advantages, especially in the setting of climate change. Including a variety of crops on farms enhances biodiversity, thereby creating a more versatile biological system. This suggests that farmers of Panchkhal Municipality have been cultivating various crops like rice, millet, vegetables, and vegetables to create a useful agricultural pattern. They are very much aware of the fact that the adaptive strategies are mainly due to climate change. The interview with farmers indicates that the use of chemical fertilizers and pesticides is prevalent in multiple crops.-

Farmers are achieving high production rates by planting this type of crop, despite climate change. During my observation, the farmers are planting mixed traditional crops and interacting with mixed traditional crops. Farmers are struggling to produce enough crops, so we are cultivating a mix of both food crops and cash crops like vegetables. Mixed farming increases the possibility of producing another crop even if one crop is not produced well due to drought, and farmers feel secure in agricultural production. Mixed traditional crops help to mitigate the impact of climate change, ensuring a more stable food supply and livelihood for communities amid changing natural conditions.

Land fragmentation is safeguarded from negative effects on population growth and agricultural production, which is an effective strategy to adapt to climate change to make farming sustainable and ensure food security. The practice of agricultural production is land fragmentation (mean 3.23 and SD 1.13), in which the division of agricultural land into smaller, scattered areas presents potential solutions for climate change adaptive and relief strategies. Small plots help to grow crops adapted to climate change.

The practice of alternative crops is crucial for climate change adaptive strategies. Farmers are mitigating risks associated with unpredictable weather patterns by cultivating diverse and resilient crops. This method promotes sustainable agricultural practices and enhances food security. Local farmers are incorporating alternative crops like vegetables and food crops into their farming practices due to the changing climate and variability. The practice of agriculture production is alternative crop production (mean 3.23 and SD 1.13), in which alternative cropping involves modifying farming methods to mitigate the impacts of climate change. Different crops exhibit changing responses to environmental conditions, reducing the likelihood of complete crop failure.

Irrigation facilities play a crucial role in implementing adaptive strategies in response to climate change. Efficient irrigation is a crucial method for farmers to effectively manage water resources, ensuring crop growth during the dry season. This practice enhances agricultural productivity and flexibility in response to climate-related challenges. Local farmers utilize water systems for horticultural and vegetable production, enhancing crop yields and climate flexibility, particularly in areas with erratic rainfall. The practice of agricultural production is the use of irrigation facilities (mean 4.04 and SD 0.95), in which the farmers have agreed to improve irrigation on their farms.-

Non-farm employment is a crucial adaptive strategy for mitigating the effects of climate change. Diversifying income sources is helping farmers decrease their reliance on unpredictable agricultural yields. This strategy offers financial stability and flexibility in the face of climate-induced agricultural challenges. Due to limited access, decreasing agricultural income, and a desire for additional sources of livelihood, the farmers of Panchkhal Municipality are looking for non-agricultural work along with their farms. The agriculture production is engaged in non-farm employment (mean 3.76 and SD 1.20), in which agriculture provides additional income to Panchkhal agriculturists, reducing their reliance solely on farming.

Adapting to climate change requires improving agricultural productivity through innovative farming techniques and climate-flexibility crops, enabling farmers to increase yields despite changing weather patterns. This strategy ensures food security and sustainability amidst climate challenges. Local farmers are utilizing agricultural production practices aiming to increase productivity through various strategies such as improved crop varieties, improved irrigation strategies, and effective use of fertilizers and pesticides. The practice of agricultural production has increased in productivity (mean 3.85 and SD 1.01), which increases the crop production of the farmers. Farmers have improved efficiency, ensured a continuous food supply under changing climatic conditions, and minimized the water system strategies to optimize water utilization, boosting crop yields in the face of the impact of climate change on traditional crops.

Photo 23: *Water Boring Site: Panchkhal ward No.3, Source: Field work, 29th, Dec.2020*

Chemical fertilizers are a crucial adaptive strategy for climate change. Fertilizers enhance soil fertility and increase crop yields, mitigating the negative effects of changing weather patterns. This method aids farmers in sustaining

Photo 22: *Chemical Fertilizer, Site: Panchkhal ward No.3, Source: Field work, 25 Dec.2021 Source: Field work, 29th, Dec. 2020*

productivity and food security. Chemical fertilizers are utilized by farmers to increase crop yields, meet food demand, and calculate farming profit by improving soil fertility and providing essential nutrients. The objective is to enhance water use efficiency by adapting to altered precipitation patterns caused by climate change. The practice of agricultural Production is the use of chemical fertilizers (mean 3.09 and SD 1.28). The farmers have used chemical fertilizer the crop production, especially vegetables, for good production in the Panchkhal Municipality.

Compost manure is a crucial climate change adaptive strategy, enhancing soil health and fertility, enabling crops to thrive despite adverse conditions. This sustainable practice minimizes the use of chemical fertilizers and promotes long-term agricultural productivity. Local farmers use compost manure made from organic materials like leaves of the tree, animal waste, and kitchen waste, which is utilized in agricultural production to improve soil fertility, supplement availability, and boost crop growth. The practice of agricultural production is the use of compost manure (mean 3.77 and SD 1.0), which produces healthier food than the use of chemical manure.

Photo 24: *Compost Mannure, Site: Panchkhal ward No.3, Source: Field work, 29th, Dec. 2020*

Organic farming is an important climate change adaptive strategy that promotes sustainable practices that enhance soil health and flexibility. Organic farming promotes long-term agricultural productivity and environmental sustainability by reducing chemical inputs. Local farmers have been using organic farming to increase soil fertility, reduce pollution, and promote biodiversity conservation. The practice of agricultural production is the use of organic crops (mean 3.90 and SD 1.01). The farmers have taken the IPM training from Lob Green Nepal. The training encourages the farmer to grow organic farming. The farming adopting natural cropping strategies while respecting traditional biological knowledge and inbred agricultural rice enhances the social heritage of the Panchkhal area. The interview with farmers suggests that such multiple crops include the use of organic fertilizers and pesticides.

Agroforestry is a sustainable approach to climate change, incorporating trees and shrubs into crop and livestock systems to boost biodiversity and soil health. This method aids farmers in enhancing their resilience against climate impacts while ensuring sustainable agricultural productivity. Local farmers are utilizing agroforestry, a sustainable agricultural practice that integrates trees and shrubs into landscapes, enhancing soil fertility, water retention, and biodiversity. The practice of agricultural production is the use of agroforestry (mean 3.85 and SD 1.10) in which agroforestry is enhancing biodiversity by integrating trees into landscapes, creating natural habitats, and cultivating flexible biological systems. Agroforestry systems help mitigate climate change by sequestering carbon dioxide from the atmosphere by storing it in tree biomass and soil organic matter.

Shading plants is a crucial climate change adaptive strategy, safeguarding crops from excessive heat and sun damage, thereby enhancing growth and yield. This practice enhances plant flexibility to changing weather conditions; thereby promoting sustainable agriculture. Local farmers have utilized incorporating shade plants into their agricultural practices for various benefits, including temperature regulation, soil moisture retention. Additionally, these practices help with weed suppression, soil health improvement, and biodiversity promotion. Agricultural production primarily utilizes shading plants, with a mean of 3.26 and a standard deviation of 1.08. Plant shading has a significant effect on direct temperature, especially during periods of extreme heat, reducing heat and increasing plant growth and efficiency. Shading plants promotes the preservation of moisture and efficient use of water system resources, particularly in vulnerable areas in the dry season.

Mulching is a crucial Adaptive strategy for farmers to manage climate change by retaining soil moisture, regulating temperature, and suppressing weeds. This practice improves crop flexibility and productivity in response to changing environmental conditions. Local farmers have been using mulching in agricultural practices, covering the soil surface with natural or synthetic materials to conserve moisture, prevent weed growth, and improve soil health. In the dry season in the Panchkhal area, fruit plants like avocado, lychee, and mango are shaded to avoid heat and retain moisture. Likewise, the practice of agricultural production is the use of mulching (mean 3.15 and SD 1.05), which helps maintain soil dampness by reducing water dissipation from the soil surface, particularly in areas experiencing water scarcity or unpredictable precipitation due to climate change. Mulching acts is as a physical barrier that prevents weed growth by blocking sunlight and reducing seed germination, thus reducing the need for manual weeding or herbicide use.

Photo 25: *Organic Mulching Site: Panchkhal ward No.13, Source: Field work, 25th, Dec. 2020*

Changing land use patterns to sustainable practices is crucial for climate change adaptation, as it enhances soil health and water management among farmers. This strategy not only maintains productivity but also mitigates the impact of climate change. Local farmers are changing the land use patterns in agricultural production and agricultural livelihoods in the study area. The practice of agricultural production is a change in land use patterns (mean 3.33 and SD 1.27), which enhances climate change by diversifying crop varieties on a specific crop, thereby mitigating potential risks associated with climate change.

In conclusion, the various agricultural adaptation strategies were scaled between 1 (low use) to 5 (high use) on the Likert scale. Among the most common strategies with the highest mean value of 4.04 (SD = 0.95) was the utilization of irrigation facilities, indicating widespread use of water management as a reaction to climate variability. The other significant practices included the application of organic crops (Mean = 3.90, SD = 1.01), productivity intensification (Mean = 3.85, SD = 1.01), agroforestry application (Mean = 3.85, SD = 1.10), and non-farm activities (Mean = 3.76, SD = 1.20), both reflecting on-farm and off-farm adaptation responses. Moderately adopted strategies comprised the use of compost (Mean = 3.77, SD = 1.00), introduction of alternative crops (Mean = 3.58, SD = 1.06), and land use pattern shift (Mean = 3.33, SD = 1.27), reflecting farmers' responsiveness to adaptation with shifting climatic patterns. Activities such as shading the plants (Mean = 3.26, SD = 1.08), land fragmentation (Mean = 3.23, SD = 1.13), and use of mulching (Mean = 3.15, SD = 1.05) were also undertaken, but to a lesser extent. Surprisingly, the use of multiple crops and the use of chemical fertilizer both had relatively lower mean values (3.12 and 3.09, respectively), which reflects less attention in comparison to other mechanisms. These findings are a mixed set of adaptive strategies adopted by the farmers, combining the old and the new to try and offset the impacts of climate change on agricultural production.

Sources of Family Income

The study reveals that there are various sources of family income in order to livelihood. The income source includes agriculture, involvement in industry, trade petty trading, poultry, service, remittance and wage labour. Agricultural population is the people actively engaged in agricultural activities (see Table 28).

Table 28

Households' Income Sources

Income Sources	Number of Households	Percent (%)
Agriculture	369	65.0
Involvement in industry	103	18.3
Trade Petty trading	82	14.4
Poultry	7	1.2
Service	4	0.7
Remittance	3	0.5
Wage labour	2	0.3
Total	568	100

Source: Field Survey, 2020

Table 28 shows that most of the farmers (65.0%) primarily rely on agriculture as their primary income source, with other sources being secondary. Agriculture plays an important role in the local economy in the study area. The farmers are involved in the especially cash crops, in vegetables such as cauliflower, potatoes, tomatoes, cabbage, and radish. They depend on agriculture primarily due to favourable weather, fertile soil, historical agricultural traditions, and proximity to the capital. For example, agriculture is the backbone of the local economy, and the majority of farmers rely on it as their main source of income. Because this occupation is handed down from generation to generation, they consider it an easy occupation.

Farmers are actively involved in the industry to ensure their livelihood. 18.3 percent that the main occupation is industry of the farmers, especially brick and small rice mills, with agriculture as a secondary occupation. For example, farmers engage in seasonal work in the brick industry, making a primary income and secondary income from agriculture.

Farmers are effectively involved in small businesses as a means of earning their livelihood. This involvement in trade includes activities such as selling surplus agricultural produce, livestock, or high-quality goods in local markets. Only 14.4 percent of farmers are actively involved in the trade and petty trading in the study area. For example, farmers are also engaged in agriculture as a second source of income. The farmers involved in the trade are pretty trading in the house and have sold everything such as stationery, pulse, rice, and beans.

Farmers are active in labour-oriented agricultural activities for their livelihood. This involvement often includes tasks such as land preparation, planting, harvesting, and animal husbandry. The small numbers of farmers (0.3%) are actively involved in wage labour to ensure their livelihoods. They work in seasonal work within the municipality and outside the municipality for labour such as agricultural work, carpentry. For example, farmers are actively engaged in wage labour to supplement their income. Livelihood strategies that enable farmers to cope with the seasonal nature of agriculture help them contribute to broader off-farm economic activities.

There are various income sources in the study area, like Nepal. Panchkhal Municipality is an agricultural city, and it is in proximity to the Kathmandu valley. The government also implemented the Prime Minister's Modernization Agriculture Project for potatoes. Therefore, the majority of the farmers are involved in agriculture, especially in the cash crops of vegetables. Indeed, income from wages, salaries, interest, dividends, business income, capital gains, and pensions received during a given tax year is considered taxable income in the United States (Internal Revenue Service, 2020). The pattern of income source is well-experienced by the farmers. As one farmer reports, the agricultural occupation, at least for ten years, is quite prominent. He emphasizes,

> *Food crop production was the main source of economic resources. At that time, I planted local seeds, but production was low, which was enough to eat for about 6 months. Now, I changed our occupation from food crops to cash crops such as vegetable farming which now gives us good income.*

Another farmer shared that he changed the food crops to cash crops, and he reports,

> *Five years ago, food and cash crops were the main source of economic resources. At that time, the product would last me for a year. Now, I have a cash crop and animal husbandry business, which is earning a good income.*

Both of these comments suggest that food crop change is a common phenomenon in the Panchkhal area, which has been affecting crop production.

Overall, the study reveals that farmers are making substantial incomes by changing crop production to meet market demands. Thus, farmers are slowly changing their occupation to get enough income. Farmers rely not only on one agricultural product but also on multiple occupations. Due to the effects of climate change, sometimes various diseases occur in crops and livestock farming, and the entire production is destroyed, so farmers depend on two or more occupations to avoid this. This allows prevention of damage from any one product.-

Tourism

While studying tourism in this municipality, the focus is on the activity of people traveling to destinations away from their usual place of residence for recreation, exploration, or business. Tourism includes different experiences such as visiting historical and cultural sites, enjoying the natural landscape, participating in recreational activities, experiencing local food, and interacting with other cultures and different farmers. In my study, tourism is an important global industry that contributes to economic growth, job creation, and the exchange of cultural ideas. It can take many forms, such as international tourism (travel abroad), domestic tourism (travel within a country), and various specialized forms such as adventure tourism, ecotourism, heritage tourism, and medical tourism. However, climate change is one of the most important global environmental and development issues in the world today, and the topic has become prominent in tourism research. As if climate change were already affecting the tourism industry, and it is having a profound impact on travel in the 21st century (Scott et.al. 2012). It is nearer to one of the reputed tourist destinations of the country, Dhulikhel, and its natural environment and the culture and traditions of the people living attract tourists.

Palanchok Bhagwati Temple, Anaikot View Tower, Dugdheshwari Temple, Suvarneshwari Temple, and Sunkoshi River banks are known as tourist areas of the study area; this shows that there is similar potential in the local tourism industry. Panchkhal Municipality is one of the most feasible cities, especially because of its proximity to Kathmandu [44.6 km] (Shakya et.al. 2017). Therefore, even if we can bring a few tourists to Kathmandu valley by promoting the tourist spots of this place; it would help the economic development of this area through the tourism industry.

Photo 27: *Palanchock Bhagawati Temple: Panchkhal ward No.9, Source: Field work, 27th, Dec. 2020,*

Photo 26: *Aneikot View Tower, Panchkhal Ward No.1, Source: Field work, Jan., 2021,*

The hypotheses are tested with the help of statistical analysis of adaptive strategies, as follows:

Canonical Correlations

One of the main objectives of my research was to assess the relationship between two variables such as the obstacle of agricultural production and adaptive strategies of the Panchkhal Municipality. The relationship between two variables is measured by the correlation coefficient. The correlation coefficient is a measure of the asset and direction of the relationship between two variables (see Table 29).

Table 29

Canonical Correlations

SN	Correlation	Eigenvale	Wilks Statistics	F	Number D.F.	Denom D.F.	Sign
1	.333	.124	.862	5.331	16.000	1711.466	.000
2	.168	.029	.969	1.972	9.000	1365.477	.039
3	.051	.003	.997	.371	4.000	1124.000	.830
4	.003	.000	1.000	.006	1.000	563.000	.939

H_0 for the Wilks test is that the correlations in the current and following rows are zero.

Table 29 shows that the Canonical Correlation Analysis was conducted to examine the relationship between adaptive strategies and production challenge variables. The first canonical correlation was found to be highly significant, with a medium value of 0.33 (Wilks Statistic = 0.862, F=5.331, p < 001). The second canonical correlation was also significant, though to a lesser extent, with a low value of 0.168 (Wilks Statistic = 0.969, F = 1.972, p < .001). These results suggest that there are distinct relationships between the sets of adaptive strategies and production challenges. In summary, the Canonical Correlation Analysis provided evidence of significant relationships between adaptive strategies and production challenges. Third and fourth canonical correlations are insignificant.

Multiple Regression Models - 1: Agricultural adaptive strategy index (A)

The multiple regression model for the dependent variable agricultural adaptive strategy index (Table 31) concerning independent variables (Training, age, strata, or settlements, studied subject, marital status, gender, caste groups, and cluster or types of farming) is given below:

$y = \beta_0 + \beta_1 x_1 + \ldots\ldots\ldots + \beta_6 x_6 + \varepsilon$

Where

y is dependent variable

βs are regression coefficients

xs are independent variables

ε= error terms

One of the main objectives of my research was to assess the effect of training, age, settlement, subject studied, marital status, gender, ethnic group, and types of farming on the adaptive strategies of farmers. The results of my study show that the effect of training only helped farmers to choose adaptive strategies. If training increases by one level, the coefficient of 0.49 decreases the agricultural adaptive strategies adopted (see Table 31).

Table 31 shows that the p-value of training is significant and 0.01 but all other values are insignificant and greater than 0.05. This shows that training alone has a significant effect on farmers' selection of adaptive strategies. This study shows that variables such as age, gender, settlement, subject, marital status, caste group, and types of farming do not affect farmers in choosing adaptive strategies.

The regression model is accepted because the assumptions of the regression model are met. After all, the VIF value is less than 10, the tolerance value is less than 1.0, the Durbin Watson value is about 2.5, and the R-squared value is 0.29. Similarly, the R-squared value of 0.29 (Table 30) indicates that 29 percent (0.29> 0.08) of the variability in the dependent variable can be explained by the independent variables in the regression model. The dependent variable intercept of the agricultural production index (Table 30) was 29 percent, and the Durbin-Watson value was also found to be 2.65. It means that there is no problem with autocorrelation. A Durbin-Watson statistic of 2.65 indicates moderate positive autocorrelation in the residuals. This means there may be a systematic pattern or relationship between the errors in the regression model. However, this value is close to 2, suggesting that autocorrelation may not be too severe, but should be considered when interpreting the reliability of model results.

Table 30

Model Summary

	F	Sig.	
Regression	.694	.004[b]	R square value=.29
Residual			Durbin-Watson=2.65
Total			

Source: Field Survey, 2020

From Table 30 the F-value in the ANOVA table is found significant ($p>0.004$). That means the sample is random and the model can explain how the independent variables affect the dependent variables. In other words, the ANOVA results showed a significant relationship between the independent variables and the dependent variables indicating a well-fitting regression model.

Table 31

Coefficients of Linear Regression of Adaptive Strategies.

Independent Variables	B	t	SE	Sig.	Collinearity Statistics	
					Tolerance	VIF
Gender	.37	.19	.28	.18	.67	1.48
Caste/ethnicity	.27	-.69	.30	.36	.56	1.77
Marital status	-.01	.56	.59	.94	.83	1.19
Age	.12	.85	.17	.64	.71	1.40
Settlement	.40	1.11	.16	.14	.70	1.42
Farming	-.16	-1.07	.21	.58	.54	1.84
Level of education	.11	-.73	.25	.65	.83	1.19
Training	-.49	-1.08	.07	.01	.68	1.45

Source: Field Survey, 2020

Table 31 shows that all predictor variables were not found to be significant except for training. It means that gender, settlement, type of farming, caste/ethnicity, marital status, and education are independent variables that show that they have no significant effect on dependent variables such as multiple crops types divide the land into small pieces, practice of multiple alternative land use, increase of irrigation system, employment other than farming, to increase the productivity of agriculture, use of chemical fertilizers, to use of organic fertilizers, to use of organic crops, planting new plants, shading the plants, mulching and changing the size of land for crop production. In statistical analysis, the common threshold to consider variables statistically significant is a significance level of 0.05. If the p-value is less than 0.05 (P=0.05>0.01). It indicates that there is evidence to reject the null hypothesis and

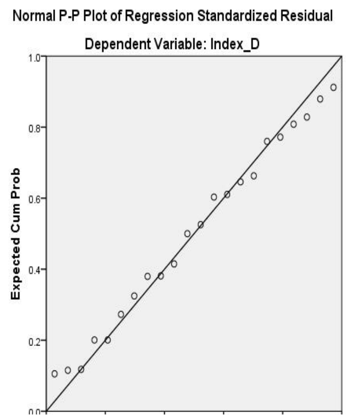


Figure 15

Normality of Model

accept the alternative hypothesis. The P-P plots (Figure, 15) also show that the residual is almost normally distributed, so the regression model does not have the issue of heteroscedasticity.

The Multiple Regression Model indicates that due to education and training, there is a significant difference in the adoption of adaptive strategies in agriculture for climate change adaptation. Women are actively sharing their experiences and opinions and adjusting their adaptive strategies over time. The data indicate that the adoption of adaptive strategies is not influenced by gender. Similarly, the data show that marital status does not play a significant role in choosing agricultural adaptive strategies. Because it shows that all the farmers who are of farming age choose the adaptive strategy according to climate change. The data also shows that they can choose agricultural seeds and plants according to the time and use fertilizers and pesticides, and get better production.

Overall, the age, settlement pattern, subject studied marital status, gender, caste group, and cluster or types of farming do not play a significant role in choosing agricultural adaptive strategies. However, training plays an important role in choosing agricultural adaptive strategies according to climate change. The excessive use of chemical fertilizers and pesticides by farmers is causing health issues.

Discussion of Findings

The discussion provides a detailed outlook into how climate change crucially affects the adaptive agricultural strategies. Due to the increase in unpredictability of climatic patterns, the farmers have been forced to shift cropping calendars, adopt climate-flexible crops, and develop improved irrigation systems. In this way, these approaches have helped in attenuating climate-related problems like droughts, floods, and pests. The section on findings and discussion provides a detailed outlook into how climate change chiefly affects the adaptive agricultural strategies in Panchkhal

Municipality. Due to the increased unpredictability of climatic patterns, the farmers have been forced to shift cropping calendars, adopt climate-resilient crops, and develop better irrigation systems. The research explores the challenges farmers face in implementing sustainable adaptations and the potential benefits of education and policy in promoting sustainable solutions. The following findings are discussed in the given below:

Over the Past 40 Years, Panchkhal Municipality has experienced a Rise in Temperature and a Decrease in Rainfall

Rising temperatures and decreasing rainfall due to climate change are affecting agricultural production. The researcher found out how climatic changes affect agriculture, water resources, and socio-economic conditions in the area (IPCC reports, 2014; Lobell et al., 2011). The significant changes in climate in recent years are affecting agriculture, water resources, and the livelihood of farmers. Due to climate change, farmers are experiencing a situation in which the temperature is increasing in the world and the rainfall is decreasing. The most important trends are the steady increase in temperature and the decrease in rainfall. The changes in global climate patterns, extensively studied and documented in climate science literature, are a result of these changes.

The spatial distribution of climate impacts within a given region is an important aspect of climate change management. We are experiencing an increase in temperature and a lack of rainfall in various parts, affecting local development and land use (Turner et al., 2003 & O'Brien et al., 2004). It indicates that the different regions tolerate varying degrees of increasing temperatures and decreasing precipitation, which affects regional development and land use. This discussion examines the findings within the context of relevant literature, focusing on their impact on climate change on agriculture.

Rising Temperatures. Researchers found that in their research, temperatures rise at a different rate at higher altitudes than at lower altitudes. Variations in agricultural productivity led to changes in crop types or shifts from agriculture to other forms of land use. Research suggests that mountainous regions may have cooler temperatures, varying crop varieties, and longer agricultural viability compared to warmer, lower regions (O'Brien et al., 2004). They reveal that the specific outcomes or trends, such as higher temperatures in mountainous regions, are based on observed data. While in the winter season of Panchkhal Municipality, the annual average temperature has increased by 0.035 degrees Celsius in the last 40 years, meanwhile, the temperature has decreased in other seasons. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), there has been a global trend of rising temperatures due to increased greenhouse gas emissions. The continuous increase in temperature has brought about environmental changes due to heat in agricultural products like rice, maize, and especially in vegetable cultivation. The temperature increase in Panchkhal is in line with the broader regional trends observed in South Asia.

As researchers, Aryal et al. (2014) found that the temperature increases in Nepal's mid-hill regions and other regions due to local deforestation, emission of industrial pollution, use of chemical fertilizer and pesticides in agriculture. It indicates that the main cause of the increase in temperature is human activities, which are affecting environmental change and raising greenhouse gas levels. Similarly, a study by Marhatta et al. (2009) showed that increasing temperatures changed the phenology of plant species, resulting in earlier crop maturity. The study focuses on the widespread nature of temperature increases and their impact on local ecosystems.

Decreasing Rainfall. The burning issue of decreasing rainfall has raised significant concerns due to climate change. Nepal has experienced significant changes in its rainfall patterns in recent decades, posing environmental, agricultural, and socio-economic challenges. The rainfall pattern has changed considerably in recent years, which indicates environmental, agricultural, and socio-economic challenges. In this context, Practical Action Nepal (2009) reports found that people are adjusting to the effects of shifting rainfall patterns on livelihoods and agriculture in various parts of Nepal. As more than two-thirds of this population depends on agriculture as their main livelihood strategy, changes in the rainy season have already reduced agricultural production in Nepal, while Panchkhal Municipality also faces a major shortfall in annual rainfall, which has affected the availability of agricultural water. The decrease in rainfall significantly impacts agricultural productivity, as water is a vital input for crop growth and livestock. The erratic rainfall patterns are causing disruptions to traditional farming schedules.

The Department of Hydrology and Meteorology (DHM, 2020) reports a 0.29 cm annual rainfall per year decrease over the past 40 years. Due to this, agricultural production has been greatly affected. Kripalani et al. (2003) reported that the decreasing rainfall in South Asia is a consequence of changes in monsoon dynamics and atmospheric circulation. It indicates that climate change is a significant issue affecting rainfall and agricultural production, as well as other areas.

The research indicates that the decrease in rainfall pattern is consistent with similar trends in Nepal and its neighbouring regions. The researchers Shrestha and Devkota (2010) found that Nepal's mid-hill and mountain regions decreased precipitation due to changes in the South Asian Monsoon. Similarly, the study by Zomer et al. (2014) reported on climate variability in the Himalayas revealed reduced rainfall as a significant factor in increasing drought frequency, impacting agricultural productivity. It shows that climate change is a major issue, and droughts and erratic rainfall are affecting agricultural production and other human activities.

Impact on Agriculture and Local Livelihoods. The decrease in agricultural production is causing economic hardship to farmers and rural communities due to climate change. Farmers who are experiencing low crop production are farming to support their families or to improve their future farming. Climate change's impact on local livelihoods and agriculture is crucial, as agriculture is the primary income source and economic backbone of Nepal. Climate change significantly impacts the socioeconomic well-being, food security, and agricultural outputs of rural populations, while the rising temperatures and decreasing rainfall have significantly impacted agriculture. Meanwhile, to cope with erratic rainfall, farmers are increasingly reliant on irrigation systems, putting additional pressure on already stressed water resources.

The unpredictability of rainfall patterns introduces economic uncertainty for farmers, as crop failures and reduced yields become more common, affecting their livelihoods. In this consequence to erratic rainfall, farmers are adopting more elastic agricultural practices, such as crop diversification and the use of drought-resistant varieties to mitigate risks. The decrease in rainfall has a significant impact on water resources, affecting both surface and groundwater supplies.

In this context, the researchers Gautam and Thapa (2018) found that the traditional farming practices in the region, heavily reliant on monsoon rainfall, are becoming increasingly. The decrease in water availability has resulted in decreased crop yields and, in some instances, the complete failure of certain crops. The situation has prompted farmers to either adopt drought-resistant crop varieties or abandon agriculture altogether. Similarly, Vörösmarty et al. (2000) focus on the reduced precipitation that leads to decreased river flows, shrinking reservoirs, and reduced groundwater recharge, exacerbating water scarcity, posing threats to drinking water supplies, sanitation, and industrial use. These situations also faced by farmers in the Panchkhal area are similar to those in other regions of Nepal and South Asia. Local communities and policymakers are collaborating to develop adaptive strategies, such as improved water storage infrastructure and sustainable farming training programs, to tackle these challenges.

The powerful water flows during flash floods erode the topsoil, which is essential for agriculture, stripping the land of its most fertile layer and reducing its productivity. As reported in the findings of research conducted by Devkota et al. (2011) focuses that the decreasing rainfall and increasing temperatures in Nepal's Terai region have significantly reduced rice and wheat yields. Similarly, Paudel and Andersen's (2010) study underscored the vulnerability of rain-fed agriculture to climate change, emphasizing the necessity of adaptive strategies to adapt. It reveals that the rainfall variability impacts rain-fed agriculture, a significant global food production, particularly in developing countries, leading to reduced rainfall, drought conditions, and food insecurity. Farmers are adopting various adaptive strategies to minimize the impact of increasing climate change in Panchkhal Municipality. Researchers Shrestha and et.al (2020) found that farmers are adopting alternative water management methods such as rainwater harvesting and drip irrigation to cope with declining rainfall. Additionally, the cultivation of more flexible crop varieties has been shifted towards enduring higher temperatures and reduced water availability.

Adaptive strategies adopted in Panchkhal Municipality are generally similar to adaptive strategies adopted in other climate-affected areas of the world. In this context, the researchers Smit and Wandel (2006) reported the significant role of local knowledge and adaptive practices in enhancing climate change flexibility. Similarly, Adger et al. (2007) emphasize the significance of community-based adaptive strategies in enhancing rural communities' ability to manage climate variability.

The conclusion of the 40-year record of gradually increasing temperatures and decreasing rainfall in Panchkhal Municipality underscores the pressing challenges posed by climate change. These climatic shifts have profound implications for agriculture, water resources, and community livelihoods. Effective adaptive strategies, supported by robust policy interventions, are crucial to mitigating these impacts and ensuring the sustainability of the region's agricultural and ecological systems.

Different Diseases and Pests have appeared in Agriculture

As a result of climate change, some areas are more vulnerable to the introduction of new pests and diseases. For example, temperatures in colder regions or even at higher altitudes are now promoting the growth of diseases and pests that were not present before. Geographical location can also affect differences in humidity and rainfall patterns, which can affect the spread of various agricultural hazards. Research on "Climate Change and Agriculture in Developing Countries" highlights the harmful impact of climate change on agricultural productivity and the economic challenges faced by rural communities. While in the process, this agriculturally developed world faces the onslaught of pests and diseases that seriously challenge the pace at which agricultural development advances by either slowing it down or turning it in reverse (Mendelsohn et al., 2000). Meanwhile, climate change significantly impacts global agriculture by increasing temperatures, altering precipitation patterns, and affecting the prevalence and distribution of pests and diseases. The changes are posing a significant threat to food security and the livelihoods of farmers.

This discussion explores the literature on climate change's role in the emergence and spread of agricultural pests and diseases, focusing on their mechanisms and implications for sustainable farming. While climate change impacts plant diseases' distribution, intensity, and timing, it affects their lifecycle and spread as temperatures rise and changes in precipitation patterns occur. Meanwhile, climate change is causing an increase in crop disease incidence, affecting crop health and yields due to warmer temperatures and altered precipitation patterns. The researchers Juroszek and von Tiedemann (2013) reported that climate change's rising temperatures have accelerated the life cycles of agricultural pests. Similarly, Deutsch et al. (2018) reveal that the increasing temperature has led to a rise in the number of generations of the corn earworm, resulting in more severe infestations. It shows that due to climate change, various types of unknown diseases appear and, as a result, cause damage to agricultural production.

Pests previously restricted to tropical and subtropical regions are now expanding their range into temperate areas, as reported by Bebber et al. (2013). The expansion of cultivated areas presents new challenges for farmers who have not previously encountered these new pests and lack effective control measures for these pests. Due to climate change, increased humidity and temperature fluctuations have led to a rise in pests affecting crops like tomatoes, cucumbers, and potatoes. The increase in crop diseases is affecting production, which often leads to financial difficulties due to a lack of resources and knowledge to effectively manage these threats. An increase in plant diseases can lead to the loss of biodiversity, as farmers may turn to monoculture practices to mitigate risks, reducing the variety of crops grown and further increasing vulnerability to diseases. Warmer temperatures have led to an increase in pests, such as the fall armyworm, armyworms, root knot disease, cutworm, agrotis, and segetum/ agrotis ipilon, which has become a significant threat to crops. In this context, Bell et al. (2015) find that the increased winter temperatures are causing aphid species to survive at higher rates, which can wreak havoc on crops like wheat and barley. In the same way, Goergen et al. (2016) connected the spread of the autumn armyworm (Spodoptera frugiperda) in areas of Africa, Asia, and, more recently, Europe to climate change trends.

The researchers Frona et al. (2021) revealed that elevated CO2 levels can boost the growth of certain invasive plant species, posing a threat to crops and pest control. While climate change has altered the life cycles of numerous pests and microorganisms, leading to increased frequency and severity of infestations due to multiple breeding cycles. As reported in the findings of research conducted by Chakraborty & Newton (2011) stated that climate-induced stress, such as drought or excessive moisture, can weaken plant defences, making them more susceptible to infections by microorganisms and pests. At the same time as climate change impacts plant health and agricultural productivity by weakening plant defenses and increasing susceptibility to infections by microorganisms and pests.

In this way, due to climate change, various pests appear in crops, and if those pests cannot be treated in time, they will destroy the crop. The main cause of climate change is the identified and unidentified pests in the crops and heavy loss of crop production in the world, like the Panchkhal Municipality.

As climate change reduces agricultural resistance to illnesses by stressing plants, making them more vulnerable to infections from fungi and other microorganisms when the plants are under stress from heat. Additionally, the frequency of plant illnesses is also impacted by climate change, as increased humidity and temperatures foster the growth of bacteria, viruses, and fungi. According to the researchers, Chikaire et al. (2011) found that the changes in host susceptibility, pathogen life cycle, and effectiveness of disease management measures are some of the ways that climate change is predicted to increase the risk of plant diseases. Due to the gradual increase in temperature, various identified and unidentified diseases and insects are appearing in agriculture, and this is causing damage to the crops. While farmers are utilizing alternative crops for various purposes to mitigate the impacts of climate change, these adaptations reflect their efforts to build resilience and sustain livelihoods. As long as warmer conditions have facilitated the spread of microorganisms, allowing diseases that were once localized to expand their range, affecting a wider variety of crops in the region.

Climate change will affect livestock production through competition for natural resources, the quantity and quality of feeds, livestock diseases, heat stress, and biodiversity loss (Garnett, 2009).

At the same time, the incidence of plant diseases has increased due to climate change factors such as rising temperatures, changing precipitation patterns, and increased humidity, which create favourable conditions for microorganisms. Essential crops such as rice, maize, and potatoes are increasingly vulnerable to diseases like blight and downy mildew, leading to significant reductions in yield and quality. As temperatures rises, the dynamics of diseases also change, with some microorganisms becoming more aggressive and others emerging as new threats, complicating disease management strategies. The influence that climate change is having on diseases and pests combined is significantly affecting agricultural productivity. According to the researcher Oerke's (2006) estimation, crop losses worldwide resulting from pests and diseases are already significant and are expected to rise as these threats are intensified by climate change.

This is further supported by a study conducted by Chaloner et al. (2021), which demonstrates how the interplay of biotic stressors and climatic change can result in more severe crop losses, especially for staple crops like wheat, rice, and maize. While farmers are implementing a variety of adaptive strategies to lessen the effects of diseases and pests brought on by climate change. The process involves modifying planting schedules, utilizing resistant crop varieties, and implementing integrated pest management (IPM) techniques.

. In this context, researchers Laderach et al. (2017) state that in areas such as Central America, where the coffee leaf rust fungus (Hemileia vastatrix) has had a severe negative impact on coffee output, the development of climate-resilient crop variants has been imperative. The obstacles that climate change presents to agriculture will largely depend on the results of future studies and legislative initiatives. According to Chakraborty and Newton (2011), the literature highlights the need for more focused studies to create efficient plans for managing diseases and pests in the face of changing climate circumstances. Furthermore, Garrett et al. (2014) make the case for the significance of bolstering international surveillance networks to identify and address new pest and disease risks.

Information of Climate Change on Erratic Rainfall, Drought, Landslide, and Flood.

Erratic rainfall, drought, landslides, and floods are hindering development due to climate change. For example, erratic rainfall disrupts agricultural production, leading to food poverty and unstable economies. Landslides and floods can cause infrastructure destruction, hinder economic growth, and increase development costs. Meanwhile, certain landforms are more vulnerable to erratic weather events like rainfall, drought, landslides, and floods. Researcher Stern (2006) addressed how disruptions brought on by climate change, including droughts and floods, obstruct economic growth and exacerbate poverty. Natural disasters such as unexpected rainfall, landslides, and floods are becoming more frequent and severe due to climate change. While ecosystems, infrastructure, and human livelihoods are all significantly impacted by these changes, especially in vulnerable and steep slope areas. The literature on how climate change is causing various environmental statuses will be examined in this debate, with an emphasis on the mechanisms at play and the wider impact on ecosystems and communities.

Patterns of Erratic Rainfall. Rainfall patterns have been disturbed by climate change, increasing variability, and unpredictability. Due to the disruption of normal rainfall cycles brought about by climate change, there have been significant global shifts in rainfall patterns, with some regions experiencing frequent droughts and others experiencing heavy rainfall. Unpredictable rain arrivals in the wake of climate change have disrupted traditional agricultural techniques as areas once reliant on rain now receive this earlier or later. Additionally, rising global temperatures increase the atmosphere's capacity to retain moisture, which makes rainfall events more powerful and unpredictable and can cause both extended dry spells and unexpected floods. In this context, Trenberth (2011) asserts that an atmosphere that is warming retains more moisture, which increases the intensity of rainfall events and prolongs dry spells.

Many regions have reported unpredictable rainfall patterns, which are making agriculture and water management increasingly challenging. Similarly, research on the Economics of Climate Change (Stern, 2006) explores how unpredictable rainfall patterns impair agricultural output and cause instability in the economy, especially in developing nations where agriculture plays a significant role in the economy. It shows that climate change's unpredictable rainfall patterns negatively impact agricultural production, particularly in developing nations. These disruptions lead to erratic rainfall patterns and economic instability, affecting livestock, water supplies, and agricultural output, and affecting food security, livelihoods, and overall economic growth.

In this context, for example, the research of Easterling et al. (2000) shows that, contrary to conventional seasonal patterns, many regions of the world are seeing an increase in the frequency and severity of rainfall extremes like Panchkhal Municipality. Rainfall variability has a significant impact on agricultural planning, water resources, and flood risk management.

Drought. Droughts lead to increased food prices, decreased agricultural yields, and water shortages, which negatively impact economic growth, especially in regions with a significant agricultural industry in the study area. Although in the long run, it may hinder the developmental goals of infrastructure construction being completed at a later date, reduce income, and increase the poverty rates. A drought is a result of erratic rainfall, where long periods of insufficient rainfall cause severe water shortages.This phenomenon is complexly connected to the broader effects of climate change, disrupting the global water cycle and altering traditional weather patterns. Warming of the atmosphere affects the distribution and intensity of rainfall, causing heavy rainfall in some areas and prolonged periods of dryness or drought in others. The unpredictable and increasingly extreme precipitation shifts are exacerbating the frequency and severity of global droughts.

In this context, the researchers Rai (2011) highlighted that climate change intensifies drought conditions by increasing dry spell frequency and severity, particularly in arid regions. It indicates that the researcher suggests that climate change is worsening drought conditions, leading to more frequent and severe dry spells. While global warming will intensify and prolong droughts, particularly in arid regions, it emphasizes the link between climate change and drought severity. For example, the Sahel region in Africa has been severely impacted by recurring droughts, leading to a decline in local agriculture and escalating food insecurity. Funk et al. (2008) suggest that climate change has led to changes in sea surface temperatures and weather patterns, altering the region's historical rainfall patterns. Climate change causes droughts due to changes in sea surface temperature and weather patterns, besides causing changes in rainfall patterns, frequent and severe droughts occur and have a major impact on agriculture.

Landslides. The main cause of landslides is unexpected and heavy rainfall, especially in hilly and mountain areas with very loose soil and steep slopes. The researchers Sidle and Bogard (2016) found that there is a direct correlation between an increase in landslide occurrence and climate change-related heavy rainfall events. Because of the steep slopes, the soil becomes loose, and due to climate change, sometimes there is heavy rain and sometimes there is hot sun, which results in landslides.

Hilly countries like Nepal, which also happens to be the location of Panchkhal Municipality, have such a significant issue. According to Petley's (2010) research, there has been a notable surge in landslides in the Himalayas in recent years, primarily due to altered patterns of rainfall. The report also points out that the area is now more vulnerable to landslides, which are made worse by climate change, as a result of deforestation and land-use changes that are frequently caused by human activities.

Floods.One of the effects of climate change is flooding, which is directly related to an increase in unpredictable and intense rainfall events. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), changes in precipitation patterns brought about by climate change have led to a rise in flood frequency and intensity in many places of the world. For example, Mirza (2011) found that differences in monsoon patterns in South Asia have made floods more severe and regular in countries such as Bangladesh and India. Human habitation, infrastructure, and agriculture are all severely damaged by these floods.

Similarly, Kundzewicz et al. (2019) reported that flooding events are occurring more frequently in areas like North America and Europe, which is frequently linked to changes in rainfall patterns brought on by climate change. The combination of erratic rainfall, drought, landslides, and floods is significantly affecting communities, especially in developing regions. In this context, Adger et al. (2003) focus that climate-induced disasters disproportionately impact vulnerable populations, leading to livelihood loss, displacement, and long-term socio-economic challenges.

The environmental changes are not only causing human impacts but also disrupting ecosystems. The researchers Diffenbaugh and Field (2013) reveal that climate change, including increased floods and landslides, is causing ecosystem changes, species distribution shifts, habitat loss, and decreased biodiversity. The challenges are being addressed through adaptive strategies such as enhanced early warning systems, improved land-use planning, and the construction of resilient infrastructure. The researcher found that Wilby and Keenan (2012) assert that effective climate adaptation necessitates a blend of technological, institutional, and behavioural modifications to mitigate the effects of climate-induced hazards. While future research and policy development are important to manage risks related to climate change-induced rainfall variability, landslides, and floods.

The literature underscores the necessity of thorough risk assessments and integrated disaster management strategies (Field et al., 2012). It indicates that on-going need for research and policy development to manage risks suggests that current measures may not be sufficient, necessitating continuous improvement and adaptation. The study focuses on climate change risks, specifically rainfall variability and natural hazards like landslides and floods, which may be exacerbated by climate-related factors. The paragraph emphasizes the importance of thorough risk assessments and integrated management strategies for effective disaster response, referencing relevant literature.

Adoption of Climate Flexibility Crops

The adoption of climate-flexible crops, such as flood or drought-tolerant cultivation, has been facilitated. By providing food security and income to farmers in the face of climate unpredictability, these crops help stabilize agricultural production and promote economic growth and stability. The adoption of these crops represents adaptive development, where communities adapt their practices to sustain progress despite environmental challenges. To mitigate the effects of climate change on development, research by Adger et al. (2003) emphasizes the importance of using adaptive agricultural techniques such as climate-flexibility crops. These strategies are essential to sustaining economic growth in regions experiencing increasing climate variability. It shows that climate flexibility crops are essential for agriculture to withstand extreme weather conditions, ensuring food security and sustainable practices. Climate variability is causing significant changes, such as rising temperatures, decreased annual rainfall, and more frequent extreme weather events.

In this regard, traditional crop varieties are increasingly unable to cope with these changing conditions, resulting in reduced yields and heightened food insecurity for local farmers. At the same time as traditional crops like barley, millet, paddy, corn, and wheat are difficult to adjust due to climate change, and those crops are gradually disappearing, so farmers are planting hybrid crops in place of those crops. Those hybrid crops are the types of crops that are adapted to climate change, which are being adopted by farmers. To address these challenges, farmers are adopting climate-resilient crop varieties that can withstand extreme weather conditions.

The farmers have adopted the hybrid seeds, such as maize, paddy, and vegetables, which produce good yields in the study area. The data indicates a lack of coping mechanisms against climatic impacts due to the continued use of traditional agricultural practices (Karki et al, 2020). Similarly, Varshney et al. (2011) focus is on the significant yield increases achieved through drought-tolerant maize varieties in sub-Saharan Africa, which help stabilize food production and reduce the risk of crop failure. While drought-tolerant varieties of rice, maize, and vegetables are being introduced, which can grow with minimal water and survive prolonged dry spells? It shows that the drought-tolerant maize varieties are enhancing crop yields, stabilizing food production, and reducing crop failure risk, thereby ensuring food security and predictable agricultural outcomes. While flood-resistant rice varieties, which can survive prolonged submergence, are planted in areas prone to flash floods to save the crop during heavy rains.

This type of crop is planted especially around the river. Which cannot be significantly affected by climate change? Farmers are also turning to heat-resilient varieties of wheat and vegetables, which can tolerate higher temperatures without significant yield loss. Meanwhile, the early-maturing crop varieties allowed the farmers to harvest before adverse weather conditions set in, reducing the risk of crop failure. While local governments and NGOs are actively involved in promoting these flexible crops through seed distribution programs, ensuring that farmers have access to improved seed varieties. Regarding the farmers receiving training on the benefits and management of climate flexibility crops, with extension services providing technical support for effective integration into traditional farming systems.

In this context, the researchers Rogers (2003) suggest that many farmers may be unaware of climate-resilient crops' benefits or lack the necessary skills, necessitating the implementation of extension services and farmer training programs. It indicates that due to a lack of knowledge in choosing crops according to climate change, it is not possible to produce crops on time and resulting in losses. The adoption of these crops has contributed to improved food security as more reliable yields are achieved despite climatic challenges.

By ensuring agricultural production according to time, climate flexibility crops help sustain livelihoods and reduce the economic vulnerability of farming households. The increased adoption of resilient crops enhances the overall resilience of the farming community, allowing it to better withstand and recover from climate-induced shocks. Drought-tolerant and early-maturing crops reduce dependency on irrigation, conserving water resources and lowering the stress on already depleting groundwater reserves. By diversifying the types of crops grown, farmers help preserve agricultural biodiversity, which is crucial for ecosystem health and resilience. Ongoing research by agricultural institutions focuses on developing and testing new flexible crop varieties tailored to the specific climate conditions. Government policies are increasingly supporting the adoption of climate-flexibility crops through subsidies and incentives, making them more accessible to farmers. The integration of climate-flexibility crops encourages the adoption of sustainable agricultural practices, such as crop rotation and inter-cropping, which further enhance flexibility. Farmers report a significant reduction in crop losses due to extreme weather, attributed to the improved hardiness of climate-flexibility varieties.

By adopting these crops, farmers gain greater control over their agricultural outcomes and are empowered to make informed decisions about a variety of farming practices. The widespread adoption of climate flexibility crops is an important step in ensuring the long-term sustainability of agriculture, enabling communities to thrive despite the challenges posed by climate change.

Diversification of Crops

Crop diversification, which involves growing a variety of crops instead of relying solely on one, is a strategy that fosters regional growth. Diversification enhances agricultural production, income, and food security while minimizing the risks associated with crop losses from pests, diseases, or climate change. This strategy enhances agricultural systems' resilience to environmental changes, thereby promoting sustainable development and economic stability. Research on regional agricultural adaptive strategies, such as those discussed by IPCC (2014), shows how regions facing different climatic conditions or climate variability are more likely to adopt crop diversification as a strategy to manage environmental risks.

Similarly, Adger et al. (2003) conducted research that highlights the significance of adaptive agricultural methods, such as crop diversity, in advancing sustainable development. By following these procedures, agricultural systems are made elastic to environmental shocks and can sustain economic expansion, while crop diversification is an important strategy for increasing agricultural flexibility and sustainability. To investigate the notion, Nepali farmers' primary adaptive strategies involve income diversification and migration from their origin. However, Adhikari et al. (2021) suggest communities can adapt to climate change impacts by constructing artificial ponds, controlling pests and weeds, altering plantation and harvesting times, and changing cropping patterns. Additionally, crop diversification involves growing different types of crops instead of relying on a single type, which can reduce risks associated with climate change and market fluctuations.

Crop diversification has the potential to significantly enhance food security and income stability for farmers in Nepal. Diversifying one's sources of income is a good way to respond to the effects of climate change since it increases people's capacity to make the best decisions (Ellis, 1998). It indicates that crop diversification is one of the adaptive strategies of agriculture, which helps to increase crop production according to climate change. While climate variability poses a significant threat to traditional farming, diversification provides a means to adapt and grow crops.

The farmers harvest the benefits by planting various crops like vegetables, fruits, and pulses along with main crops like rice, maize, and wheat. This practice maximizes the use of available resources and also improves soil health. Meanwhile, the successful introduction of high-value crops like avocado is attributed to market demand and favourable climatic conditions. The diversification also helps in pest and disease management, as different crops help break the life cycle of pests and reduce disease outbreaks. This is confirmed by research from the International Food Policy Research Institute (IFPRI), which emphasizes the role of crop diversity in integrated pest management. The use of climate-flexibility crops, such as drought-tolerant and flood-resistant varieties, enhances the flexibility of Panchkhal agricultural systems.

At the same time, through government and non-governmental organization (NGO) initiatives, farmers have also promoted crop diversification through training and provision of inputs. As the least-developed countries, we are significantly impacted by climate change (Shrestha, 2023; Malik & Ford, 2024). Similarly, the COP platform is the ideal place for us to advocate for the loss and damage fund and to seek climate money (Dhungana et al., 2020). This study highlights the need for local preparedness and advocacy strength in global forums such as COP gatherings to address the difficulty of our climate change coping strategies. As climate change is the primary source of this diversification, it requires rapid responses and successful outcomes.

Crop diversification helps us escape the climate crisis and improve our agricultural economy. Improved infrastructural development has enabled farmers to produce and sell a variety of crops, thereby increasing their income. The establishment of local cooperatives has significantly increased collective marketing efforts, reduced transaction costs, and increased bargaining power. However, challenges remain, including the need for continuous training and the availability of quality seeds. Additionally, initial investments for transitioning to diversified farming systems are often a barrier for farmers. Addressing these challenges requires a coordinated effort by the government, NGOs, and the private sector. Further, this research reveals farmers' use of agricultural adaptive strategies to manage their sustainable living. In conclusion, crop diversification is a promising adaptive strategy to cope with the impacts of climate change and improve farmers' livelihoods.

By reducing dependence on a single crop and promoting sustainable practices, diversification increases agricultural resilience and ensures food security. Successful implementation of diversified cropping systems in Panchkhal requires continuous support and investment in infrastructure, training, and market access.

Farmers have changed the cropping calendar due to climate change.

Climate change has led to adaptive strategies in the planting and harvesting schedule or cropping calendar. Farmers adjust their cropping schedules to accommodate seasonal variations in temperature or altered rainfall patterns due to climate change. These changes significantly enhance the lives of farmers' communities, thereby enhancing their food security and agricultural production. While farmers are important agents in changing farm structures that bring about the overall growth and elasticity of their regions.

The researchers Adger et al. (2003) conducted research emphasizing how to combine adaptive measures, including modifying planting schedules, improving the resilience of agricultural systems, and promoting sustainable development in areas affected by climate change. It indicates that farmers have adjusted their cropping schedules in response to a changing climate, a strategy supported by research and agricultural extension programs. The shift in rainfall patterns and rising temperatures has significantly altered conventional farming methods, necessitating farmers to adjust their harvest times. In this context, researchers Klein et al. (2005) emphasize the importance of adaptive strategies like changing cropping calendars in managing climate change effects, ensuring stable agricultural productivity, and mitigating risks.

This adaptation will be made with the view of tuning up critical growth stages of crops to more favourable weather conditions to optimize production and reduce climate-related risks. A notable example is the adjustment of rice planting time. While Paddy, maize, and wheat are traditionally planted late in the monsoon season, they are now being planted earlier to accommodate unpredictable rainfall patterns. In this context, Lobel and Field (2007) investigate how changes in global climate affect crop production, highlighting the need to modify agricultural techniques. Their findings indicate that differences in temperature and rainfall patterns can have a large impact on crop yields, prompting farmers to adjust their planting schedules to minimize negative impacts and maximize yields. Research by Lobell et al. (2008) reveals that cropping calendar changes are influenced by regional climatic variability, emphasizing the importance of geography in determining crop planting and harvesting.

It indicates that the cropping calendar modifications are directly impacted by the distinct climates of particular locations. This emphasizes how crucial location is in dictating when and how agricultural techniques are carried out. To maximize agricultural production, farmers necessarily modify their planting and harvesting schedules based on local climatic variations. The geographic factors play a significant role, like local climate patterns, in agricultural decisions and adaptive strategies.

Adjusting their planting schedules ensures water supply to the rice plants during their early growth stages, thereby minimizing drought problems during the dry season. Similarly, planting of winter crops such as wheat and barley has been promoted to avoid the late-season cold and utilize the remaining soil moisture from the monsoon rains. This change ensures that the crop matures before extreme cold, preventing potential yield losses.

Furthermore, vegetable farmers in Panchkhal have also adjusted planting times for crops such as tomatoes and cauliflower, shifting planting dates to early season to take advantage of the extended growing season and avoid extreme heat (Gautam & Koirala, 2020). These changes are supported by the findings of the Nepal Agricultural Research Council (NARC), which suggests that changing crop calendars can significantly reduce the adverse effects of climate change.

Researchers Poudel and Regmi (2018) indicate that such adjustments have increased elasticity and productivity in many Nepali farming communities, including Panchkhal. Moreover, this temporal shift in cropping practices is facilitated by improved access to climate information services. Weather forecasting and early warning systems are crucial in aiding farmers in determining the most suitable planting and harvesting times. These services, often disseminated through mobile technology and local agricultural extension offices, provide time- and location-specific advice that is critical to decision-making. Farmers need continuous access to reliable climate data and support to effectively understand and implement new practices. There is also a need for new planting schedules and crop varieties adapted to climatic conditions (Pant & Thapa, 2019). It shows that farmers are planting different varieties of crops to adapt to climate change for better production.

Community-based adaptive strategies, such as farmer field schools and training, are crucial in disseminating knowledge and promoting collective action among Panchkhal farmers. These programs, often supported by NGOs and government agencies, provide training and resources that enable farmers to use and adopt new crop calendars (Sharma &Adhikari, 2020). It indicates that the government and non-governmental organizations provide training to farmers from time to time in which helps farmers to choose crop seeds and plants according to the time.

Improved Irrigation Systems

Improved irrigation systems play a crucial role in enhancing agricultural water use efficiency and promoting regional development. The improved irrigation systems stabilize agricultural output by providing a consistent water supply, even in areas with limited resources or erratic rainfall. As a result, this promotes economic growth, food security, and rural development. Investing in and implementing these systems helps regions overcome environmental barriers and promote continued growth. In this context, researchers Molden et al. (2007) investigated the impact of topography and water availability on irrigation system design and execution in different locations.

The study suggests that the most suitable irrigation techniques should be tailored to the specific environmental and geographical conditions of the local area. It indicates the influence of topography and water availability on the design and implementation of irrigation systems in specific locations. The study emphasizes the importance of local context in designing and implementing effective irrigation systems, emphasizing the need for tailored techniques for each location. The farmers reveal that the improved irrigation systems have become an important adaptive strategy to cope with the effects of climate change. As climate change increasingly affects water availability, efficient irrigation systems are essential to maintain agricultural productivity. The traditional irrigation methods are insufficient for meeting crop water demands, necessitating the adoption of advanced and effective technologies.

One of the major improvements is the introduction of drip irrigation, which delivers water directly to plant roots, reducing water wastage and maximizing efficiency. Drip irrigation systems have been shown to reduce water use by up to fifty percent compared to conventional methods, while also improving crop yields (Gautam & Koirala, 2020). This method is especially used in high-value crops such as vegetables and fruits, which require precise water management. Boring irrigation is another technique used in Panchkhal. It is effective for crops and covers small areas with uniform water distribution. This technique not only conserves water but also reduces labour costs and improves the efficiency of irrigation. In addition, farmers dig ditches in the river during the dry season, and the water collects little by little, which is used to irrigate crops through boring.

Governmental and non-governmental organizations (NGOs) have played an important role in the promotion of these technologies. The farmers have been facilitated by programs that subsidize the cost of irrigation equipment and conveyance technical training. Water harvesting technology has also been integrated into the improved irrigation system. Farmers are encouraged to construct rainwater harvesting ponds and tanks, and dig boreholes that store rainwater for use during dry periods. This practice not only provides a reliable source of water but also reduces dependence on erratic rainfall.

The adoption of improved irrigation systems has had a significant positive impact on agricultural productivity and sustainability. According to a survey by Poudel and Regmi (2018), farmers who adopted these systems reported increased crop yields and reduced water stress even during periods of low rainfall. This has improved food security and living standards. Furthermore, these systems contribute to better water management at the community level. They help conserve local water resources by reducing water wastage and optimizing use, which is critical in the face of climate-induced water scarcity. This is in line with the findings of the International Water Management Institute (IWMI), which emphasizes the importance of efficient irrigation for sustainable water management in agriculture. Implementing improved irrigation systems faces challenges like high initial equipment costs, financial assistance, and ongoing training for small farmers, despite subsidies and financial assistance programs.

To address these challenges, community-based approaches have proven effective. Farmer cooperatives and local drinking water consumer associations have been established to collectively manage the irrigation system, share costs, and provide mutual support. These institutions also facilitate access to training and resources, ensuring that all members benefit from improved irrigation practices (Adhikari & Shrestha, 2019). It indicates that the farmers have adopted irrigation practices, which are beneficial even in areas with limited water sources, as per the training.

In conclusion, the adoption of improved irrigation systems in Panchkhal Municipality represents an important adaptation to climate change. By enhancing water use efficiency and ensuring a reliable water supply, these systems help safeguard agricultural productivity and sustainability. Continued support from the government, NGOs, and community organizations is needed to scale up these practices and address the challenges associated with their implementation. As climate change continues to affect water availability, efficient irrigation systems will remain the basis of elastic agricultural practices in Panchkhal.

Chapter Summary

The climate is the long-term weather in a particular location. This chapter shows the 40-year (1980-2020) rainfall and temperature pattern of Panchkhal Municipality. The highest temperature was 29.47°C, and the lowest temperature was 26.77°C. In this period, the highest rainfall was 110.12 cm, and the lowest rainfall was 66.86 cm. The impacts of climate change were erratic rainfall, fluctuations in rainfall and temperature, landslides, floods, insect infestation of crops and fruits, and not ripening crops and fruit on time. The farmers got information about climate change from various sources such as radio/TV, the internet, newspapers, experiences, neighbours, and booklets. Some of the farmers got the information from two or more sources on climate change.

The study shows that the farmers are getting information through radio/TV. Most farmers have reported that the temperature gradually increases and the rainfall decreases. Due to the change in temperature and rainfall, most of the farmers have changed their agricultural sowing and harvesting time.

Climate change is increasing the number of insects affecting agriculture, causing significant animal deaths in both the agricultural and livestock sectors. To adapt to climate change, farmers are gradually changing their adjustment strategies, such as the section on climate mitigation in crops and market-oriented crops. It indicates that farmers can get more production if they can choose crops according to climate change. Farmers are now experimenting with crop rotation, selecting drought-resistant, heat-tolerant, and pest-resistant seeds to improve their crop yield. Local farmers have demonstrated the value of adaptive farming techniques and information sharing, increasing community resilience and adaptability to changing conditions.

The farmers are growing tomatoes off-season regarding climate change and agricultural adaptive techniques. While the farmers are choosing plants and seeds for agriculture, following climate change is crucial for adaptive plans. Although the challenges posed by the changing climate, farmers may maintain their livelihoods and achieve high yields by selecting crops and farming practices that are climate-appropriate. This demonstrates how educational resources and information exchange can support farmers in their efforts to adapt to climate change.

CHAPTER VI

THE ROLE OF CLIMATE CHANGE EDUCATION IN ENHANCING FARMERS' CAPACITY FOR ADAPTIVE AGRICULTURAL STRATEGIES

This chapter seeks to explore the role of climate change education in Panchkhal Municipality, with a focus on how it strengthens farmers' capacity to mitigate and adapt to climate change challenges in agriculture.

Role of Climate Change Education

Climate change education is vital for farmers to develop adaptive agricultural strategies that are tailored to their specific environmental conditions from a geographical perspective. This education enhances farmers' adaptation strategies to regional climate patterns, promoting crop resilience and fostering agricultural growth in diverse settings by addressing local challenges. For example, educated farmers are better equipped to adopt sustainable practices and mitigate climate change impacts, which vary significantly across different landscapes, ecosystems, and proximal distances from the markets and municipal center of the study area. Climate change education emphasizes understanding spatial variations in climate effects, enhancing farmers' ability to mitigate and adapt to local and global climate challenges.

The study emphasizes the importance of clear definitions and cross-disciplinary communication for effective adaptation that is sensitive to geographical differences. This education fosters understanding and appreciation of climate dynamics, promoting responsible actions and critical thinking that considers the spatial variability of climate impacts. Formal, non-formal, and informal modes of education in climate change include school curricula, agricultural research centers, museums, demonstration farms, fairs, and community centers that provide region-specific training to farmers and other stakeholders. Climate change education focuses on active learning, place-based learning, and interdisciplinary learning using technological aids in addressing geographical diversities of climate change impact and developing strategies for adaptation. These methods enable farmers to effectively adapt and maintain resilience to their unique climate challenges in their geographic regions in the study area.

Provision of Climate Change Education in Nepal

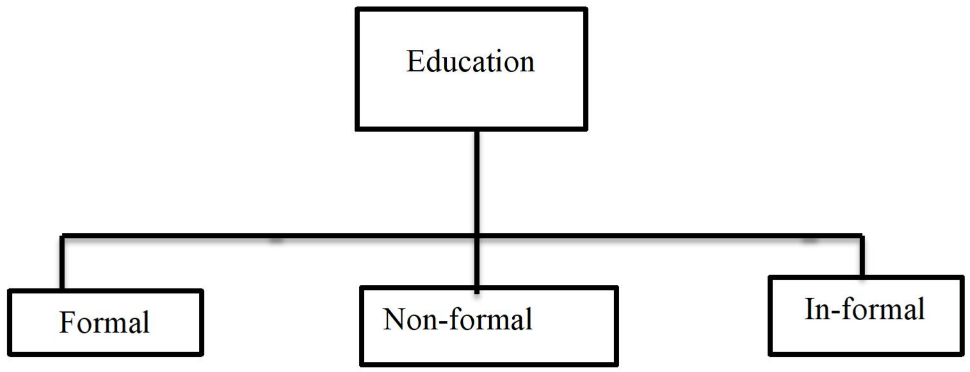
This is further supported by the national education policy of Nepal (2019), which focuses on educating children about climate change issues in different subjects, thus making them more aware of the impacts of climate change. The dissemination of CCE knowledge is still in its early stages, with proper practices and knowledge being provided through both formal and informal education. The national curriculum framework (2019) incorporates climate change into various school curricula. The framework is also involved in curriculum development, material development, and teacher training in related subjects like science, social studies, and health and environment through the Curriculum Development Center and Education Human Resource Development Center. Teacher training programs are currently being implemented to integrate climate change education into classrooms.

Climate change education (CCE) is utilized to develop climate mitigation strategies, foster adaptive communities, and drive change through learning, using diverse methods and strategies for different audiences and contexts. The International Standard Classification of Education (ISCE) categorizes education in Nepal into formal, non-formal, and informal, which are crucial in addressing climate change in the municipality.

In the study area, climate change education encompasses formal, non-formal, and informal education methods, including school curricula, agricultural research centers, museums, demonstration farms, fairs, and community centers, offering training for farmers and stakeholders. These insights are also applicable to climate change education and are discussed as follows:

Figure 16

Types of Education



Formal Education

Formal education, initially centered on respected teachers, has always served two primary purposes. The primary objective is to offer advanced education in disciplines that uphold the existing knowledge by preserving and transmitting knowledge to future generations. The second objective is to provide opportunities for research, debate, and knowledge extension. The third purpose is to provide a platform

for articulating and criticizing the values of societies that claim to be more practical in their daily lives.

The study emphasizes the crucial role of formal education, starting in schools and progressing through primary, secondary, and higher education, in preparing farmers for climate flexibility. Formal education on climate change is crucial for farmers to improve their adaptive agricultural strategies, providing them with localized knowledge and skills to implement sustainable practices and mitigate climate impacts. Educated farmers have adjusted their farming methods to suit the changing environmental conditions of their specific regions. The data reveals that only three percent of farmers in this municipality are illiterate. A farmer stated that our limited knowledge is insufficient to adopt flexible adaptive strategies to increase productivity from formal education (see Table 32).

Table 32

Educational Status

Education level	Number	Percent
Primary	188	33.1
Lower secondary	178	31.3
Secondary	112	19.7
Higher education	77	13.6
Illiterate	13	2.3
Total	568	100

Source: Field Survey, 2020

Table 32 shows that 33.1 percent of farmers have completed primary education, focusing on basic reading, writing, arithmetic, and life skills. This result indicates that farmers have completed their education up to the 0 to 5 class. A farmer reported,

> *I dropped out of class at five, 11 years old, due to a lack of financial resources. However, primary education has also enabled me to select profitable vegetables like cauliflower, cabbage, and radish in the market based on changing climate conditions.*

While some farmers in the study area have completed lower secondary education, focusing on subject-specific knowledge, fundamental thinking skills, and personal development, to prepare for academic or workforce entry. The data reveals that 30 percent of farmers have completed lower secondary education, a formal stage that bridges primary and secondary education, covering grades 6-8 or equivalent. A lower secondary education-completed farmer shared his experience as follows:

> *I completed class 8 at Shree Sarvamangala High School in Panchkhal Municipality 20 years ago. However, I dropped out of school due to a friend's influence and began working as a truck assistant, though I couldn't continue in that job for long. I have rented five Ropanis of land at Rs. 10,000 per Ropani and started cultivating climate-resistant vegetables like potatoes, cauliflower, radishes, and carrots, using the limited educational knowledge I have. This has helped me mitigate the adverse effects of climate change in recent years.*

This statement highlights the importance of formal education for farmers to share their experiences and learn, as it aids in selecting profitable and drought-resistant crops for changing climate patterns. During my observations, I found that farmers with education up to the lower secondary level can easily select seeds and plants that are suitable for adapting to climate change.

Similarly, about twenty percent of farmers have completed secondary level education, which is the bridge to the higher level of education. At this level, the age of students is adolescence. Education helps farmers develop their inner talent. In this context, one of the farmers reported,

> *I passed class 10 but had to drop out due to financial problems. While reading, I learned that plants play a major role in mitigating climate change. I planted 50 plants including avocado, salla, dhupi and champ, and selected agricultural crops like rice, corn and vegetables to mitigate the effects of climate change.*

This suggests that formal education and experiences are always important for learning. While the farmers have several ways of learning, formal learning from school is significant for climate change strategies. School education provides farmers with the knowledge to plant trees, thereby helping to mitigate the effects of climate change. During my observation, I interacted with farmers about schooling. Farmers said that school education and their experience will help them plant trees to minimize the effects of climate change.

Formal education and climate change education are vital in enhancing farmers' adaptive agricultural strategies. Farmers who are educated are better equipped to comprehend and adapt to the evolving climate conditions. This knowledge aids in the implementation of effective practices to maintain and enhance crop production. Local farmers have acquired higher education that provides higher standards and vocational education, including colleges, technical institutes, and vocational training centers, which equip people with advanced skills for a rapidly evolving global landscape. A small number of farmers (13.6%) have completed higher education to achieve specific boundaries and curriculum. In this context of this study, higher education indicates that farmers have completed the Bachelor's and Master's levels of education. Farmers who have acquired higher education have been able to obtain higher yields, according to climate change, by implementing effective adaptive strategies in agriculture. For example, one of the farmers shared,

> *I have passed bachelor of education level, and then taught in primary school for 10 years in private sources. Due to a low salary, I resigned from the job and began pursuing commercial vegetable farming. Also took training related to vegetable cultivation by Lob Green Nepal.*

This suggests that formal communications and experiences are always important for learning. While the farmers have several ways of learning, formal learning from college is significant for climate change strategies. Educated farmers were trained by INGOs to help select seeds according to climate change and to use chemical fertilizers and pesticides. During my observation, the farmers have a higher literacy rate in this municipality compared to than in Nepal. The findings indicate that education is important for improving agricultural productivity. Formal education is a systematic and step-by-step process of acquiring knowledge and skills, typically provided in schools, colleges, or universities. Formal education, including school and university degrees, is crucial. The third hypothesis is tested about the relationship between educational level and adaptive strategies (see Table 33).

Multiple comparisons include: primary, lower secondary, secondary, and higher education (see Table 33).

Table 33

Dependent Variable: Index A

(I) Level of education of the respondent	(J) Level of education of the respondent	Mean Difference (I-J)	Std. Error	Sig.
Primary	Lower secondary	-.04500	07114	.527
	Secondary	-.8808	05371	.102
	Higher education	-22507	07581	.003
Lower secondary	Primary	.04500	.07114	.527
	Secondary	-04307	06435	.504
	Higher education	-18006	08369	.032
Secondary	Primary	08808	05371	.102
	Lowers Secondary	04307	06435	.504
	Higher education	-.13699*	06948	.049
Higher education	Primary	22507*	.07581	.003
	Lower secondary	18006*	08369	.032
	Secondary	13699*	.06948	.049

The mean difference is significant at the 0.05 level.

Source: Field Survey, 2020

Table 33 shows that the farmers who have acquired higher education effectively adopt various adaptive strategies to deal with the effects of climate change. ANOVA presents of that table there is a significant difference in index (adaptive strategies) among different levels of education, and is less than 0.05 (p 0.05) for higher levels of education. Thus, it confirmed that there is a statistical difference between the higher education level and the lower level (primary, lower secondary, and secondary) of the farmers. It is also confirmed that there is a significant difference in the index between different levels of education. For example, "higher education vs.

primary education" has a Sig. Value of 0.003 (less than 0.05), higher secondary vs. lower secondary has a Sig. Value of 0.032 (less than 0.05), higher education vs. secondary has a Sig. Value of 0.049 (0.05) score value of less than 0.05. It means that education has a significant role in decision-making as a vector for adaptation to climate change. Higher education farmers are more likely to adopt adaptive strategies than low-level farmers. Educated farmers are role models for improving new techniques of agricultural practices. Higher-educated farmers also have greater exposure, social networking, and services compared to low-level education farmers, enabling them to assess and use adaptive strategies and practices in their agriculture. Elsewhere, the researchers indicate that education plays a significant positive role in adapting to climate change (Deressa et al., 2009; Ndamani & Watanabe, 2016; Tiwari et al., 2014). This indicates that education plays an important role in the adoption of adaptive strategies, as it shows that educated farmers are more likely to adopt adaptive strategies over time than other levels of farmers.

The Pace of Climate Change Education in School Curricula

Climate change education is being integrated into school curricula to increase student awareness and knowledge about the issue. This education is essential in helping future farmers develop adaptive agricultural strategies. Understanding climate impacts enables farmers to make informed decisions and adapt their practices to ensure sustainable crop production. Local farmers promote climate education to prepare students for future challenges, promote adaptive skills, and prepare them for future management roles. The school-level curriculum in Nepal is mainly divided into two levels: Basic Level (Classes 1 to 8) and Secondary Level (Classes 9 to 12). The course is designed to include a combination of theoretical knowledge and practical skills. At the basic level, students study subjects like Mathematics, Science, Social

Studies, English, and Nepali. Basic education focuses on the holistic development of children.

At the secondary level, the curriculum is more specialized, and students can choose between science, business administration, and humanities. A secondary education student is in their chosen field of study and prepares them for university or professional training. In addition, technical and professional education is included in the curriculum and provides academic knowledge as well as practical skills. The curriculum also includes extracurricular activities, cultural studies, and moral education to promote excellent character. It focuses on the preservation of Nepali culture, heritage, and values through the process of education. In this context, the Secondary Education Examination (SEE) is a crucial academic milestone, typically evaluated at the end of each academic year. The curriculum of SEE is being revised to provide a more comprehensive, relevant, and international-standard education to students across the country. As Nepal's governments teach students about climate change in various subjects like Science, Social Education, and Agriculture education at the basic education level. The study focuses on the need to adapt social studies, science education, and agricultural education curricula to incorporate climate change adaptive strategies to enhance student knowledge (Appendix G).

Non-Formal Education

Non-formal education is essential for farmers to develop adaptive agricultural strategies and adapt to environmental changes. This includes climate change workshops and training sessions. It helps farmers in implementing effective strategies to enhance and sustain crop production. Local farmers are utilizing informal education as an alternative learning experience, acquiring knowledge outside the formal school curriculum system. Non-formal education provides education and skills to farmers who do not have access to formal education to mitigate climate change. According to climate change, such education provides students with skills and knowledge adapted to their needs. It provides literacy and need-based education and training to marginalized or disadvantaged farmers in this study area. It is not provided by any educational institution, and generally, there is no verification of certificates. It includes out-of-school education and on-the-job training and is often structured [UNESCO Institute for Statistics (UIS, 2012)]. Non-formal education aids in the acquisition of knowledge and skills for children, adolescents, youth, and adults regarding climate change.

Farmers in the study area have adopted various adaptive strategies in agriculture. GO and I/NGO-have given various types of agricultural training in planting, seeds, chemical fertilizers, insecticides, pesticides, and agricultural implements. Lob Green Nepal, the Agricultural Knowledge Center, and the Prime Minister's Agriculture Modernization Program are actively involved in agriculture, emphasizing the crucial role of education in agricultural activities. The farmers are utilizing agricultural training as an informal education method in Panchkhal Municipality. The farmers in the study area have successfully implemented various agricultural training strategies, resulting in significant benefits. The government and I/NGOs have provided the following agricultural training to the farmers:

Agriculture Training

Agriculture training is essential for farmers to adapt to climate change, as it aids in understanding and effectively implementing adaptive agricultural strategies. Climate change education through targeted training programs provides farmers with the necessary skills to adapt to changing environmental conditions. This empowers farmers to adopt sustainable practices and enhance crop flexibility**.** Local farmers are focusing on various types of agricultural training for climate change adaptation, developing climate-adaptive strategies, and implementing climate-smart strategies (Climate-Smart Agricultural Training and Capacity Building, Promotion of Climate-Resilient Agricultural Practices and Policy, and Institutional Support Through Education for farmers in the study area. There are various agricultural training programs in this municipality on agricultural processes and production**.** The training includes IPM Seeds, dairy farming, mushroom cultivation; animal husbandry, poultry farming, and tunnel farming (see Table 34).

Table 34

Types of Agriculture Training

Statement	Types of training	Numbers (n=568)	percent
Agriculture Training	Participated in training	170	29.9
	Tunnel farming	151	26.6
Types of Agriculture Training	IPM	149	26.3
	Seeds related	142	25.0
	Mushroom cultivation	113	19.9
	Livestock	105	18.5
	Poultry farming	101	17.8

Source: Field Survey, 2020

Table 34 presents that a few farmers (29.1%) have taken the training in agriculture to mitigate climate change. Tunnel farming provides a controlled and protected environment for crop production, maximizes yields, and helps extend the growing season. Among the large numbers of farmers (26.6%) who have received training on tunnel farming to mitigate the impact of climate change. Farmers have adopted tunnel farming, which helps in off-season production of vegetables in an environmentally friendly manner. In the changing climatic conditions, the farmers have utilized integrated pest management (IPM), which is important for improving farmers' adaptive strategies in response to climate change. Climate change education aids farmers in understanding and effectively implementing IPM practices. This knowledge enables farmers to control pests, protect crops sustainably, and enhance agricultural productivity. Local farmers have received training on pest management focusing on sustainable pest control strategies, crop rotation, biological controls, and specialty enemy protection. About twenty-six percent of farmers have received training in IPM to reduce the impact of climate change. Lob Green Nepal organization provides training for agriculture production in the municipality. The promotion of training encourages the reduction of the use of chemical fertilizers and pesticides. For example, one of the farmers shared, "*The farmers promote IPM agriculture farming for healthy foods. Some of the conscious farmers are aware of the effects of the use of chemical fertilizers and pesticides in agricultural production.*" This suggests that non-formal communications and experiences are always important for learning. Farmers are getting knowledge of modern fertilizers and pesticides through experience and training, which is important for the climate change strategy. During my field observation, I saw the IPM farming of cauliflower in the study area. The cauliflower production was not satisfactory, so I interacted with the farmers about it. The farmers said that, due to a lack of sufficient chemical fertilizer and pesticides, the crops could not produce well, but the organic crops are healthy.

Hybrid seeds significantly enhance farmers' ability to adapt to climate change. Climate change education equips farmers with the knowledge to select and effectively utilize these seeds. This education helps farmers in enhancing crop flexibility and productivity in response to evolving environmental conditions. Local farmers are utilizing hybrid seeds to reduce climate-related risks and optimize crop production. Farmers choose climate-tolerant seeds that are drought-resistant, disease-resistant, and have early growth capabilities. The knowledge of farmers enhances agricultural efficiency and ensures potential crop production and food security. Twenty-four percent of farmers have received training on choosing seeds to cope with climate change.

The farmers are being trained to select hybrid seeds that are adaptable to climate change to ensure optimum production. Trained farmers are succeeding in getting a good yield by selecting seeds. For example, in the past, farmers used local rice seeds, which resulted in less production. But these days, the farmers have the training in the use of hybrid seeds, such as paddy production, which has contributed to an increase in production by three times. One of the farmers shared, "Under the Prime Minister's Agriculture Modernization Project, I have received training in selecting seeds according to climate change. The training has enhanced knowledge on selecting climate change-resistant seeds of paddy, leading to improved yields." This suggests that non-formal communications and experiences are always significant for learning. The farmers got the knowledge through training about the drought-resistant crops, while farmers are using hybrid seeds that increase yields more effectively than local seeds. During my field observation, I observed cauliflower cultivation in the study area. Cauliflower was a good crop, and I talked to the farmers about it. The excessive use of chemical fertilizers and pesticides in crops produces good yields, but such types of crops are harmful to health.

Climate change education provides farmers with the essential skills and knowledge to successfully cultivate mushrooms as an effective adaptation strategy. This education aids farmers in enhancing agricultural sustainability by diversifying their crops and adapting to changing climate conditions. Local farmers are receiving training on practical skills for successful mushroom cultivation, including moisture and temperature management, pest and disease control, and harvesting techniques. About twenty percent of farmers have received training in mushroom cultivation to cope with climate change. The farmers have implemented mushroom adaptive strategies to mitigate the effects of climate change. One of the farmers reported,

> *I got the training on mushrooms from the Agriculture Knowledge Centre in 2074. After sowing the mushroom seeds, the straw was made into a plastic bag. It took about 30 days to develop and was ready for collection. The mushroom produced well and some of it was sold to the neighbors.*

This suggests that formal communications and neighbourliness are always important for learning. Farmers have taken mushroom training on climate change strategy to improve the economic condition of farmers. During my field observation, I saw mushroom cultivation. The mushroom was a good production, and I also talked to the farmers about production. The farmers said, the use of a small amount of pesticides in mushrooms increased production, which is relatively health-friendly. Farmers are employing mushroom cultivation methods to mitigate the effects of climate change, which provides a good income generation.

Climate change education is significant for farmers to effectively manage livestock under changing environmental conditions, as animal husbandry is essential for adaptation. This knowledge enhances the flexibility and productivity of animal husbandry, which supports farmers' livelihoods. Local farmers have received training on animal husbandry, aiming to enhance their knowledge, skills, and productivity, contributing to the overall development of livestock farming. About nineteen percent of farmers have received training on livestock from the Agricultural Knowledge Center. One of the farmers shared, "*I took the livestock training from the Agricultural Knowledge Center. Then, I bought a cow and began selling milk in a dairy. Now I am getting a good profit from milk."* This suggests that formal learning and ideas of neighbours are always important for learning. The farmers took the training from the formal communication about the livestock and applied it to help mitigate the impact of climate change. Livestock farming helps organic farming, which is crucial for climate change strategies due to its healthy production practices. During my field observation, I saw that livestock farming is significant for enhancing agricultural flexibility and livelihoods in the face of the impacts of climate change. It improves animal husbandry practices, disease management, and sustainable production methods.

Climate change education is important for poultry farmers to optimize production despite environmental shifts, making it essential for climate adaptation. This education enhances the flexibility and efficiency of poultry farming, thereby improving farmers' adaptive agricultural strategies. Local farmers have received training in poultry farming, focusing on breed selection, housing development, feeding practices, disease management, and marketing strategies to increase productivity and profitability. Around eighteen percent of farmers have received training in poultry farming from the government and non-government organizations. One of the farmers shared, *"I have taken the training in Poultry farming by the Lob Green Nepal. After that, I made a chicken coop and bought 200 chickens. The current situation of poultry farming is providing me with a significant income*. "This suggests that non-formal communication and friends are always important for learning. Farmers have received training in poultry farming and are implementing it to improve agricultural production and enhance economic conditions. During my field observation, I observed poultry farming in the study area, and I interacted with the farmers. They said poultry farming training is significant for enhancing agricultural flexibility and livelihoods to face the impacts of climate change. The farmers have taken training on poultry farming and used it to increase their income while minimizing the effects of climate change. Appendix H mentions the curriculum of Lob Green Nepal.

The relation shows the difference between agricultural training and adaptive strategies of the Panchkhal Municipality (see Table 35).

Table 35

Participation in Training

Group statistics

Training	Number of Respondents (n=568)	Mean	Std. Deviation	Std. Error Mean
Participated	170	3.6118	.35796	.02745
Not participated	398	3.5068	.46196	.02316

Source: Field Survey, 2020

Levene's Test for Equality of Variances

Levene's Test for Equality of Variances	F	Sig.	t	df
	2.924	.019	2.643	.566
			2.924	407.249

Table 35 presents thtrained farmers effectively adopt various adaptive strategies to mitigate the impacts of climate change. Table 35 shows the relationship between training and adaptive strategies of the farmers. The result of the independent sample t-test indicates that there is a significant statistical mean difference, $t=0.019 < p=0.05$ ($t=.019$, $p>0.05$) in training across the adaptive strategies. This means there is a link between agricultural training and adaptive strategies.

Trained farmers quickly adopt agricultural adaptive strategies to climate change that lead to improved yields and higher returns than untrained farmers. Trained farmers provide an example for their communities by showing effective agricultural adaptive techniques. Their capacity to plant crops at the ideal times and locations demonstrate their experienced understanding and use of adaptive methods. They also have greater exposure, social networking, and better service delivery than untrained farmers, which helps them to assess and adapt strategies and practices in their agriculture. Studies have shown that education has a significant positive role in climate change adaptation elsewhere (Deressa et al., 2009; Ndamani & Watanabe, 2016; Tiwari et al., 2014). The trained farmers are planting crops timely manner considering the climatic conditions. The t-test also showed that untrained farmers could not adopt agricultural adaptive strategies according to time and need compared to trained farmers.

While summing up, the study reveals that the farmers who have received agricultural training tend to adopt more agricultural adaptive strategies over time. Thus, despite the challenges of climate change, agricultural production has provided significant benefits to the people. Government and non-government organizations are implementing timely training schedules for farmers to effectively utilize adaptive strategies, while the farmers are benefiting from such training.

Market Support Technology

Climate change education is important for farmers to effectively utilize market support technology in adapting to climate change. This education improves market access, enhances agricultural productivity, and enhances flexibility. Local farmers are utilizing the Market Support Technology initiative, which focuses on using market-centered technologies for climate change mitigation. The various market support techniques are being used in the study area for agricultural process and production. The technology includes mobile application, virtual training and extension services, data analytic for market insight and online market platform.

Mobile applications play a crucial role in farmers' adaptive capacity to mitigate th impact of climate change. Climate change education teaches farmers how to use apps for real-time weather updates and agricultural advice. This education empowers farmers to make informed decisions and enhance crop flexibility. Local farmers are utilizing a mobile application for crucial agricultural data, enabling informed decision-making and optimization of farming practices, including weather forecasts, market prices, and government schemes (see Table 36).

Table 36

Market Support Technology

Variables	Number (n=568)	Percent
Mobile Application	106	18.6
Virtual training and extension services	74	13.0
Data analytics for market insight	25	4.4
Online market platform	16	2.8

Source: Field Survey, 2020

Table 36 presents, about nineteen percent of farmers are using mobile applications for agricultural activities. It helps farmers to find out the weather conditions and buy and sell agricultural products. However, these days, only a few of the farmers are utilizing the mobile application. For example, some of the farmers have been utilizing mobile applications for the planting and harvesting of crops. One of the farmers in Ward No. 2 reported,

> *I have used mobile apps for the marketing of agricultural production since the COVID-19 pandemic. A neighbour's son who studied computer engineering at Kathmandu University in Dhulikhel gave me this knowledge. The mobile apps are connected to the Kalimati vegetable market. The app has been instrumental in helping the user determine the price of vegetables, which has enabled them to effectively sell their production.*

This suggests that non-formal communication and neighbours are always important for learning. Farmers have utilized new technology to sell their agricultural products directly to the main agricultural selling center. This direct connection allows farmers to earn higher profits by reducing brokers' channels. As a result, they have increased their income through selling agricultural products.

During my field observation, I interacted with the farmers about how mobile apps play a crucial role in marketing agricultural production at the appropriate price. Local farmers are utilizing virtual training and extension services to enhance agricultural skills, adopt sustainable farming strategies, and adapt to climate change.

Virtual training and extension services are vital in climate change education, providing farmers with the knowledge and skills to adapt their agricultural practices to changing environmental conditions. It offers farmers the opportunity to learn innovative techniques that enhance their flexibility and productivity. Local farmers are utilizing digital platforms like webinars and mobile apps to provide remote agricultural training to farmers. Farmers are educated in advanced farming techniques, crop management practices, pest control strategies, and market patterns through virtual training and extension services. Thirteen percent of farmers have utilized the virtual training and extension services in the process and production of agriculture. The farmers have received virtual training for the use of seeds, chemical fertilizer, and pesticides in agricultural production. In this context, one of the farmers from Ward No. 12 shared,

> *I have taken virtual training through Krishi Gyan Kendra on how to choose seeds for growing climate-resistant crops especially vegetables like cauliflower, cabbage, potato, and tomato during the covid-19 pandemic. The tomato plant was successfully planted according to training, but due to lack of market, it was unable to be sold, resulting in a significant loss.*

This suggests that formal communication and experience are always relevant for learning. According to climate change, farmers have gained knowledge of extension through training, helping them to choose climate-resistant crops. Different ways of learning, from training to formal learning, are important for climate change strategies.

This motivates the farmers to plant the crop on time. During my field observation, I also interacted with the farmers having virtual training. The farmer said, the virtual training is helping farmers to be empowered to choose seeds, chemical fertilizers, and pesticides to minimize climate change and increase agricultural production.

Data analytics is crucial in climate change education to improve farmers' adaptive agricultural strategies. Data analytics enables farmers to make informed decisions about crop selection, planting schedules, and market trends. This method aids farmers in adjusting to climate change, thereby enhancing their productivity and profitability.

Local farmers are utilizing information analytics to make informed decisions on crop selection, preparation, and production, identifying profitable opportunities, adjusting techniques, and contributing to economic development. About four percent of farmers have utilized data analytics for market insight about the process and production of agriculture. Farmers analyze past weather data and choose crops according to climate change. For example, the farmers have studied the weather data about past rainfall and drought and choose crops accordingly. One of the farmers shared,

> *I am using data analytics tools. The neighbour had learned this method from the agricultural expert of the branch of Panchkhal Municipality and he taught it to me. It is helping me make informed decisions about crop selection, planting time, irrigation schedules, and resource allocation. This method helps to improve productivity, profitability, and sustainability in agriculture.*

This suggests that informal communication and neighbours are always important for learning. The farmers took the training on utilizing the climate technology tools of climate change, while the tools are used to choose the seeds according to the climate change for the adaptive strategies. Farmers are utilizing this method for improved crop production. During my field observation, I interacted with the farmers using analytics for the market. The farmer said, the analytics for the market are helping farmers to be empowered to choose seeds, chemical fertilizers, and pesticides to minimize climate change and increase agricultural production.

Online market platforms enhance farmers' adaptive agricultural strategies by providing real-time market information and enabling direct product sales, thereby improving profitability. The integration of climate change education with these platforms aids farmers in adapting to changing conditions and making informed decisions. Local farmers are using online marketing platforms to improve farm management, increase buyer-supplier interaction, expand markets, and negotiate an affordable delivery cost, which promotes financial sustainability. A small number of farmers (2.8%) have utilized the online market platform to process and produce agricultural products. This method was used by some trained and educated farmers during the coronavirus pandemic. But now some farmers are using it to sell their product. For example, as the agricultural products produced by this method help to reach out to the customers directly, the farmers get more profit. One of the farmers reported,

> *Since the coronavirus pandemic, I have been using an online market platform. I got the knowledge of online computer marketing through a friend who graduated in computer science. The coronavirus made it difficult to sell agricultural products. The use of online marketing has made it easier to communicate directly with customers. Online marketing has enabled a better understanding of demand and pricing, linking the purchase and sale of agricultural products, and the successful sale of small quantities of vegetables. But now I sell vegetables in direct contact with vegetable wholesalers, and sometimes I sell vegetables through this method as well.*

This shows that informal communication and friends are always important for learning. The farmer acquired knowledge of online marketing through a friend. The knowledge gained enabled him to sell agricultural products even in the absence of suitable conditions. During that time, this knowledge served as an intermediary, enabling suppliers and buyers to directly contact each other to maximize their income from agricultural products is significant for climate change strategies. During my field observation, I had the opportunity to interact with farmers regarding the use of online marketing. The farmers emphasized the various advantages that technology offers to their marketing strategies. The system facilitates farmers ' efficient connection with buyers and expands their customers beyond local markets through convenient market access routes.

Moreover, farmers have emphasized the role of online marketing in ensuring that they receive fair prices for their production. By passing the broker and connecting directly with consumers, farmers can negotiate better prices and increase their profit margins. The farmer's direct access to market information allows them to make informed decisions about pricing and market trends, thereby enhancing their competitiveness in the market. The integration of technology, especially through online marketing platforms, significantly enhances modern agricultural practices. The implementation of digital tools and opportunities not only enhances market efficiency but also contributes to the economic well-being of farmers.

Role of GOs and I/NGOs

Government and international/non-government organizations (GO and I/NGO) play a crucial role in providing financial and technical support to farmers to enhance their adaptive agricultural strategies. These entities offer climate change education to farmers, assisting them in understanding and implementing sustainable practices. This adoption empowers farmers to adapt to changing climate conditions, ensuring food safety and economic stability. Local farmers are using the GOs, and I/NGOs are collaborating to support climate-smart communities, providing technical and financial support for climate-adaptive and empowering communities. Various organizations are providing technical and financial support to farmers. The organization includes the government; Lob Green Nepal, Co-operatives, and the Agricultural Knowledge Centre (see Table 37).

Table 37

Financial and Technical Support

Statements	Response	Numbers (n=568)	Percent
Financial Support	Supported	473	83.7
	Government	157	27.7
Supported organizations	Lob Green Nepal	145	25.6
	Co-operatives	103	18.2
	Agriculture Knowledge Centre	68	12.2

Source: Field Survey, 2020

Table 37 shows that 83.7 percent of farmers received financial and technical support for the process and production of agriculture. Government financial support and climate change education are crucial for improving farmers' adaptive agricultural strategies by enabling them to invest in necessary resources and technologies. Climate change education equips individuals with the knowledge to adopt sustainable practices, thereby enhancing flexibility and productivity. Among the financial and technical support, the government provided 27.7 percent financial support to farmers through subsidies such as tractors, hand spray machines, and boring machines. One of the farmers shared, *"In 2072, I got 50 percent financial support from the government for hand tractors, which helped me ease agriculture."* This suggests that formal communication and experience are always important for learning. While the farmers have several ways of learning, formal learning from the government is significant for climate change strategies. Farmers have been provided with financial assistance to purchase necessary tools for agricultural cultivation, thereby making it easier for them to grow their crops. In this context, one of the farmers shared, "*Although the government has been providing a subsidy of 50 to 75 percent on the price of agricultural tools, it has also been distributing chemical fertilizers, pesticides, seeds,* *and plants at free and cheap costs."* This suggests that formal communication always provides important knowledge for learning. The farmers got subsidies from the government for the agricultural tools, which help to make agricultural cultivation significant for climate change strategies. During my field observation, I interacted with the farmers about subsidy loans for agricultural tools. The farmers said few farmers have received the subsidy loan and agricultural tools from the government. The government and non-government organizations provide technical and financial support that helps agricultural production.

Lob Green Nepal provides technical and financial support to farmers, enhancing their adaptive agricultural strategies and providing resources and knowledge for effective climate-flexibility practices. Climate change education empowers farmers to make informed decisions, enhancing their flexibility and productivity. Local farmers are receiving technical and financial support from Lob Green Nepal to enhance farming practices, access quality seeds, and support framework reform for economic empowerment. About twenty six percent farmers received technical and financial support from Lob Green Nepal.

Lob Green Nepal has been providing free IPM training and seedlings to farmers. The plant species provided by Lob Green Nepal include orange, avocado, mango, lychee, and lemon. For example, farmers have planted plants like oranges and mangoes, which help to mitigate the impact of climate change. It also supports enhancing agricultural production.

Co-operatives offer crucial technical and financial assistance to farmers, enabling them to adopt adaptive agricultural strategies. The support and climate change education presented to farmers provide them with the necessary knowledge and resources to effectively adapt to changing environmental conditions. Farmers are subsequently able to enhance their productivity and resilience against the adverse effects of climate change. Co-operatives provide technical and financial support to the local farmers, enhancing their efficiency, livelihoods, and economic practices, thereby overcoming economic challenges. About eighteen percent of farmers received technical and financial support from the co-operative. The government has distributed crop seeds, chemical fertilizers, and pesticides to cooperatives for agriculture and the cooperatives have provided crop seeds, chemical fertilizers, and pesticides. In this context, one of the farmers in Ward No. 12 shared,

> *I have taken a loan of 50,000 from the Community Savings and Credit Cooperative. An interest rate of 15 percent has been set for investing in vegetable crops like cauliflower, bitter gourd, radish, garlic, and ginger. Governmental and non-governmental organizations distribute seeds, chemical fertilizers, and pesticides through cooperatives during farming. Therefore, it is mandatory for farmers to be a member of an agricultural group or cooperative even if it is to get fertilizers, seeds, and pesticides.*

This recommends that non-formal and informal communication is always important for learning. Although the interest rate is high, due to the easy process, farmers who have taken loans from cooperatives have received them immediately and invested especially in vegetable farming, which helps to make agricultural cultivation and well production, as you're interested. During my field observation, I interacted with the farmers about co-operatives. The farmers said the co-operative provides loans to the farmers in a limited area, which helps them to invest in agriculture, especially in the vegetable crops.

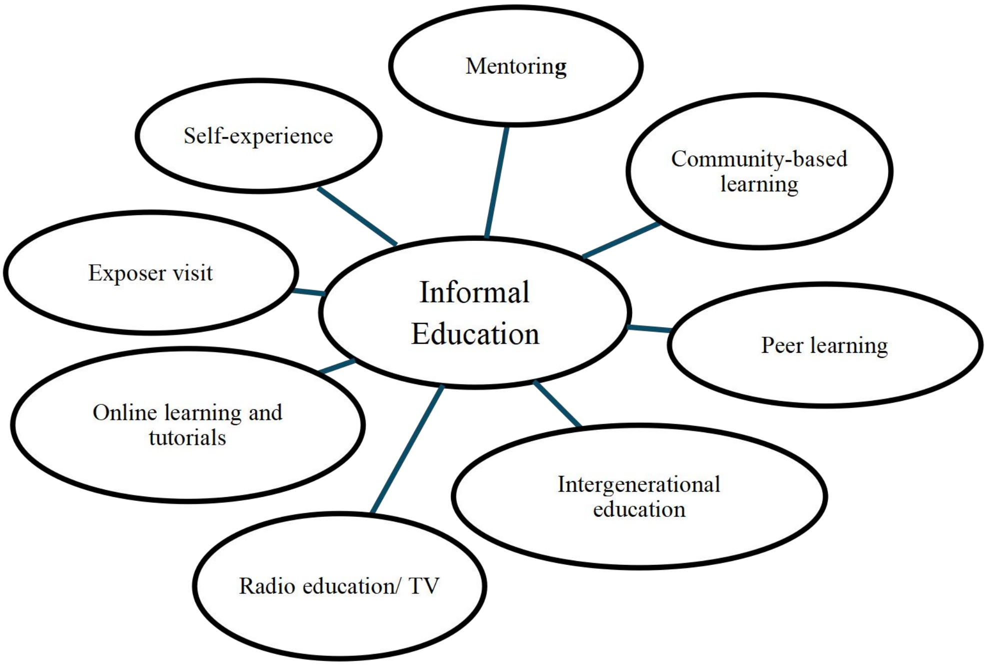
Krishi Gyan Kendra offers technical and financial assistance to farmers, promoting adaptive agricultural practices and climate change education, enabling them to tackle climate-related challenges. Farmers are enhancing their crop yields and sustainability in response to climate change. It presents financial support to local farmers, including grants, subsidies, and low-interest loans, to improve agricultural efficiency, sustainable farming, and economic prosperity. Only about twelve percent of farmers received financial support from the Agricultural Knowledge Center. It provided 50 percent subsidies for agricultural tools like hand tractors and spray machines, along with free and low-priced seeds, chemical fertilizers, and pesticides. One of the farmers shared, "*I have bought the hand trailer machine with 50 percent subsidies, which were provided by the Krishi Gyan Kendra in 2071. The machines are helping to facilitate agriculture and increase crop production*." This suggests that formal communication and experience are always important for learning. Farmers received subsidies from government organizations for purchasing agricultural tools, enabling easier cultivation and adaptive strategies for climate change. During my field observation, I interacted with the farmers about the Krishi Gyan Kendra offers technical and financial support to farmers in comprehending and implementing new technologies and methods. As a result, farmers are gaining the benefits by planting crops on time.

Informal Education

Informal education enhances farmers' adaptive agricultural practices, providing valuable awareness of sustainable farming techniques through community workshops and local training sessions. This basic strategy empowers farmers to effectively tackle climate-related issues and enhance agricultural productivity. Local farmers are utilizing informal education to promote climate-adaptive strategies and experiential learning to tackle climate change. The study explores the role of informal education in addressing climate change, focusing on knowledge and skills acquired through experiences and everyday activities among local farmers. Informal education is often voluntary and can happen anytime, anywhere. Informal education is often self-directed, learner-led, and can take place in a variety of contexts. It is the result of daily life activities related to work, family, or leisure (UIS, 2012). Informal education occurs naturally because the individual participates in various informal contexts and situations. Various strategies are being implemented in informal education to mitigate climate change. The informal education includes peer learning, hobby-based learning, community-based learning, mentoring/agricultural expert, life experience, travel experiences/exposure visit, online learning and tutorials, radio television and intergenerational learning .They are as follow:

Figure 17

Types of Informal Education



Peer Learning

Peer learning significantly improves farmers' climate change education, promoting adaptive agricultural practices**.** Farmers collaborate by sharing knowledge and experiences to develop effective strategies to mitigate climate impacts. This collaborative approach enhances flexibility and ensures sustainable agricultural development. Local farmers are utilizing peer learning to promote climate change and its consequences through community expression and collaborative learning. The study emphasizes the significant role of informal learning in climate change education for local farmers, emphasizing the significance of peer learning. As peer learning is a collaborative process, farmers learn from each other to help them plant crops and select fertilizers, pesticides, and seeds. Climate change education is fostering the exchange of knowledge and practical skills related to sustainable agriculture within the study area. For example, peer learning who have successfully implemented climate adaptive measures mentors other farmers and shares knowledge gained from years of practical experience. In peer learning, the farmers are sharing their ideas on the use of growing techniques, irrigation strategies, and organic farming methods suited to local climatic conditions in this municipality. They have shared their experiences, as follows:

The pattern of peer learning is well-experienced by farmers. As one farmer reports, peer education is quite prominent. He emphasizes,

> *I had a little knowledge about organic farming methods, but not much about producing agriculture according to climate change. Thus, I got a lot of knowledge about organic farming from the peer group. Then the knowledge applied in small areas of leaf vegetables and such types of vegetables is helping to increase healthy crop production in the face of changing climatic conditions. However, the lack of a market is unable to significantly increase these types of agricultural production.*

This suggests that informal learning and peer groups are always important for learning. Farmers have acquired knowledge about new technologies through peer groups that help in the selection of climate-resilient crops for adaptive strategies. It is indicated that some of the farmers have adopted agricultural practices by peer learning which is helping to increase agricultural production and mitigate the impact of climate change.

Overall, the study reveals that peer learning in climate change education significantly increases the effectiveness of promoting adaptive strategies among farmers in Panchkhal Municipality. This collaborative approach provides adaptive strategies, promotes shared knowledge, and adaptive measures for sustainable agriculture. The success of climate change education in Panchkhal Municipality depends on facilitating peer learning. Peer learning aids farmers in addressing climate change by enabling them to select suitable crop seeds, chemical fertilizers, and pesticides.

Hobby-based Learning

Hobby-based learning is an important technique in climate change education, aiding farmers in developing adaptive agricultural strategies. Integrating personal interests into farming practices enhances farmers' engagement and innovation. This strategy enhances their capacity to effectively tackle climate-related challenges. Local farmers are utilizing hobbies to learn and implement the mitigation of climate change strategies. The hobbies of farmers and their interests play a crucial role in adapting to climate change strategies due to their unique characteristics in the study area. In this context, people with a hobby of gardening may have a natural desire to understand different plant species, soil types, and gardening techniques.

Farmers are adopting organic and sustainable farming methods, incorporating climate-conscious strategies. It focuses on promoting knowledge sharing through leisure-based learning. Farmers with a passion for gardening have been sharing their ideas and experiences with others. It is creating an informal educational platform that fosters a shared understanding of adaptive agricultural practices. The pattern of hobby-based learning is well-experienced by a few farmers. As one farmer reports, hobby-based learning is quite prominent. He emphasizes, ‘*my hobby is flower farming, aiming to learn sustainable flower production methods. I have used organic methods* *to cultivate drought-resistant flowers."* This suggests that the experience is a significant source of knowledge about climate change. To acquire climate change knowledge through their hobby this helps in mitigating the effects of climate change. Farmers have planted flowers in the kitchen garden, which is helping to minimize climate change, even if it is a little. Another farmer reported, "*My hobby is flower cultivation, so I have planted five Juniperus indica (dhupi) plants. It helped to mitigate climate change, which increases sustainable development."* This suggests that informal learning and hobby-based learning are always important for learning. Farmers gained knowledge through hobby planting, thereby reducing the impact of climate change. Local farmers are interested in flower production in this area. However, hobby-based learning shows that the trends of agricultural practice are common, and it helps to mitigate the impact of climate change.

Overall, the study reveals that the integration of hobbies into climate change education offers a unique opportunity for farmers in Panchkhal Municipality to develop adaptive strategies. This method enhances comprehension and execution of climate change adaptive strategies. The combination of hobby-based learning and climate change education motivates farmers to adopt sustainable practices and help mitigate climate change.

Community-based Learning

Community-based learning significantly improves climate change education, aiding farmers in developing adaptive agricultural strategies. Farmers collectively tackle climate challenges by sharing knowledge and resources. This collaborative approach enhances the flexibility and sustainability of agricultural practices.

Local farmers are focusing on the mitigation of climate change through community-based education, promoting climate-smart strategies, and utilizing community learning for adaptation. Community initiatives like collaborative gardening projects significantly enhance the mitigation of climate change for local farmers in this scenario. For example, a community-based gardening project serves as a hands-on training site where farmers come together to learn and implement sustainable farming methods adapted to the changing climate in their area. Participants at the community garden shared knowledge about climate-resistant crop varieties, effective water management, and biological pest control techniques through hands-on experiences in the study area. Community-based learning enhances climate adaptive efforts by fostering teamwork and co-operation among members, learning from experts and each other's successes, and creating a network of support.

The farmers who participate in community gardening projects become envoys of climate-flexibility agriculture, raising awareness and disseminating knowledge of adaptive strategies to a wider audience in Panchkhal Municipality. The pattern of community-based learning is well-experienced by a few farmers. As one farmer reports, community-based learning is quite prominent. He emphasizes,

> *Organic farming from the communities means leading the community in taking up flower farming for recreation and informing them about sustainable methods of flower farming. I have planted drought-resistant flowers and used organic methods, which provide the training through the leader of the community. I left organic farming due to the lack of a suitable market.*

This suggests that informal learning and community-based learning are always important for learning. Farmers learned about hobby-based planting from community leaders, promoting climate mitigation and sustainable agriculture strategies while benefiting from this learning. In this context, another farmer reported,

> *I had little knowledge about cauliflower cultivation, but one of the farmers' leaders provided me with a lot of knowledge about it. The leader suggested dry season cultivation techniques and adjusting drought resistance crops of cauliflower. In this context the leader told me techniques of cultivation in the dry season while adapting methods of the drought resistance crops of*

> *cauliflower. Based on this knowledge, I have cultivated seasonal and off-season cauliflower in two ropanis. Now, I am getting a good income from cauliflower.*

The study suggests that a knowledgeable community leader has urged farmers to plant more profitable crops in response to climate change. According to their suggestions, the farmers have planted drought-resistant crops to adapt to climate change. The farmers planted the vegetables, especially seasonal and off-season farming while they confirmed the well production. In terms of good production, farmers have benefited more from this agricultural crop than from other crops.

Mentoring

Agricultural experts are an important factor in enhancing farmers' adaptive strategies in response to climate change. Expert guidance aids farmers in effectively implementing climate-smart techniques. This education empowers farmers to enhance their flexibility and productivity. Local farmers are utilizing expert guidance on climate-smart agriculture to enhance their knowledge and expertise through strategies and solutions. The advisors are experienced agricultural experts or climate-adapted farmers who share their knowledge and practices with the concerned farmers. In this context, the older farmers who have successfully adapted to climate change and growing challenges in the sector can act as mentors for younger or less experienced farmers. They share their knowledge on breeding climate-adapted crop varieties, implementing effective water management techniques, and adopting sustainable agricultural practices. The pattern of agricultural expertise is well-experienced by a few farmers. A farmer reported that,

> *I had limited knowledge about livestock farming, but the livestock expert has provided extensive knowledge related to livestock. The expert advised me to purchase two milking buffaloes. I sold their milk in dairy and generated significant revenue from it.*

This suggests that informal learning and expert knowledge are always important for learning. Farmers have acquired more essential knowledge from agricultural experts. Based on this knowledge, farmers are adopting animal husbandry practices that contribute to better production and economic status. In this context, another farmer said,

> *Under the guidance of an agricultural expert, I am focusing on potato cultivation. The Prime Minister's Agricultural Modernization Project for potatoes has been implemented in this municipality. Compared to other crops, this municipality produces the most potatoes*.

The comment indicates that Panchkhal region farmers are adapting their farming methods to climate change-based crop selection, facilitated by agricultural experts. The study reveals that the mentoring/agricultural expert plays an important role in educating the farmers of Panchkhal Municipality about climate change and providing them with suitable adaptive strategies. In order to expert guidance and climate change education foster associated relationships, enabling farmers to effectively implement adaptive strategies and sustainable agricultural practices. It helps to mitigate climate change and generate better income over time.

Self-experience

Life experiences and climate change education enhance farmers' adaptive strategies, providing valuable insights into their personal experiences with climate impacts**.** The combination of informal education and these perceptions enhances decision-making and improves agricultural practices**.** Local farmers are playing a particularly important role in adaptive strategies by making use of their life experience through informal education. Life experiences help people adopt climate change adaptive strategies. Farmers' life experiences help them adapt to climate change, test new irrigation techniques, adjust planting schedules, and develop more flexible crop varieties in the study area. For example, Local farmers are coping with numerous climate-related challenges, including erratic rainfall, drought, and new pest outbreaks, which impact their daily activities. The pattern is well-experienced by the farmers. One of the farmers shared,

> *I had little knowledge about livestock farming, but the veterinarian doctor provided me with a lot of knowledge about livestock farming such as how to make cattle sheds, selection of cattle of animals, animal feed, and medicine. After obtaining a loan from the cooperative, I purchased two buffaloes and began selling their milk in a dairy. I am currently earning a substantial income from animal husbandry and plan to expand the number of buffaloes in the future.*

This suggests that informal learning and expertise are always important for learning. The farmers got the knowledge about animal husbandry from the expert, while the farmers applied it in practice and helped to improve the economic condition of the farmers. In this context, another farmer said,

> *I had some knowledge about the cultivation of potatoes, but an agronomist has provided a lot of knowledge about the cultivation of potatoes. I focused on potato cultivation because the agricultural expert gave me information about it. After that I added the area of potatoes in the cultivation area. Then I added the potato area to the farm area and compared it with cauliflower and potatoes. In this, the production of potato is more than that of cauliflower.*

This comment indicates that the farmers got the knowledge through experts about agriculture and to increase the confidence level then the farmers added the area for potato. The study also reveals that the local farmers are benefiting from a more effective climate change education method that incorporates their life experiences into their adaptive strategies. This method promotes climate change mitigation by adapting to farmers' specific challenges and knowledge. The farmers develop effective strategies by incorporating their unique challenges and knowledge by incorporating life experiences.

Exposure Visit

Life experiences and climate change education enhance farmers' adaptive strategies, providing valuable perceptions into their personal experiences with climate impacts. Local farmers focus on promoting climate-smart communities through experiential learning, exploration, and travel-based learning for the mitigation of climate change**.** It is crucial in promoting a comprehensive understanding of the climate challenge, particularly in the field of farmers' adaptive strategies. The farmers have been facing climate change, which has led to extreme weather events, changes in agricultural practices, or water scarcity, and interacting with farmers that are adapting to these changes. Only limited farmers (17.8%) have visited role model firms to learn about agricultural adaptive strategies to mitigate the impact of climate change. It shows that only a few farmers have visited other successful agricultural firms in the country. Agricultural groups visit farmers to identify changes in crop production methods. The pattern of exposure visits is well experienced by few farmers. As reported by a farmer, the exposure tour is quiet famous. He said,

> *The group of women conducted an exposure visit to animal husbandry in Morang district in 2073. The livestock industry, effectively managed, was demonstrating successful implementation of animal husbandry practices, resulting in substantial income generation. After the trip, I bought a cow and started selling milk in my dairy. I now have three milking cows, which are giving enough income.*

This suggests that informal learning and visits are always important for learning. The farmers received the knowledge through the exposure visit, and some of the farmers also applied it to increase alternative crop production. According to changing agriculture practices, the farmers also get a good income from informal learning. Another farmer said, *In 2071, we visited the cultivation of dragon fruit in a commercial farm located in Dudhauli Municipality-6 of Sindhuli. The dragon fruit was well produced and sold at the average price is I also planted the dragon fruit in a half ropani and now, I also sell the fruits at an average price Rs. 500 in local markets and Kathmandu, Lalitpur, Bhaktapur and getting a good income from it.*

Photo 28: *Dragon Fruit, Site: Panchkhal Municipality Ward, 3 Dec. 29, 2020*

The study suggests that the farmers have implemented the new agricultural practices while they learnt from the exposure visit. The objective of this method is to mitigate the impacts of climate change and increase income. The study showed that some of the farmers have travelled to different places to study the role model firm of agriculture while travel experiences and exposure visits emphasize climate change education for farmers in Panchkhal, promoting robust adaptive strategies based on a global understanding of climate change.

Online Learning and Tutorials

Online learning and tutorials significantly enhance farmers' adaptive agricultural strategies by providing accessible information on climate-flexibility practices and techniques. Online education enhances farmers' knowledge and skills to effectively manage the effects of climate change. Local farmers are utilizing online education to become climate-ready, focusing on climate-adaptive strategies and digital pathways to mitigate climate change. It is the acquisition of diverse skills, a powerful tool for the adaptive strategy of farmers in Panchkhal Municipality. In an age where digital resources abound, these online platforms can serve as valuable sources of knowledge and empowerment for farmers facing the challenges of a changing climate. Online courses and tutorials provide local farmers with a wide range of climate-mitigation agricultural techniques and best practices. These resources can provide insight into drought-resistant farming methods, innovative irrigation systems, and sustainable soil management practices tailored to their specific region. The pattern is well online learning and tutorials by the farmers. According to a farmer's report, online learning is quite prominent. He reported,

> *Once, there was a disease attack on my paddy crop in 2072 in the summer season. The disease was yellow rice stem borer and was identified by watching YouTube, the treatment of which I found out by watching YouTube and using it, as a result of which I was able to produce good paddy.*

This suggests that informal communication and online learning are always important for learning. Farmers were provided with various learning methods, including informal online learning and climate change strategy tutorials. Some educated and information technology-friendly farmers have used agricultural knowledge to identify the knowledge needed to protect crops from disease. In this context, one of the farmers said,

> *Once when I was watching YouTube, climate resistant rice and DY 80 rice touched my heart because the required geographical conditions for that rice crop were compatible with Panchkhal Municipality. The chosen time resulted in better results for the rice planted. The item is still being planted. Online education also helps to choose climate resistance agriculture according to the impact of climate change.*

This statement indicates that some of the farmers adopted online learning as a common practice in agricultural practice in the Panchkhal area. It helps to select the climate-resistant seeds and to mitigate the impact of climate change. The study reveals that the online learning and climate change education tutorials provide farmers in local communities with the necessary knowledge and accessibility. It empowers farmers to actively participate in the development and execution of effective adaptive strategies. The technology's use among farmers is limited, necessitating government and non-government organizations to provide training and emphasize its significance.

Television and Radio

Television and radio are immensely useful in enhancing adaptive agricultural strategies amongst farmers due to the infusion of practical knowledge in the fields of climate change and farming. Additionally, the contents of television-based programs are also more illustrative and comprehensible to help farmers in applying workable solutions to the challenges related to climate change. In Panchkhal Municipality, farmers have benefited from TV programs focusing on improved irrigation, soil conservation, and climate-adapted crop varieties. Many farmers focus on the importance of television in promoting climate-friendly practices and influencing their strategies for adapting to climate change.

The radio programs also keep the farmers up to date with any weather and climate-related topics at the right time. Farmers rely on radio broadcasts for timely updates on weather conditions, drought conditions, water-saving techniques, or changes in crop timing. Over time, this source of influence is also decreasing since most farmers are moving towards the Internet for reliable information. However, a few still consider it a significant and trustworthy source for agricultural education. Radio and television have played an important role in the education of farmers on climate change and sustainable farming practices in the Panchkhal Municipality. Radio programs broadcast by Radio Nepal have provided information to farmers on drought conditions, water-saving techniques, and crop timing. The pattern is a well-known radio programme by a few farmers. A farmer reports, the radio programme is quite prominent. He reports,

> *In 2071, Radio Nepal used to broadcast agricultural programs from 6.30 to 6.45 pm. I heard a program about mushroom cultivation. After that, I started mushroom cultivation by making 10 jute sack straw packets, which took 30 days to mature.*

This suggests that, as an informal education, radio plays a significant role in aiding farmers in adopting climate change-resistant seeds and plants, improving economic conditions, and mitigating climate change effects through accessible methods. Similarly, the pattern is a well-known television program among a few farmers. Farmers emphasize that TV programs are very important and influential. He reports,

> *One of the times I was watching television, at that time a bee-related agricultural program on Nepal Television touched me. After the program proved effective, I began beekeeping in two beehives. Now, the honey is produced and utilized for household purposes. Another farmer said, "About six years ago, in 2075, I was watching an agricultural program on lemon farming on television, which touched my heart. After that, I have planted 10 lemon plants; some of the fruit produced from them I use for domestic work, and some I sell. Now I prefer to watch agricultural programs on the internet instead of watching television.*

This suggests that, as an informal education, TV plays a significant role and provides knowledge on weather-resistant crops and climate change adaptation strategies. These programs encourage farmers to adopt alternative agricultural practices and choose climate-resistant crops.

In conclusion, the study shows that both radio and television have been vital sources of informal education, providing farmers with the knowledge needed to adapt to climate change. While the internet is becoming more popular for agricultural information, television and radio remain important tools for promoting climate-adaptive strategies in Panchkhal Municipality. These media help farmers select climate-resistant seeds and implement adaptive agricultural strategies, contributing to their economic resilience and climate change mitigation.

Knowledge Transfer

Intergenerational learning significantly improves farmers' adaptive agricultural strategies by sharing climate change education, providing insights into traditional and modern farming practices**.** This exchange facilitates the implementation of sustainable strategies to effectively tackle climate-related issues. Local farmers are utilizing intergenerational learning, which involves sharing knowledge, skills, and experiences among different generations within families or farming communities. As an adaptive strategy of farmers in the study area, intergenerational education involves the transfer of traditional knowledge and contemporary climate mitigation practices from one generation to the next. For example, in my study, elderly farmers share their experiences of coping with changing climatic conditions over the years. It also reveals the knowledge to their children and grandchildren about how their family adapted to past challenges, such as changing monsoons or unexpected droughts. The pattern is well-integrated intergenerational learning by the farmers. According to a farmer's report, intergenerational learning is quite prominent. He reported,

> *Agriculture is an occupation that my grandfather has been doing ever since. But due to climate change, since rice production was not good in the year 2071, I have replaced food crops with cash crops such as cauliflower, cabbage, radish, carrots, and vegetable farming. Now, I am getting a good income from vegetables.*

This suggests that informal learning and intergenerational learning are always an important for learning. The farmers have received the knowledge about the changing climatic conditions through the elderly persons who have applied the adaptive strategies according to climate change. The elder person taught me about the selection of climate-resistant crops for well production due to climate change. Another farmer said,

> *My family had been adopting the agricultural occupation since my grandfather. In the past, we used to grow food only for livelihood, but due to climate change, food crops were not produced well, and now I am also raising food crops as well as livestock five years ago.*

This suggests that the farmers are utilizing intergenerational communication to acquire knowledge, which is beneficial for their adaptive strategy to climate change. Intergenerational learning indicates that individuals are adapting farming methods and trends from the past to the present, thereby generating substantial income. The study shows that integrating intergenerational learning into climate change education combines traditional knowledge with modern insights to promote sustainable knowledge transfer, strengthening farmers' adaptive strategies in the Panchkhal Municipality. Thus, it focuses on fostering generational and ensuring that farming communities to mitigate climate change.

Newspaper

Newspapers play an important role in educating farmers on climate change by providing timely information on adaptive agricultural strategies and innovative practices. This aids farmers in staying informed and implementing effective strategies to tackle climate-related issues. As this municipality is close to Kathmandu valley, daily, weekly, fortnightly, and monthly, many types of newspapers are available. Such as The Nagarik, Kantipur, Krishak, Krishi Khabar, and Agriculture Nepal. In addition, providing information about current events, such as a magazine, also provides some topical information. The pattern is well documented by the farmers. According to a farmer's report, newspapers are quite prominent. He reported,

> *I read about local poultry farming in the monthly agricultural newspaper in 2076 chaitra 15 which touched my heart. After that, I made a chicken coop*

and bought 50 boiler chicken chicks. It took a minimum of 50 days for maturity. It is giving me a good income as per market demand.

This suggests that informal learning and newspapers are always important for learning. Farmers gained knowledge about poultry farming through the newspaper. After reading the newspaper, the farmer started raising chickens, and now he is getting a good income from this business, which helps to improve the economic situation, which is favourable to climate change. In this context, one of the farmers said,

I read in Kantipur newspaper in 2067 Mansir 17 about kitchen gardening which touched my heart. After that I planned the kitchen gardening. This method is easy and can be done with the water used to wash the vegetables. Due to which I have also done kitchen gardening. I have used vegetables from here. It is helping to reduce climate change even if it is a little.

The statements show that the farmers are getting knowledge through the newspaper about gardening. The study indicates that newspaper education is an important means for the farmers of Panchkhal Municipality, and it helps the farmers to make timely and accurate information about climate change. It gets to address agricultural information gaps and motivate farmers to develop effective adaptive strategies. It focuses on empowering farmers to understand climate change and develop strategies accordingly. The accessibility and readability of newspaper education contribute to the empowerment of farmers and promote agricultural flexibility through healthy adaptive practices. The educational role of newspapers encourages farmers to adopt agricultural strategies following climate change.

Challenges for Agricultural Production

Climate change education is crucial for farmers to understand and adapt to the challenges posed by climate change, thereby enhancing their adaptive strategies. This education empowers farmers to adopt innovative practices and enhance their flexibility against climate impacts. The questionnaire mentions the challenges faced by local families, which are assessed using a Likert scale. The questionnaire was conducted using a 1 to 5 Likert scale. Local farmers are tackling the challenges faced in cultivating crops in response to changing climatic conditions. There are various challenges to agricultural production as an adaptive strategy to mitigate the effects of climate change on agricultural processes and production. This study categorized challenges to crop production into sixteen variables, assessed on five Likert scales, such as SD=strongly disagree, D= disagree, U= undecided, A= agree, and SA= strongly agree with numerical value from 5 (SA) to 1 (SD) (see Table 38).

Table 38

Challenges of Crop Production Caused by Climate Change (n=568)

Variables	Min	Max	Mean	SD
Illiterate farmers	1.00	5.00	3.10	1.16
Inadequate training on crop production expansion	1.00	5.00	3.70	1.00
Inadequate access to information on crop adjustment strategies for farmers	1.00	5.00	3.78	1.03
Government's limited plan for climate risk management	1.00	5.00	3.83	1.07
Farming land far away from farmers' houses	1.00	5.00	3.48	1.26
Inadequacy climate change projection technology	1.00	5.00	3.62	1.12
Lack of supportive institutional facilities such as: cooperatives, education programs.	1.00	5.00	3.64	1.08
Not getting agricultural workers on time	1.00	5.00	3.76	1.09
High prices of fertilizers, seeds and agricultural commodities	1.00	5.00	4.01	1.07
High price has to be paid for irrigation	1.00	5.00	3.73	1.18
The high price of buying land or renting land	1.00	5.00	3.32	1.24
Traditional perceptions for the selection of crop varieties	1.00	5.00	2.93	1.28
Farmers' religious beliefs on agricultural practices	1.00	5.00	2.88	1.39
Lack of warehouse for storage of agricultural inputs	1.00	5.00	3.43	1.20

Source: Field Survey, 2020

Table 38 shows the challenges for agricultural production in the study area. The obstacles of crop production are illiterate farmers (mean 3.10 and SD 1.16) in who illiterate farmers lack access to climate change data, agricultural best practices, and modern advances, hampering their ability to adapt and make informed decisions, leading to imperfect farming practices and reduced crop yields.

Insufficient training facilities delay farmers' ability to effectively adapt to climate change, and comprehensive climate change education can improve their adaptive strategies. Enhancing training facilities is vital for providing farmers with the necessary skills and knowledge to effectively manage evolving agricultural conditions. Local farmers often lack access to comprehensive training programs for modern agricultural procedures, crop administration, and pest control, hindering their ability to adopt innovative practices and mitigate production risks. The obstacles to crop production are inadequate training on crop production (mean 3.70 and SD 1.00), in which, without adequate training, farmers are struggling to optimize the use of resources such as water, fertilizers, and pesticides, waste aspects, natural corruption, and reduced agricultural efficiency. To prevent training, farmers make less use of accessible innovations such as climate-resistance crop classification, precision agribusiness tools, and climate forecast management that can improve agricultural efficiency and power.

Lack of information on climate change challenges hinders farmers' ability to manage climate change effects. Climate change education enhances adaptive strategies and improves information access for agricultural productivity. Local farmers are facing crop production constraints due to insufficient information on adaptation, affecting agricultural efficiency and livelihoods. The challenges of crop production are insufficient access to information related to crop adjustment (mean

3.78 and SD 1.03), in which farmers cannot get timely information about the effects of specific climatic changes affecting production in the Panchkhal area, such as changes in rainfall, changes in temperature, and various diseases caused by changes in temperature. Farmers are uncertain about climate change knowledge, and cannot change planting dates and use of irrigation methods on time.

Climate change education is crucial for farmers to develop strategies to mitigate climate risks, as limited plans delay effective crop production. Enhancing farmers' knowledge improves their ability to effectively manage climate challenges and improve agricultural outcomes. Local farmers are facing challenges in crop production due to inadequate climate risk management strategies. The challenges of crop production are a limited plan of government for climate risk management (mean 3.83 and SD 1.07), in which limited planning by the government results in insufficient allocation of resources for climate opportunity governance activities. This includes conducting inquiries and progress, establishing framework enterprises, and providing extension administration for farmers. Similarly, limited government institutions cannot provide farmers with convenient and accurate weather data and early warning systems to forecast and anticipate weather-related hazards.

Climate change education aids farmers in developing adaptive strategies to overcome challenges posed by remote farming land and house proximity. Efficient farming techniques and resource management help farmers overcome challenges in distant farming locations. Topographical distances pose challenges for farmers, increasing transportation costs, time constraints, and difficulties in crop observation, irrigation, and support, resulting in poor yields and productivity. The challenges of crop production are far away from farmers' homes for cultivated land (mean 3.48 and

SD 1.26), where farmers often have trouble reaching their areas when farms are far away, causing them trouble in maintaining crops.

Climate change education is crucial for farmers to understand and adapt to changing conditions, as inadequate projection technology hinders crop production. The increased understanding of climate projections aids farmers in making informed decisions, thereby enhancing their flexibility and agricultural productivity. Local farmers are facing different crop production challenges due to insufficient climate projection technology. The challenges of crop production are the inadequacy of climate projection technology (mean 3.62 and SD 1.12). Lack of climate projection innovation leads to limited understanding of future threats to farmers, including temperature changes, precipitation patterns, and the recurrence of extreme climate events.

Inadequate climate forecasting innovation is undermining the improvement and dissemination of early warning systems for extraordinary climate events, such as dry spells, surges, and violent winds, leaving defenceless farmers to deal with misfortune and work disruptions.

Farmers are facing challenges in crop production due to inadequate organization offices, limiting farmers. The obstacles of crop production are lack of supportive institutional facilities (mean 3.64 and SD 1.08) in which farmers require access to agrarian expansion programs, including training, specialized assistance, and advisory support, to promote climate-smart farming and adapt to changing natural conditions.

Farmers are confronting challenges in getting credit, protection, and other budgetary administrations required to contribute to climate change in agriculture framework, input supplies, and business expansion openings. Lack of infrastructure and transport systems, seeds and fertilizer and pesticides hamper farmers' ability to successfully demonstrate their capacity, reach value-added markets and get fair prices for their crops.

The lack of institutional support facilities significantly hinders crop production, but climate change education empowers farmers by providing essential knowledge and skills. Institutional support and climate education assist farmers in overcoming challenges and enhancing agricultural outcomes. Local farmers are facing challenges in crop production due to inadequate organization offices, limiting farmers' access to resources, and requiring improvement in efficiency. The challenges of crop production are a lack of institutional support facilities (mean 3.64 and SD 1.08), while the farmers are experiencing a lack of good institutional organization. As a result, farmers could not invest in agricultural production on time, so production was not good.

Climate change education helps farmers adapt to labour shortages, as the lack of agricultural workers during critical periods delays crop production. Adaptive agricultural practices help farmers reduce the negative effects of insufficient labour on crop yields. Local farmers face labour shortages in agriculture, disrupting basic activities and reducing crop yields. An obstacle to crop production is not getting agricultural workers on time (mean 3.76 and SD 1.09). Farmers' involvement challenges in contracting agricultural labor in seasonal planting and collecting periods, due to labour deficiencies caused by work or relocation to urban areas. Farmers dependent on external labour sources, such as migrant workers or regular workers from neighbouring districts, are experiencing challenges in recruiting and retaining specialists due to factors such as transportation costs, wage rates, and convenient courses of work schedules.

Climate change education aids farmers in adopting cost-effective, adaptive agricultural strategies due to rising fertilizer, seed, and pesticide prices, thereby enhancing crop production. Farmers enhance production costs and crop yields by learning about alternative inputs and efficient practices. Local farmers are facing financial obstacles due to high fertilizer, seed, and agricultural input costs, which can be addressed through settlement, credit offices, or alternative resource management strategies. Challenges of crop production are high prices of fertilizers, seeds, and agricultural land (mean 4.01 and SD 1.07) which many farmers believe that high prices of fertilizers, seeds and arable land hinder agricultural production. It indicates that, most of the season during the planting period in agriculture, it was not possible to obtain the necessary seeds, fertilizer, and pesticides at a time. For example, most of the farmers plant rice on time, but if they don't get fertilizers and pesticides on time, they cannot get a good yield, and there is a shortage of food. The interview with farmers suggests that such obstacles to crop production include the use of chemical fertilizers and pesticides.

High irrigation costs, including electricity and diesel, pose significant challenges to crop production and make it challenging for farmers to effectively manage water resources. Climate change education assists farmers in adopting energy-efficient practices and technologies to reduce their expenses. High irrigation costs for local farmers are causing farmers to struggle with crop production, affecting their profitability and competitiveness. Obstacles to crop production are the high price paid for irrigation (value 3.73 and SD 1.18), in which farmers face challenges in accessing suitable water sources, such as drip irrigation, borings, and canals for their irrigation systems. Similarly, mechanized irrigation systems demand substantial energy inputs, leading to high operating costs for farmers, fuel, and energy taxes. To ensure productive operation and support of water system structures, canals, reservoirs, and drip irrigation systems, additional costs are involved for farmers, which causes financial problems for farmers.

Local farmers are facing challenges in crop production due to high land costs, requiring land reform policies, affordable credit, and alternative land management to promote sustainable farming. An obstacle to crop production is the high price of buying or renting land (mean 3.32 and SD 1.24). Farmers face challenges in securing agricultural inputs for development due to high land costs, land scarcity, land use controls, or land patterns that are limited to small and marginalized communities. For example, one of the farmers shared,

> *Rapid urbanization and growth in population resulted in a rise in land prices. In those days, farmers could not afford to buy or rent land due to the high prices of land, which involved a high cost of production. Earlier, the farmers could purchase land at a moderate price, and they were also provided with free of cost for agricultural cultivation. In that period, the cultivation was mainly done for home or household purposes only. But now it has grown commercially.*

This suggests that the farmers have been involved in agriculture in the past. The agricultural industry is shifting from domestic use to commercial use, reflecting a shift from traditional land use to a more sustainable approach. Modernization has led to an increase in land prices for both buy and lease.-

Traditional crop selection practices are obstacles to climate change adaptation and pose significant challenges to crop production. Climate change education is vital in assisting farmers in adopting more flexible and suitable crop varieties, thus enhancing their adaptive capacity. Local farmers are facing climate change challenges in crop production due to traditional perceptions, requiring awareness and evidence-based approaches to improve management preparation and adoption of climate-resilient farming strategies. In addition, an obstacle to crop production is traditional perceptions of climate change (mean 2.93 and SD 1.28). The perceptions of climate change are based on social beliefs, or verbal assumptions, rather than logical information, leading to misinterpretation, uncertainty of climate-related threats, and vulnerabilities. For example, some of the farmers of Panchkhal Municipality follow the traditional planting calendars, crop classifications, and farming practices through the generations, even though changes in temperature, rainfall, or pest pressure may require changes in agricultural practices due to climatic forces. Therefore, government and non-government organizations should be managed to provide technical and financial support, preparation, and budget support for crop production. For example, one of the farmers said,

> *I have selected species of seeds and fertilizers based on traditional perceptions. Even in the absence of formal learning and training, experience is helping me to choose a crop. Sometimes these types of crops grow well and sometimes they don't. It seems that if they had the opportunity to get formal education and training, they would have chosen the crop varieties according to time that produced good agriculture. These seeds of species and fertilizer are selected based on the traditional perception.*

This comment states that many farmers in Panchkhal Municipality are unaware of extension administration, agricultural inquiries, and credit offices, limiting their ability to obtain the necessary assets and data for specific crops.

Religious beliefs of farmers significantly influence agricultural practices and crop variety selection, hindering modernization and limiting the adoption of climate-resilient practices. Climate change education helps local farmers integrate traditional beliefs with adaptive strategies, enhancing agricultural outcomes by addressing obstacles in crop production and agricultural practices. Similarly, an obstacle to crop production is the farmers' religious beliefs about agriculture (mean 2.88 and SD 1.39) in which that religious belief does not significantly influence agricultural production. Most of the farmers do not plant the crops according to their religion. Religious beliefs influence cultural practices, but economic, technological, market, and environmental factors often dominate religious guidelines in modern agriculture that affect agricultural production. Religious beliefs, customs, and spiritually significant agricultural practices, choices based on social values and traditions, and conservation practices influence agricultural practices. For example, in Panchkhal municipality, Hindu farmers can worship the goddess of soil (bhumipuja) or perform religious ceremonies to celebrate favourable dates (muhurta), seek divine wealth, protect and prosper their crops, create agricultural calendars and agricultural practices that affect agricultural production.

The lack of storage facilities significantly impacts crop production by causing post-harvest losses and decreasing farmers' income. Climate change education teaches farmers about proper storage techniques and the benefits of investing in storage infrastructure to overcome this obstacle. Farmers' knowledge improves harvest preservation and food security, but a lack of storage facilities (mean 3.43 and SD 1.20) hinders crop storage for fixed periods. Farmers struggled to store crops efficiently due to a lack of storage facilities, resulting in a shortage of crops for timely production. Farmers must be sold at a lower price than the investment, as one farmer shared.

> *The low market price last year made the production season lose its way to sell the product. During this period, there is a shortage of storage for crop production. As the market price is cheaper than collecting tomatoes from the farm, the tomatoes fell in the field, which resulted in a huge loss of investment.*

This suggests that due to the lack of storage space for the produce produced by the crops and the low demand for the produce produced in the market, the farmers have to suffer huge financial losses.

The hypothesis is tested using the following regression analysis:

Binary Logistic Regression Model - 2: Challenges of Crop Production index (B)

Estimated odds ratio (OR) for using a new strategy to adapt to climate change by selected predictors (education and Training received) (see Table 39)

Table 39

Binary Logistic Regression Model

		B	S.E.	Odd ratio (Exp (B)	95% CI Lower	Upper
Level of education of the respondent	Illiterate (ref.)			1.00		
	Primary	.002	.336	1.002	.519	1.936
	Lower secondary	-.303	.429	.739	.319	1.713
	Secondary	.115	.267	1.121	.665	1.892
	Higher education	.215	.408	1.240	.557	2.758
Training received	No (ref.)			1.00		
	Yes	.756	.224	2.130***	1.374	3.304
Constant				.169***		
-2 Log likelihood				531.2		
Cox & Snell R Square				.022		

Note: ***=P<0.001

Interpretation of the Result of Binary Logistic Regression

This binary logistic regression analysis examines the predictors influencing whether an individual adopts a new strategy to adapt to climate change. The results indicate that the respondent's level of education is not a statistically significant factor in this decision. When compared to the reference group of illiterate respondents, the odds ratios for those with primary, secondary, or higher education fluctuate slightly (ranging from 0.739 to 1.240).

In contrast, receiving training is a highly significant predictor of behavior. The analysis shows an odds ratio of 2.130 for those who received training compared to those who did not, a result supported by a p-value of less than 0.001. This means that individuals who underwent training were more than twice (Odds ratio=2.13) more likely to adopt new strategies for climate change than those who received no training. However, it is important to note the Cox & Snell R Square value of 0.022, which indicates that the model only explains 2.2 percent of the variation in the outcome. This suggests that while training is clearly impactful, there are likely many other unmeasured factors contributing to the decision to adapt.

Discussion of Findings

The specific focus of this research is on Climate Change Education, whose deliverable enables farmers to adopt resilient agricultural strategies. This study emphasizes the deficiency in the current educational programs and develops some strategies for improving effectiveness. The following findings are given for the discussion:

Education Adopting Adaptive Strategies to Climate Change

There is a relationship between the level of education of farmers and the ability of agriculture to adapt to climate change. Farmers with education are better equipped to adopt adaptive methods like improved irrigation systems, diversifying crop yields, or adopting new agricultural practices. Education alters the socioeconomic structure of a society by enhancing decision-making skills and enabling interaction with new government programs and technological advancements.

Education research, such as "Education for Sustainable Development" UNESCO, 2006), highlights how education plays a vital role in equipping individuals and communities with the knowledge and skills needed for adaptation to altered environmental conditions. It indicates that education is crucial for adapting to environmental changes, as individuals with higher education are better equipped to manage and mitigate climate change effects through effective adaptive methods. Higher education levels lead to improved socioeconomic outcomes, including enhanced livelihoods, economic stability, and increased resilience against environmental challenges.

The impact of climate change on adaptive strategies found that the level of education has a great impact on the socio-economic transformation of the community. Educated farmers are increasingly adopting innovative farming techniques and climate-friendly practices. It focuses on implementing new methods that can significantly enhance productivity and income levels. Education provides farmers with the necessary information to make informed decisions about crop selection, irrigation methods, pest management, chemical fertilizer, and compost manure management. While farmers with higher education levels are better equipped to understand and timely implement advanced agricultural techniques, such as drip irrigation and integrated pest management, which are important for adapting to changing climatic conditions (Gautam & Koirala, 2020). It shows that the educated farmers are more likely to diversify their crops, thereby enhancing their risk diversification and elasticity to climate variability.

Furthermore, education empowers farmers to improve financial management, access credit facilities, and participate in cooperatives, thereby enhancing their bargaining power and market access. According to the Nepal Agricultural Research Council (NARC), educated farmers are more likely to take advantage of government and NGO programs designed to support climate adaptation, including training sessions and grant schemes for climate-resilient infrastructure (Bhandari et al., 2017).

The study also found that education affects farmers' ability to effectively use weather forecasting and early warning systems.

Educated farmers are more adept at interpreting climate data and adjusting their farming practices accordingly, which helps reduce the impact of extreme weather events (Pant & Thapa, 2019). This is confirmed by the findings of the International Food Policy Research Institute (IFPRI), which indicate that literacy and education are key factors in the successful adoption of climate-smart agricultural practices. Education also plays an important role in promoting sustainable agricultural practices. Farmers with higher education levels are more likely to adopt organic farming, agroforestry, and soil conservation techniques, contributing to long-term agricultural sustainability (Regmi & Poudel, 2021). This practice not only increases productivity but also improves the elasticity of agricultural systems to climate change.

Furthermore, the socio-economic benefits of education extend beyond individual farmers. Educated farmers invest more in their children's education, creating a cycle of knowledge transfer and community development (Thapa et al., 2021). In this way, compared to educated farmers, it is difficult for illiterate farmers to provide education to children according to age, and it is also difficult to transfer knowledge and skills between generations to build a flexible agricultural community. The involvement of all stakeholders is crucial in promoting inclusive and sustainable adaptive strategies.

Despite the clear benefits, the study identifies challenges in providing education to all farmers. Many smallholder farmers, especially in remote areas, have limited access to educational opportunities and resources (Adhikari et al., 2019). The study addressing these barriers requires targeted policies and programs to improve access to education and vocational training in rural areas.

In conclusion, this study emphasizes the critical impact of education on farmers' adaptive strategies and the broader socioeconomic transformation of Panchkhal Municipality. Educated farmers are better equipped to adopt innovative and sustainable practices, access resources, and engage in community-based adaptive efforts. To increase resilience to climate change, it is important to invest in educational initiatives that empower farmers with the knowledge and skills needed to navigate a changing climate. For all farmers to benefit from education and to contribute to the sustainable development of Panchkhal Municipality, the continuous support of the government, non-governmental organizations, and community organizations is necessary.

Government and Non-Government Organizations are Providing Training

Government and NGO grants, along with short and long-term training programs, support the development of sustainable agricultural practices in the context of climate change mitigation. Interventions are crucial in equipping farmers with the necessary knowledge, skills, and financial resources to adopt climate-resilient practices like conservation agriculture, drought-resistant crops, and improved irrigation methods. This support promotes regional development by fostering more resilient and sustainable farming systems, which are vital for the community's long-term economic stability and growth. In this context, the researchers Thornton et al. (2009) focus on the significance of tailoring treatments to the unique geographic features of the area by examining how environmental factors affect the adoption and performance of various farming methods. It indicates the influence of environmental factors such as soil type, climate, and water availability on the effectiveness and uptake of different farming techniques.

The study suggests that a universal approach to agricultural interventions is ineffective due to the unique geographical and environmental characteristics of each region.

The training program significantly enhanced farmers' understanding of climate change impacts, improved their ability to assess risks, and supported the implementation of adaptive strategies in Panchkhal Municipality. According to Regmi and Poudel (2019), found that the programs provide important knowledge about how climate change affects agricultural productivity and ecosystem stability. Training sessions on climate science and weather patterns help farmers understand the complexities of climate change and enable them to make timely decisions. One of the critical areas of focus in these training programs is risk assessment. As farmers learn to identify and assess risks posed by climate variability and extreme weather events, it is essential for developing effective adaptive strategies (Shreshta & Paudel, 2020). By understanding potential hazards, farmers can better prepare and respond to climate-induced challenges, thereby reducing risk and increasing resilience.

Crop rotation is a widely adopted adaptive strategy due to the implementation of training programs. The practice involves alternating different types of crops in the same field over the seasons, which helps improve soil health and reduce pest and disease cycles (Adhikari et al., 2019). It indicates that crop rotation training helps farmers maintain soil fertility and increase crop production despite changing climatic conditions.

Training plays an important role in selecting climate-resistant crops. The program educates farmers about drought-tolerant, flood-resistant, and heat-tolerant crop varieties that help combat climate change (Gautam & Koirala, 2020). The climate-resilient seeds are important for maintaining productivity and food security under adverse weather conditions. Research by Thapa and Regmi (2018) showed that the use of resilient seeds improved crop performance and reduced losses due to climate extremes.

Furthermore, the training programs emphasize the importance of integrated pest management (IPM) and sustainable agricultural practices. Farmers learn to use biological control agents, crop rotation, and other non-chemical methods to manage pests and diseases, reduce reliance on chemical pesticides, and increase environmental sustainability (Sharma & Adhikari, 2020). This holistic approach to pest management contributes to the overall resilience of the farming system.

Through training, it helps farmers to choose techniques like tunnel farming, organic farming, crop diversification, hybrid seeds, chemical fertilizer, and pesticides. Similarly, learning environments promote knowledge sharing and collective problem solving, which are important for effective adaptation to climate change. While governmental and non-governmental organizations have been playing a vital role in facilitating the farmers through training programs, Lob Green Nepal has been providing different types of training to farmers to reduce climate change related to agriculture. Via training, farmers are choosing the best crop at to time. According to Bhandari et al. (2017), partnerships between government agencies and NGOs have ensured that high-quality training and resources are provided to farmers. These collaborations have also helped scale successful adaptive practices across municipalities.

Through the training programs, farmers have benefited collectively rather than individually. Communities benefit from increased awareness and collective action, leading to improved community resilience and sustainable development (Paudel &

Regmi, 2018). Trained farmers often take on leadership roles in their communities, promoting best practices and driving local adaptive efforts.

However, the study also focuses on the need for continued support and follow-up training.

The researchers Shrestha et al. (2020) emphasize that continuing education and technical support are essential to maintain the gains made through initial training programs. Farmers need constant access to updated information and resources to adapt to climate change conditions and emerging challenges. The training programs have significantly improved agricultural practices and resilience in Panchkhaal Municipality.

Farmers participating in the training program can achieve higher yields, better income stability, and reduced losses due to climate-related events (Adhikari et al., 2019). The positive results underscore the importance of investing in farmer education and capacity building as key components of climate adaptive strategies.

In conclusion, the study showed that the training programs in Panchkhal Municipality significantly increased farmers' understanding of climate change impacts, risk assessment, and implementation of adaptive strategies. By equipping farmers with the knowledge and skills needed to adopt practices such as crop rotation and flexible seeding, these programs contribute to greater agricultural resilience and socioeconomic transformation. Continued support and investment in these educational initiatives is essential for sustainability and sustainability.

Highly Eucated Farmers Adopt Better Adaptive Strategies

Highly educated farmers in Panchkhal Municipality are better equipped to adopt more effective adaptive strategies compared to their peers with only school-level education. Higher education enhances critical thinking and problem-solving skills, enabling farmers to analyze and respond more effectively to climate challenges. Farmers who stay updated with the latest agricultural research and technologies are more likely to develop innovative adaptive strategies. For example, highly educated farmers tend to have better access to scientific knowledge and online resources, which provide them with the knowledge to implement timely agricultural practices that help them manage inputs such as seeds, water, and fertilizers in real-time. The enlightenment of resource management can significantly improve the elasticity of farming systems to climate variability.

Moreover, higher education often includes training in environmental sciences and sustainable practices, providing farmers with a deeper understanding of ecological principles. This knowledge enables them to implement strategies like agroforestry, which integrates trees into agricultural landscapes to improve soil health and microclimate regulation (Gautam & Koirala, 2020). Agroforestry has been shown to enhance biodiversity and reduce vulnerability to climate-induced pests and diseases.

Research by Thapa and Regmi (2018) indicates that highly educated farmers are more practiced at utilizing climate information services, such as weather forecasts and early warning systems, to make timely decisions about planting and harvesting. This proactive approach helps mitigate the risks associated with extreme weather events, such as droughts and floods.

In addition, these farmers are more likely to engage in crop diversification, planting a variety of crops to spread risk and ensure food security even when certain crops fail (Adhikari et al., 2019). Crop diversification is a well-documented strategy for enhancing elasticity to climate change, as it reduces dependency on a single crop and improves soil health through varied crop rotations.

Higher education also equips farmers with better financial literacy, enabling them to access and manage credit effectively. This financial plan process allows them to invest in adaptive infrastructure, such as improved irrigation systems and greenhouses, which can protect crops from adverse weather conditions (Bhandari et al., 2017).

Community leadership is another area where highly educated farmers excel. They are often more influential in local decision-making processes and can advocate for policies and programs that support climate adaptation (Pant & Thapa, 2019). Their leadership can drive collective action and foster a community-wide approach to climate resilience.

The role of education in enhancing adaptive capacity is supported by the findings of the International Food Policy Research Institute (IFPRI), which focuses on the correlation between education and the adoption of climate-smart agriculture practices. Highly educated farmers are more likely to participate in training programs and extension services, where they can learn about and implement the latest adaptive techniques (Shrestha & Paudel, 2020).

Furthermore, these farmers often have better networks and access to external support, such as NGOs and government programs, which provide additional resources and technical assistance (Regmi & Paudel, 2019). Their ability to take advantage of these networks can significantly enhance their adaptive capacity and overall elasticity to climate change.

However, the benefits of higher education are not limited to individual farmers. The study by Adhikari et al. (2019) shows that educated farmers often share their knowledge with others in their community, facilitating broader adoption of effective adaptive strategies. This knowledge dissemination can lead to a more resilient and informed agricultural community overall.

Despite these advantages, it is important to note that educational opportunities must be accessible to all farmers to maximize community resilience. Providing scholarships, vocational training, and continuous education programs can help bridge the gap between highly educated and school-educated farmers (Sharma & Adhikari, 2020). Due to this, they plant crops according to the time and are succeeding in getting good returns. It shows that only an average of 29.9 percent of farmers took the training in this municipality. The IMP training provided by Lob Green Nepal seems to be the most popular among those trained. But it seems that this system is used only as a test. Because, according to this method, the cost will be high, but there is no market facility to sell the produced goods. Therefore, the farmers are not attracted to this farming. Therefore, the local level government should ensure the market, and besides encouraging the farmers, the training system for all the farmers should be arranged at the local level.

In conclusion, highly educated farmers in Panchkhal Municipality are better positioned to adopt effective adaptive strategies compared to those with only school-level education. Their enhanced critical thinking, access to information, financial literacy, and community leadership contribute to more resilient agricultural practices and greater overall adaptive capacity. Investing in educational opportunities for all farmers is essential for fostering widespread climate resilience in the region.

Chapter Summary

Education significantly enhances farmers' capacity to mitigate climate change and adapt to new situations. Formal, non-formal, and informal education have played an important role in mitigating climate change. Most of the respondents are literate in Panchkhal Municipality. Formal education plays an important role in the adoption of adaptive strategies, as it shows that educated farmers are more likely to adopt adaptive strategies over time than other levels of farmers. Similarly, most of the farmers didn’t participate in agricultural training. Trained farmers have used agricultural adaptive strategies over time as compared to untrained farmers, and agricultural production is better, and returns are higher. Informal education is education, knowledge, and skills that individuals acquire through experiences, interactions, and everyday activities rather than through educational institutions or organized and structured programs in Panchkhal Municipality. Few farmers had travelled to other farms and acquired knowledge of agricultural activities during climate change.

An organization of Panchkhal Municipality plays an important role in supporting climate change and adaptive strategies at the local level. Government and non-government organizations have been providing various types of agricultural training and subsidies for agricultural equipment, as well as chemical fertilizers and pesticides. There are several barriers to crop production, such as economic resources, information, capacity, and human resources. Climate change is one of the most critical problems facing Nepal and the global community. The integration of climate change into the curriculum contributes to forming professionals prepared to address the problems climate change will pose for Nepal. Farmers have adopted various adaptive strategies to mitigate climate change. Because some farmers are unaware of agricultural education, they use chemical fertilizers and pesticides indiscriminately. Government initiatives and NGOs should conduct workshops, seminars, and awareness campaigns at local, national, and international levels to promote community participation in climate change education.

Limitations

i. A limitation of this study is that the CBS 2078 data were not available at the time of sampling; therefore, the research applied on CBS 2068 data.

ii. A limitation of this study is that it did not include actual measurements of quantitative data.

CHAPTER VII

JOINT DISPLAY, SUMMARY, CONCLUSIONS, AND IMPLICATIONS

In this section, I have included the major findings of the study. In addition, I have provided the major conclusion drawn from this work. Finally, I have presented the major related to both the policy and practice.

Joint Display of the Findings

A joint display is a method that enables the integration and comparison of various forms of data within a unified framework. It is an essential methodological tool, particularly when the study adopts the mixed methods approach to collect quantitative and qualitative data to form a comprehensive understanding of the phenomenon or problem. By using the joint display method, the researcher is able to visualize the relationship and interconnection between the data collected from the various sources. For example, the quantitative data show the statistical trends of farmers' perceptions regarding climate change, such as the level of satisfaction with the adaptation methods, while the qualitative data may show the reasons behind the perceptions, such as cultural and traditional practices, knowledge, and resource limitations.

By using the joint display method, the researcher able to clearly understand both the 'what' and the 'why' of the data, thereby adding to the authenticity of the research and making it possible to interpret the findings in a comprehensive interpretations that are easily applicable in context of .real-world

Summary of the findings

The following joint displays summarize the objective-wise major findings of the study.

Objective 1: Resource Characteristics and Utilization

Variables	Quantitative findings	Qualitative insights	Mixed/Integrated/ Interpretation
Land use distribution	There are 51.5 Percent and 46.5 percent area is respectively covered by forest and agriculture land.	The forest area is more than other areas. This is because the concept of community forestry and the temporary migration of people due to climate change without selling land have resulted in more forest area than arable and other land	This study shows that due to community forest development and the hilly terrain, Panchkhal's forest area (51.5%) is higher than Nepal's average forest area (41.49%), reflecting a balance between conservation efforts and agricultural land use.
Water resources	The water resources are gradually decreasing	The farmers reported that the water resources are gradually decreasing due to climate change.	The study indicate that the water resources is gradually decreasing and the farmers have utilized the different alternative water resources such as boring, plastic pond, drip irrigation.
Forest resources	Forest area is gradual increasing	Due to the decrease in agricultural production due to climate change, some people have left their land fallow and migrated temporarily, resulting in an increase in the area of vegetation on private land.	It reveals that the climate change has led to increased migration due to reduced production, resulting in an increase in private, and community forests.

Temperature pattern	Temperature is gradually increasing during the 40 years was recorded 1.31°C.	Farmers observed rising temperature trends in the study area, although the changes vary by season. . The increase in temperature is linked to a positive correlation with drought and soil moisture losses and affect in the agriculture production. There was extreme heat in April, but no rain falls in time and the corn plant dried up.	It indicates that the temperature is gradually increasing the rainfall due to climate change. These days, the farmers have experienced that the hot days and use the alternative adaptation strategies.
Rainfall pattern	The rainfall is gradually decreasing during the 40 years was recorded 11.57cm.	Rainfall patterns are varying across regions, with some areas experiencing a decrease in rainfall, resulting in water shortages in river sources. Consistent decline in rainfall has posed significant challenges for farmers, resulting in deeper groundwater levels, dried-up surface water, and soil degradation, thereby underscoring the complex local effects of climate change on water resources and agriculture.	It reveals that the due to the climate change is rainfall gradually decreasing the water resources and the farmers are utilizing the alternative water resources such as underground water resources through boaring, wells, , drip irrigation, collection of water in the dig hole.
Education	97.7 percent are literate.	The farmers reported that the majority of the farmers are literate and they can easily choose	It indicates that the Panchkhal region (97.7%) is located near Nepal's capital, Kathmandu, and has a

		the different types of climate resistance crops during the climate change.	higher literacy rate than the national average (65.9%). As a result, farmers are adopting adaptation strategies to mitigate climate change over time.
Objective 2 : To assess the relationship between adaptive strategies and agriculture production challenges			
Drought	The majority of farmers, especially 81.7 percent, reported drought as one of the major impacts of climate change.	Droughts caused by climate change have led to water shortages, delayed planting, economic hardship, and food shortages for farmers. As a result, farmers have sometimes had to plant rice in July instead of June. This has also caused significant losses in agricultural production.	The study reveals that the drought leads to severe water shortages in agricultural regions, affecting daily life and irrigation-dependent crops like rice. Delayed agricultural activities disrupt traditional calendars, causing economic shortage and farmers utilized the adaptation strategies to mitigate the impact of climate change.
Erratic rainfall	The majority of farmers especially 72.5 percent, reported erratic rainfall as one of the major impacts of climate change	Farmers adjust planting and harvesting schedules due to erratic rainfall, as plants requiring constant moisture face water shortages. Low rainfall leads to crop losses, delayed planting, and barren land.	Erratic rainfall patterns disrupt traditional agricultural practices, affecting crops like rice and other water-intensive plants. Water scarcity and prolonged dry periods lead to crop losses and reduced productivity. The study findout the essential to promote climate-resilient crops, adaptive farming techniques, and sustainable land-use practices to address barren land caused by irregular rainfall.

Increase in diseases	The majority of farmers, especially 87 percent, reported increase in disease as one of the major impacts of climate change.	Farmers have reported the appearance of various known and unknown diseases in their crops due to climate change. Early detection of crop diseases can lead to substantial crop production losses if not addressed promptly.	Climate change is causing intensified crop diseases due to temperature, humidity, and rainfall variations, affecting previously unaffected crops. Farmers' observations highlight the impact, prompting proactive measures like disease monitoring systems.
Not ripening crops and fruits on time	The farmers, 40.8 percent, reported not ripening crops and a fruit on time is the major impacts of climate change.	Earlier, paddy used to ripen in the month of Mangsir, but now due to climate change, paddy has started ripening in the month of Kartik. Crops like mango, banana, tomato, cauliflower, bitter gourd, etc. have been affected by climate change. Bombay mangoes bloom in April and ripen in June, unlike 15 years ago when they bloomed towards the end of April.	Climate change has led to changes in crop phenology, with paddy ripening earlier in Kartik and mangoes blooming earlier in April. This affects other crops like mango, banana, tomato, cauliflower, and bitter gourd, affecting yield, quality, and market timing. Researchers need to study these changes, develop climate-resilient crop varieties, and adapt market systems to accommodate these changes. Long-term challenges include crop suitability, and agricultural policies should integrate climate adaptation strategies to ensure crop viability.
Cold waves	The majority of farmers, especially 90.7 percent, reported cold waves as one of the major	Cold waves cause tissue damage to ginger plants, affecting buds, flowers, fruits, and roots.	Cold waves damage ginger plants, reducing productivity and vitality. Buds and roots are most affected, leading to tissue necrosis and

	impacts of climate change.		economic losses. Research is needed to develop cold-tolerant varieties and adapt strategies.
Application of indigenous knowledge	The majority of farmers, especially 78 percent, reported application of indigenous knowledge is the major adaptation strategies to mitigate the climate change.	Farmers have received training on integrated pest management and organic farming from Lob Green Nepal, reducing chemical fertilizers and pesticides in vegetable farming.	Integrated Pest Management (IPM) is a sustainable farming method that uses biological, cultural, mechanical, and chemical methods to manage pests, reducing reliance on chemical pesticides and promoting healthier soil and crops. Training programs like Lob Green Nepal promote sustainable agriculture.
Traditional Pest and Management	16.2 percent the farmers, reported traditional pest and management is the adopted adaptation strategies to mitigate the climate change	Some of the farmers have used only compost manure and pesticides of the Neem, Titepati (Artmesia vulgaris) juice and cattle urine in the green leaf. However, the production process could not be carried out effectively without the use of chemical fertilizer and pesticides	Organic farming practices, including compost manure and natural pesticides, are gaining popularity for their ecological benefits and sustainable resource management. However, challenges like labor-intensity and inconsistent yields need further research and policy support.
Community based adaptation	The farmers, especial 14.5 percent, reported Community based adaptation strategies is the adopted adaptation	The farmers reported Community-Based Adaptive (CBA) encourages farmer collaboration, resource sharing, and ecosystem-based approaches,	Community-Based Adaptation (CBA) empowers farmers to adapt to climate change through local knowledge, collective action, and resource-sharing. It focuses on sustainable land

	strategies to mitigate the climate change	preserving biodiversity and ecosystems. Farmers select climate-friendly seeds and irrigation systems based on local conditions.	management, biodiversity preservation, and ecosystem restoration, enhancing productivity and resilience, and requiring government policies.
Selection of early-growing crops and vegetable	The majority of the farmers, especially 93.3 percent, reported selection of early-growing crops and vegetable is the adopted adaptation strategies to mitigate the climate change	Farmers had earlier planted cauliflower with the local name Kauli Jyapu, Kathmandu cauliflower, which ripens in 90-110 days, but today due to climate change, farmers have planted cauliflower varieties like Pusa Deepali, Hiun Rani and Hiun Raja, which ripen in 60-70 days.	Climate change is driving farmers to adopt faster-maturing cauliflower varieties like Pusa Deepali, Hiun Rani, and Hiun Raja, ensuring food security and crop productivity. This shift is supported by research on agricultural adaptation strategies, improved seeds, climate-resilient farming practices, and educational programs.
Use of compost/ organic manure	The farmers, especially 36.1percent, reported use of compost/organic manure is the adopted adaptation strategies to mitigate the climate change	Farmers use compost manure from kitchen waste, animal feces, and urine for vegetable farming, but only for personal use due to higher costs and market price inconsistencies.	Compost manure, derived from kitchen waste, animal feces, and urine, is a valuable sustainable vegetable farming tool. However, high production costs and market price inconsistencies limit its use in commercial agriculture. Market development, price stabilization, and government support are needed.
Crop rotation	The farmers, especially 37.9 percent, reported use crop	Farmers have been using crop rotation between vegetables, grains and	Crop rotation is a crucial practice for farmers, enhancing soil health, reducing pest and

	rotation is the adopted adaptation strategies to mitigate the climate change	legumes to naturally renew soil nutrients and reduce the chances of pests and infections. Cropping practices that improve soil fertility also help maintain humus in the soil. While it works to maintain soil humus by planting different crops in different seasons.	disease pressure, and promoting biodiversity. It supports sustainable agriculture, reduces chemical dependency, and improves climate resilience, ultimately leading to improved agricultural productivity.
Mulching	The farmers, especially 31.6 percent, reported use mulching adaptation strategies to mitigate the climate change	The farmers are using mulching to prevent plants like lemons, avocados, and mangoes from drying out, maintaining soil health and moisture. They also planted mangoes and litchi plants with grass and dry straw to prevent drying out and drought, highlighting the effectiveness of this old method in conserving soil.	Mulching is a sustainable, low-cost practice used to conserve soil moisture, improve soil health, and protect crops from extreme weather. It's effective in building resilience against climate change, enhancing soil fertility, and reducing chemical inputs, making it a cornerstone of sustainable agricultural practices.
Changing cropping calendar	The farmers are utilizing the changing cropping calendar for the adaptation strategies to mitigate the climate change	Farmers have experienced changes in the timing of planting and harvesting crops due to climate change. For example, the planting time of other crops, such as rice, has shifted earlier	Climate change has influenced agricultural practices, causing farmers to adjust planting and harvesting dates. Early crop planting is an adaptation to warmer temperatures, but it can reduce crop resilience. Adaptation strategies

		than in the past. As a result, planting and harvesting times have also changed.	include modifying planting times, using drought-resistant varieties, and improving water management. However, these strategies require continuous research and technological advancements for long-term sustainability.
Changed the crop species	The farmers are utilizing the changed the crop species for the adaptation strategies to mitigate the climate change	The farmer reported that local seeds were used; good production could not be obtained from such seeds. However, the CEPRED, INGO provided the training of hybrid seeds of different crops and vegetables.	Hybrid seeds enhance agricultural productivity by adapting to climate, pests, and disease, resulting in higher yields and efficient water and nutrient use. Balancing short-term gains with long-term sustainability is crucial.
Use of chemical fertilizer and pesticides	The majority of farmers, especially 87.7 percent, reported use crop rotation is the adopted adaptation strategies to mitigate the climate change	The farmers reported that the climate change delays crop production, leading to increased use of chemical fertilizer and pesticides. Cepred's Nepal support since 2035 has significantly improved agricultural production.	Climate change delays crop production, causing lower yields. Cepred Nepal's support since 2035 improves agricultural practices, promotes sustainable techniques, and enhances food security through training programs

Changes the planting and harvesting seasons	The farmers, especially 84 percent, reported **c**hanges in agricultural planting and harvesting seasons for the mitigation of the climate change	Farmers in the study area are adapting their planting and harvesting schedules due to rising summer temperatures, shifting from April to May and June for corn.	The study reveals that the rising summer temperatures are forcing farmers to adjust their planting and harvesting schedules, shifting corn planting from April to May and June. This climate adaptation strategy is crucial for food security and maintaining agricultural productivity.
Crop diversification	The farmers, especially 87.1 percent, reported crop diversification is the adopted adaptation strategies to mitigate the climate change	The farmers have adopted a crop diversification strategy, cultivating paddy, pulses, and vegetables, following their grandfather's teachings.	Crop diversification, a traditional practice combining modern strategies, is crucial for sustainable agriculture. It boosts productivity, stabilizes income, enhances soil fertility, manages risks, and improves climate resilience, ensuring food security amidst climate change.
Use of tunnel farming	29.2 percent, farmers are utilizing tunnel farming for the adaptation strategies to mitigate the climate change.	The farmers have adopted tunnel farming especially in vegetable farming such as cauliflower and tomato cultivation to adapt to climate change. It makes an environmentally friendly and promotes vegetable cultivation according to climate change..	Tunnel farming is a crucial adaptation strategy for vegetables like cauliflower and tomatoes, regulating temperature and humidity, reducing environmental impact, and providing a stable growing season. I/NGOs have offered training programs to farmers, empowering them to adapt successfully, improve economic security, and ensure sustainability.

Organic farming	57.6 percent, farmers are utilizing organic farming for the adaptation strategies to mitigate the climate change	Lob Green Nepal offers organic farming training to farmers in limited areas, using natural pest control methods like animal urine and green leaf juice. However, the lack of organic farming in all areas is attributed to market problems, as farmers do not plant organic crops in all areas.	Lab Green Nepal promotes organic farming through training and natural pest control, but low demand and limited access are hindering widespread adoption. Market access, consumer demand, and economic incentives will be critical for organic farming production.
Off- season farming	58.7 percent farmers are utilizing off-season farming for the adaptation strategies to mitigate the climate change	Farmers trained in off-season vegetable farming from Lob Green Nepal, planting vegetables like cauliflower, cabbage, tomato, and leaf, but excessive use of chemical fertilizers and pesticides negatively impacts health.	Lob Green Nepal provides the sustainable farming practices like integrated pest management, organic farming, and natural pest control to mitigate health risks and environmental damage from excessive chemical fertilizer use.

Objective 3: To examine the role of climate change education for enhancing farmers' adaptive agriculture strategies

Formal education	97.7 percent farmers have successfully completed their formal education.	Farmers who have received formal education have outperformed the uneducated in this regard and have adopted climate adaptation strategies for their crops, which have enabled literate and educated farmers to reap the benefits of agriculture over time.	The study indicate that education is crucial for farmers to adopt climate adaptation strategies, interpret scientific information, attend training, and apply new techniques, leading to higher productivity and better financial returns.
Non- formal education (Training)	29.9 percent farmers took the agriculture related training through GO and I/NGOs.	The farmers reported that who have received agricultural training through GO and I/NGO have adopted agricultural adaptation strategies over time, enabling them to obtain greater benefits than untrained farmers.	The study reveals that the farmers trained through GOs and I/NGOs are better equipped to adopt climate adaptation strategies, leading to increased agricultural benefits. Training programs equip farmers with knowledge, skills, and resources, resulting in higher yields, improved income, and sustainability.
In-formal education	Farmers are implementing various methods to educate themselves on climate change through the informal education.	Farmers are acquiring agricultural education through informal education apart from formal and non-formal education. Farmers are implementing adaptation strategies based on the current situation. Farmers who have received formal and informal education are also acquiring knowledge through informal education. Informal education involves various methods such as mentoring, community-based learning, peer learning, intergenerational learning.	The study reveals that the informal education in farming communities enhances climate adaptation strategies through peer learning, community-based learning, mentoring, intergenerational knowledge transfer, and media use. It provides practical knowledge, self-experience, and access to resources, improving agricultural productivity and climate resilience.

Summary

The study analyses climate change education for the adaptive strategies of farmers in Panchkhal Municipality. In this research, the mixed methods have been used to understand farmers' perceptions and experiences. They are quantitative and qualitative approaches (QUAN+QUAL). The researcher has utilized both primary and secondary data sources and used a concurrent research design. Primary data were collected through questionnaires focus group discussion, key informant interview and observation. The secondary data was collected through the meteorological records of Panchkhal Municipality and CBS. A total of 568 farmers were selected through purposive and random sampling methods. Meanwhile, the study also discusses resource characteristics and utilization, and the information of climate change and adaptive strategies of the farmers. Similarly, the role of education in empowering farmers is emphasized, with educational interventions focusing on climate-sustainable practices and innovative technologies. As community involvement is also emphasized, with the importance of community-based education programs involving local agencies and NGOs. The research focuses on the importance of education and training for the long-term sustainability of adaptive strategies. The summary of the objective-wise findings is presented below:

Resource Characteristics and Utilization in the Study Area

This study explores the characterization and utilization of agricultural resources in Panchkhal Municipality, focusing on how climate change affects these resources. The area utilizes two types of resources: natural and human. The natural resources encompass location, topography, slope gradient, temperature, rainfall, vegetation, land use patterns, and water availability. Panchkhal Municipality spans 103 square kilometers, with agricultural land, pasture, forest, and other categories covering approximately 46.5 percent, 1.5 percent, 5 percent, and 0.5 percent, respectively, indicate that the majority of the area is forested. This study reveals that forest cover is increasing primarily due to the abandonment of cultivated land, often accompanied by migration from ancestral land. However, the percentage rates of forest-covered areas vary based on factors such as location, distance from municipal proximal and sociocultural groups.

Panchkhal Municipality is a region rich in natural resources. While the municipality features fertile agricultural land, some areas are characterized by steep slopes. Its proximity to the Kathmandu Valley positions it as an agricultural hub, benefiting from fertile soil and high agricultural productivity. The valley's unique geographical features enable the cultivation of a diverse range of crops, particularly vegetables, making it an essential area for agricultural production in the region. This spatial analysis highlights the interplay between the municipality's physical geography, resource utilization, and the impacts of climate change on agricultural practices.

The richness of agricultural resources is further reinforced by the governmental support in the Pachkhal region. For example, the government has initiated the Prime Minister Agriculture Modernization Project (PMAMP) to enhance agricultural production in Panchkhal Municipality, with a particular emphasis on improving potato cultivation. Farmers in the area primarily focus on cash crops, although food crops are also cultivated effectively. Panchkhal is bordered by Dhulikhel, a prominent tourist destination, and is traversed by the Araniko Highway, which connects various regions and facilitates economic activity.

Most of the irrigated land in Panchkhal relies on temporary water resources and seasonal rainfall due to a lack of permanent irrigation sources. The area is served by two seasonal rivers, Jhiku Khola and Thokare Khola, which contribute to local irrigation. To address the water scarcity, both government and non-government organizations are implementing plans to transport water from the Sunkoshi River through a lifting system. Successfully bringing water from the Sunkoshi River would significantly alleviate irrigation and drinking water challenges in Panchkhal Municipality.

The Sunkoshi River, classified as an A-grade river in Nepal, is a vital resource for preserving water availability in the region. Notably, 97.7 percent of farmers in the area are literate, and approximately 52 percent of the population comprises females. Additionally, 70.5 percent of the population falls within the active age group of 15 to 64 years, indicating a literate and engaged demographic that contributes to economic production and income generation, facilitating savings and development initiatives. While 65 percent of farmers primarily engage in agriculture, many also participate in non-agricultural activities as a secondary occupation. Education plays a crucial role in resource management by promoting resource-efficient technologies and conservation methods, leading to long-term benefits for the community.

The study investigates the characterization and utilization of agricultural resources, focusing on the effects of climate change on the resources. There are two types of resources utilized in the study area, i.e., natural and human. Under natural resources, this Municipality possesses geographical conditions, topography and slope gradient, climate, vegetation, land use pattern, water resources, and tourism. The total area of Panchkhal Municipality is 103 square kilometers, of which agricultural land, pasture, forest, and other categories cover 46.5, 1.5, 51, and 0.5 percent, respectively. While the majority of the area is covered by forest land.The forest area is gradually increasing due to migration without selling the ancestral land.

The farmers are predominantly engaged in cash crops, although food crops are also well-produced. Dhulikhel, a renowned tourist destination, is bordered by Panchkhal and is crossed by the Araniko highway. Most irrigated lands depend on temporary water resources and seasonal rainfall because of the absence of permanent sources for irrigation. Especially, there are two seasonal rivers, i.e., Jhiku Khola and Thokare Khola. Due to a lack of water resources, the government and non-government organizations are implementing plans to bring water from the Sunkoshi River through a lifting system. If water can be brought from the Sunkoshi River by a lifting system, the irrigation and drinking water problems will be solved in the Panchkhal Municipality. The A-grade river of Nepal is the most valuable resource in preserving the water resources. While the majority of the farmers (70.8%) are literate, around 52 percent of the female population lives in the study area. Similarly, the majority of the population (70.5%) lies in the age group between 15-64 years. It indicates that the majority of the population is literate and an active population in the study area. It indicates that most people are active in manpower, leading to increased economic production and income, enabling savings, and easier development work.

While the majority of farmers, 65 percent, primarily engage in agriculture, with non-agricultural farming as the second occupation. As education plays an important role in resource management, it helps to promote resource-efficient technologies and methods of conservation of long-term resource benefits.

The availability of resources significantly influences agricultural production, influenced by factors such as slope gradient, proximity to the road, and municipal center. Climate, water sources, market access, and farmers' self-efforts are crucial factors in replicating available resources for sustainable food production. Human knowledge and education are enabling the alternative utilization of resources to develop climate-resilience adaptive strategies. For example, this study reveals that developed countries are efficiently using resources through education and modern equipment, while developing countries are utilizing fewer resources and reducing their natural resource utilization.

Information of Climate Change on Farmers' Adaptive Strategies

The study explores the influence of climate change on farmers' adaptive strategies and the correlation between agricultural production challenges and adaptive strategies. Climate change has had a significant impact on the agriculture of Panchkhal Municipality because of shifting rainfall patterns, fluctuating temperatures, and increased extreme weather events. The temperature extremes ranged from 38°C in the summer to -10°C in the winter season for a period of the last 40 years, with an increasing trend. Rainfall, however, has been decreasing. While farmers in Panchkhal have various sources for climate change information, most (72.5%) rely on radio or TV, with only 1.4 using booklets. The primary climate impact is erratic rainfall (81.7%), and the least is cyclonic winds (2.4%). Climate change has also introduced various diseases, some recognized and others unknown, posing financial risks if untreated. Farmers have adopted both indigenous and modern adaptive strategies to cope with these challenges. Indigenous methods include using local seeds, traditional pest control, and community-based adaptation, with 78 percent of farmers applying indigenous knowledge and 14.5 percent adopting community strategies.

Through training and education, farmers are also implementing modern strategies like crop diversification, altering planting times, and using hybrid seeds, fertilizers, pesticides, and tunnel farming, which have increased crop yields. Despite efforts, challenges persist, including limited financial resources, a lack of understanding of climate change, and challenges in accessing new technologies.

Research has shown a moderate positive correlation ($r = 0.32$) between the adoption of adaptive strategies and challenges in agricultural production. The regression model A explains 29 percent of the data, showing that as training increases, the adoption of climate-resilient strategies also improves. Educated and trained farmers are more successful in applying modern strategies and achieving higher agricultural production compared to those with lower education levels. Training enables farmers to better implement climate change strategies, leading to increased long-term profits and improved resilience against the effects of climate change.

Overall, Panchkhal Municipality agriculture faces climate change challenges due to shifting rainfall patterns, temperature fluctuations, and extreme weather events, with farmers relying on radio or TV for climate information. Climate change poses financial risks to farmers, necessitating a blend of indigenous and modern strategies, incorporating indigenous knowledge and community-based methods. Farmers are utilizing modern strategies like crop diversification, hybrid seeds, and tunnel farming to increase crop yields, but they are facing challenges such as resource limitations and climate change awareness. However, climate change mitigation and adaptation strategies vary across regions, largely influenced by an individual's education level and available financial resources. The study indicates that developed countries are incorporating modern equipment and adaptive strategies into commercial farming, while developing countries continue to rely on traditional farming methods.

Role of Climate Change Education

In my observation, farmers educated at the lower secondary level in specific regions are better equipped to select seeds and plants suited to the spatial impacts of climate change in their local environments. Educational background allows individuals to make informed decisions based on their unique climatic conditions, leading to more effective agricultural practices that address time and space challenges. Localized knowledge not only enhances adaptive capacity but also contributes to more resilient farming systems in their respective communities from a spatial perspective.

The study investigates the influence of climate change education on farmers' agricultural adaptation strategies. Climate change education is crucial for farmers to adopt successful adaptive farming practices. Farmers need education to develop elasticity as climate change impacts agricultural output through unpredictable weather patterns, droughts, and other environmental challenges. While farmers are educated on climate-resilient crops, sustainable farming practices, and efficient water management techniques through targeted educational programs. The information provided enables individuals to mitigate the effects of climate change by making informed decisions, changing farming practices, and developing innovative solutions. While climate change education (CCE) is important in Panchkhal Municipality, it helps farmers understand and respond to climate-related risks. It communicates knowledge, raises awareness, and promotes practical skills. CCE encourages innovation and diversification of agricultural practices, allowing farmers to explore alternative approaches.

The challenges caused by climate change have been addressed with the knowledge, skills, and awareness of this municipality through educational activities related to the mitigation of climate change and its effects. While formal, non-formal, and informal education provide farmers with timely knowledge on climate change adaptation strategies. Education plays a vital role in mitigation and elasticity in climate change due to the provision of knowledge. At the same time as education, training, and experience of the farmers contribute to their access to information and services, as well as income diversification. Thus, farmers who are trained and educated tend to adopt better adaptive strategies and agricultural techniques compared to those who are untrained and uneducated. Collaborative efforts among stakeholders are essential for widespread adoption and sustainable impact. As CCE fosters a learning environment, it ensures the elasticity and sustainability of farmers' livelihoods for future generations.

As of 568, 51.1 percent of government organizations and 48.9 percent of non-governmental organizations have provided various tools such as hand tractors, fertilizers, seeds, spray machines, and techniques to mitigate the impact of climate change on farmers. 31.1 percent of farmers have taken a loan from different financial institutions such as banks, finance, agriculture groups, landlords, and others for agricultural activities. However, there are many constraints on agricultural production; most of the farmers agree that the high cost of fertilizers, seeds, and pesticides is a major contributing factor. Farmers benefit from climate change education by understanding the importance of monitoring climate change, developing long-term sustainability plans, and collaborating with NGOs and governmental organizations. This enhances their resilience to changing environmental conditions, thereby ensuring food security and the long-term sustainability of agricultural livelihoods.

Overall, Panchkhal Municipality is implementing climate change education to educate farmers on climate-related risks, promote practical skills, and encourage innovation in agricultural practices. Education is crucial for mitigating climate change and promoting knowledge access. Farmers with education and training adopt better agricultural techniques, leading to income diversification. Collaborative efforts among stakeholders ensure widespread adoption and sustainable impact, ensuring farmers' livelihood elasticity for future generations. Education plays a crucial role in enhancing CC resistance in both developed and developing countries. For example, developed countries receive vocational training to address sustainable use of farm equipment, seeds, fertilizers, and pesticides, while developing countries prioritize product and productivity growth without considering the long-term effects of harmful inputs.

Conclusion

The study reveals the relationship between natural and human resources in Panchkhal Municipality and shows the importance of sustainable resource management for fostering development and environmental sustainability. In this regard, the sustainable management of natural resources like water, land, and forests is a essential factor for the development of agriculture and means of livelihood. Resource characteristics are shaped by human activities such as farming, industrialization, and urbanization, which can either sustain or degrade ecosystems. In this regards, intensive farming practices, overuse of groundwater, rainfall unpredictability, and fertilizer use have resulted in water scarcity, soil erosion, loss of soil nutrients, and low soil productivity, although community forests, although helping in regeneration and increasing biodiversity, face a threat of over-exploitation and deforestation. Sustainable practices like-soil health, manages conservation of water, and enhances resilience against erosion and drought through the use of crop rotation, organic farming, terracing, rainwater harvesting, and watershed management, Moreover, development of community forests and alternative sources of energy are effective ways of conserving forests.

The use of natural resources is shaped by education, training, and economic conditions, with developed countries utilizing them more efficiently through investment and capacity-building, while developing countries face challenges due to limited resources and opportunities. Although developing countries possess abundant natural resources, ineffective utilization has slowed their development; however, by promoting environmental balance and sustainable resource management. They are now striving to use resources more effectively and move toward a sustainable future, aligning with practices in developed countries. As climate change intensifies globally, Panchkhal Municipality faces environmental, agricultural, and public health challenges, with unstable weather and increased rainfall driving frequent landslides that threaten infrastructure, farmland, and community safety. In Panchkhal, heavy rainfall has damaged roads and cut rural access, while rising temperatures, prolonged dry spells, and erratic rainfall have worsened water scarcity and disrupted farming, leaving rice and vegetable farmers struggling with reduced yields, economic pressures, and food insecurity. Adapting to climate change requires crop replacement and water conservation, yet small-scale farmers face financial and technical barriers that limit access to modern technologies and reduce production. In Panchkhal, farmers demonstrate resilience by blending indigenous knowledge with modern practices, particularly in water management through rainwater harvesting and pond construction.

Farmers face high adaptation costs from expensive irrigation and chemical fertilizers that overexploit groundwater, while climate change simultaneously increases insect- and water-borne diseases such as malaria, dengue, cholera, and typhoid, posing serious public health challenges. Climate change effects such as rising temperatures and flooding create breeding conditions for diseases, increasing community health risks and compounding the difficulty of recovery from climate-related events. Coping with climate change requires farmers to adopt climate-smart practices such as crop diversification, water conservation, and agroforestry, while governments must invest in sustainable infrastructure, promote renewable energy, strengthen resilient agriculture, and enforce policies for resource protection and reforestation. Farmers are adapting to climate change through drought-resistant crops, rainwater harvesting, and modern irrigation, which enhance yields, prevent soil erosion, and protect soil and water resources essential for long-term sustainability. Farmers' climate adaptations reflect resilience and resourcefulness, underscoring the urgent need for collective sustainable practices to confront climate change and its impacts**.** Farmers in Panchkhal Municipality are adapting to climate change through crop diversification, adjusted planting schedules, and improved irrigation, marking a significant transition from traditional practices that strengthens resilience and supports sustainable development.

Adapting to climate change requires crop replacement and water conservation, yet small-scale farmers face financial and technical barriers that limit access to modern technologies and reduce production. In Panchkhal, farmers demonstrate resilience by blending indigenous knowledge with modern practices, particularly in water management through rainwater harvesting and pond construction. In Panchkhal, resources support irrigation during dry seasons and livestock water needs, while farmers' adaptation strategies—shaped by national practices, economic status, education, and land type—reflect broader contrasts: developed countries rely on advanced technology and infrastructure, whereas developing regions emphasize community-based approaches such as capacity building and sustainable farming.

While developed countries like the United States invest in advanced early warning systems, farmers in Panchkhal focus on drought-resistant crops and improved irrigation to address local climate challenges. Despite significant risks, their adaptive capacity, supported by government and organizations, is paving the way toward a sustainable future. Access to finance and education is vital for resilience and sustainable development, with climate change education emerging as a key pillar in empowering Panchkhal's farmers to confront environmental challenges and adapt effectively to a changing climate. Climate change education equips farmers with knowledge and resources to adopt sustainable practices that boost productivity and resilience. In Panchkhal, training has enabled shifts to drought-resistant crops like paddy and vegetables, reducing crop failure risks and ensuring household food security.

With increasingly unpredictable rainfall, education in modern irrigation and water management is vital. Farmers, however, face financial and infrastructural barriers that demand multiagency support—governments can subsidize irrigation technologies to make them affordable, while NGOs and cooperatives can deliver training in climate-smart agriculture, particularly in remote areas. Farmers in Panchkhal have improved yields and sustainability through cooperative resource-sharing, while developed nations like the U.S. advance climate resilience with education, technology, and government support such as subsidies for renewable energy and precision farming. Similarly, developing countries like Nepal can foster sustainable agriculture by strengthening collaboration between government and NGOs to provide training and essential supplies.

Ultimately, Education and collaboration in climate adaptation position Panchkhal's farmers as a model of resilience, showing how informed strategies and community engagement can address local challenges, enhance productivity, and contribute to sustainable futures that may be emulated globally.

Implication

The findings imply that integrating climate change education into local agricultural practices can significantly improve farmers' adaptation strategies in Panchkhal Municipality. Farmers' improved understanding of climate risks and sustainable practices enables them to adopt adaptive techniques, ensuring resilient agricultural production and long-term food security amidst changing environmental conditions. In Panchkhal, climate change education encourages water conservation, community resilience, and sustainable farming methods, building self-assurance and readiness to meet climate change. This research has several implications, including:

Natural Resources Management

This study provides valuable insights for natural resource management by highlighting the importance of climate change education in promoting sustainable agriculture practices. The finding emphasizes the significance of climate-smart agriculture, efficient irrigation, rainwater harvesting, and conservation of forests, water, and soil. National governments and public education initiatives can promote more effective and resilient management of natural resources through these practices.

Educating communities about sustainable methods can lead to the adoption of sustainable practices, improving the long-term soil fertility and productivity of natural ecosystems in response to climate change.

Land Use Planning. This study provides valuable insights for preserving soil fertility, land use planning, and expanding residential areas in Panchkhal Municipality. Farmers are utilizing urban farming, roof gardens, and small-scale intensive farming to adapt to rising temperatures and decreasing rainfall, ensuring sustainable agricultural productivity in limited spaces. Sustainable farming techniques promote soil fertility and efficient land use planning by integrating agriculture into expanding residential areas. This strategy ensures that agricultural spaces are not lost in urban areas, thereby enhancing food security and environmental sustainability. Adopting these practices can enhance city resilience to climate change and preserve essential natural resources like soil through broader land use strategies. The following land use planning is given below:

Agriculture Land. Land use planning policy is a cardinal precondition regarding sustainable agricultural development, soil conservation, water resource management, climate adaptation, promotion of food security, and environmental health. Government and I/NGOs should take the following implication regarding agriculture land:

Role of Government

Soil Conservation: The formulation of policies on soil conservation, allocations for researching management practices for the soil in addition to providing incentives for the use of sustainable agriculture is indeed highly necessary.

Water Resource Management: Formulate and implement policies on the use of water, equitable distribution, protection of water bodies from pollution, and overuse.

Climate Adaptation: Investment in climate-resilient infrastructure; development of policies for climate-adaptive farming practices, supported by nationally determined contributions/climate action plans.

Improvement in Food Security: Agricultural policies should be promoted towards agricultural productivity, improvement in the network of distribution systems, and supporting the farmers either in the form of subsidy or financial aid.

Environmental Health: Enforcement of environmental legislation to minimize pollution, preservation of natural habitat, and monitoring of air and water quality.

Role of I/NGOs

Creating Land Use Planning Awareness: Organize seminars is to educate local communities on environmentally friendly land use practices and promote responsible management of land resources.

Soil Conservation Programs: Community-based soil conservation programs, training of farmers and organic farming are the ways to conserve soil health.

Water Resource Education: Educate communities on sustainable water management practices and help in implementing rainwater harvesting, drip irrigation, and other efficient technologies.

Climate Adaptation Support: Work with local communities on climate-smart agricultural practices, including rotation, diversification of crops, and sustainable livestock management.

Food Security Programs: In-service training of smallholder farmers, seeds, and tools; advocacy for inclusive food security policies to assist the cause of poor farmers.

Environmental Health Advocacy: The organization is actively involved in environmental health campaigns, reforestation, clean-up activities, and waste reduction initiatives to protect the environment.

Non-Agriculture land. Land use planning is vital for balancing urban growth and environmental sustainability, regulating construction, promoting green spaces, managing infrastructure, and enhancing community resilience. Government and I/NGOs would take the following implication regarding non-agriculture land:

Role of Government

Urban Growth with Environmental Sustainability: The establishment and implementation of zoning laws and the setting of policies in urban planning should be done along with environmental regulations that protect natural resources and preserve ecosystems while allowing for urban growth and expansion.

Regulation of Construction: Building codes safety standards, and guidelines are set up while their implementation ensures that the construction is sustainable and eco-friendly in nature and acts as a controlling factor for sprawl.

Green Spaces: Plan, allocates, and conserves public land areas for parks, gardens, and other recreational areas; finance the development and maintenance of those places with the purpose of improving the liability of cities and biodiversity.

Infrastructure Management: Plan, finance, and manage major infrastructure in such a manner that can sustainably meet the demands of urban growth with a minimum amount of environmental degradation. This shall help in the formulation of policies and programs that will enable capacity building of resilience through disaster preparedness, climate adaptation, and supportive community initiatives against natural and economic challenges.

Role of I/NGOs

Urban Growth vs Environmental Sustainability: The need to balance urban growth with environmental sustainability through land use practices can be pursued along with the help of communities, public awareness, and advocacy for sustainable development.

Supporting Construction Regulation Awareness: Provide education to communities and builders on sustainable construction practices, promote adherence to building codes, and foster initiatives is that support environmentally friendly construction.

Promoting Green Spaces: Initiate community-driven projects in the creation and maintenance of green spaces, tree-planting, and urban greening; advocate for action at the local government to protect open space.

Infrastructure Support Management: Collaborate on projects for the introduction of sustainable infrastructure into communities, including rainwater harvesting, solar lighting, and waste reduction and recycling programs operated by the community.

Community Resilience Enhancement: Training and resourcing communities on disaster preparedness, climate adaptation, and emergency response, and support community-led initiatives toward resilience.

Forest land. Panchkhal Municipality's land use planning is vital for environmental conservation, community well-being, and sustainable resource management, safeguarding forest areas, promoting biodiversity, preventing deforestation, and supporting livelihoods through eco-tourism and non-timber forest products. Government and I/NGOs should take the following implication regarding forest land:

Role of Government

Conservation of Environment: Land use regulations, policies of conservation that protect the areas of forests and ecosystems, establishment of zones of protection, monitoring of land use activities.

Community Well-being: Development of policies integrating well-rounded development with community health; access to green open spaces, initiatives on environmental health, job creation in the locality through eco-friendly practices.

Sustainable Management of Resources Thus, implication and management of sustainable forestry practices should be done; laws related to illegal logging should be strictly implemented, as well as utilization of forest resources, regulated for perpetuity and availability. Protection of Forest Areas Establish laws protecting the forests, conducts boundary patrols and management, and undertakes reforestation activities towards degraded areas for the long-term health of the forests.

Conservation of Biodiversity: The proposal explains the strategies for biodiversity conservation, delineates the regulations related to the protection against species endangering, and presents the studies regarding regional plant and animal preservation and observation.

Zero Deforestation: The suggestion of the law inhibits deforestation and controls activities that cause deforestation, with it penalizing illegal wood logging and land encroachment.

Eco-Tourism Development: Providing infrastructure, policy, and institutional frameworks for the regulation and management of tourism activities-investing in community-based eco-tourism projects generating revenues at the local level.

Non-Timber Forest Products (NTFPs): Facilitate the development of NTFPs through the provision of licenses, training and infrastructural to local business and cooperatives engaged in the sustainable harvesting of forest resources and marketing.

Role of I/NGOs

Environmental Conservation: This organization informs the people locally of the need to conserve, offers workshops, and works together with the people to develop grass-rooted projects needed for conservation.

Wellness: Engage in health and wellness activities, having locals teach methods of living sustainably while remaining healthy in the environment; sponsor events to ensure ecologically viable livelihoods. This will include sensitizing the community on the sustainable utilization of resources, alternative training, and community resource management projects.

Care for Forest Areas: Liaise with the community on forest health and tree planting within the community; locally manage forest lands where so necessary.

Biodiversity Promotion: Community activities affording opportunities for flora and fauna species conservation, including habitat restoration.

Anti-Deforestation: The project would make the villages informed of the importance of the forests besides being provided with alternative means or sources of income such that the dependence on logging is reduced and generally promotes anti-deforestation programs.

Eco-Tourism Development: This will raise awareness in villages about the importance of forests. It also provides alternative means or sources of income to counterbalance the need for logging and generally stimulates anti-deforestation programs.

Non-Timber Forest Products: The program would help local communities enhance their sustainable harvests through enabling capabilities, access to markets, and trading conditions.

Diseases and Pests' Management. This study highlights the importance of managing diseases and pests in Panchkhal Municipality due to climate change, which disrupts weather patterns, posing significant threats to agriculture. Panchkhal Municipality farmers are urged to adopt integrated pest management strategies, incorporating natural predators, biological controls, and climate-resistant crop varieties. Climate-adaptive pest management solutions are crucial for mitigating pest and disease outbreaks, highlighting the need for investment in research by governments, NGOs, and policymakers. The importance of strengthening agricultural extension services to educate farmers on IPM techniques and the adoption of landscape-suitable crops is underscored.

The study underscores the significance of implementing supportive policies and infrastructure development to safeguard agriculture from climate-related disasters like floods and landslides. Panchkhal Municipality can enhance its agricultural sector's resilience and long-term food security by integrating pest and disease management with climate adaptation strategies like water conservation and disaster preparedness. The following diseases and pests' management implications are given below:

Late Blight Diseases in Paddy. Late blight disease, caused by Phytophthora infests, primarily affects potatoes and tomatoes, causing crop losses, reduced yields, increased costs, and potential food shortages. Managing involves using resistant varieties, fungicides, and good agricultural practices. The Government and I/NGOs would take the following implication regarding late blight diseases in paddy:

Role of Government

Research and Development: Invest in research for developing resistant crop varieties with a view to minimizing the impact of late blight disease on crops.

Policy and Subsidy: Declare policies that favor disease management measures; subsidize fungicides and other resources that control the disease so as to ensure easy availability to farmers. Extension Services: Provide extension services to disseminate good agricultural practices of disease management, including judicious use of fungicides, rotation of crops, sanitation.

Integrated Pest Management: Fund integrated pest management programs that incorporate resistant varieties, fungicides, and best agricultural practices to reduce the spread of late blight.

Disease Monitoring Infrastructure: Establish an infrastructure for early detection and monitoring of outbreaks of late blight to pass timely information that can help overcome potential crop losses.

Role of I /NGOs

Training and education: Training and education on resistant varieties, fungicides, and good agricultural practices in regard to late blight should be imparted to farmers.

Resource Availability: Availability of quality fungicides and seeds of resistant varieties, more so for small-scale farmers, is necessary; provision for various means of improving disease management should be facilitated.

Awareness Campaigns: Awareness needs to be created through campaigns on timely intervention and sustainable approaches toward minimum loss of crops and maintenance of food security.

Community-Based Monitoring: Empower community-led monitoring to identify early signs of disease outbreak and enable timely response at the local level among agricultural networks.

Promotion of Sustainable Practices: Foster sustainable farming practices to reduce reliance on chemical treatments through organic means and resilience for the perpetuity of crop health.

Borer in Maize. Farmers use integrated pest management strategies like biological control, chemical treatments, and crop rotation to manage borers, insect pests that disrupt nutrient flow, weaken plants, and reduce crop yields. The Government and I/NGOs should take the following implication regarding borer in maize:

Role of Government

Research and Development: Invest in research for the betterment of methods of biological control and for effective development of friendly pesticides, eco-friendly for control of borers and other pests.

Subsidies and Support for IPM Tools: To facilitate farmers in procuring IPM tools and inputs, especially bio-control agents and safer chemical treatments. Extension Services: The agricultural extension services should be imparted to the farmers concerning the integrated pest management, comprising chemical treatment application, and rotation of crops for reducing pest impact.

Regulation of Pesticide: The strict regulations on the chemical treatments will avoid overuse and only environmentally safe pesticides shall be made available to the farmers.

Development of Monitoring and Early Warning Systems: Put in place monitoring and early warning systems for pest outbreaks so farmers could get prepared for preventing losses in their crops.

Role of I/ NGOs

Training and Education: Inform various workshops and training programs to demonstrate the methodologies involved in IPM, comprising bio-control judicious use of chemical treatments, and rotation of crops.

Biological Control Agent: Access to bio control agents, including predatory insects or microorganisms attacking the borer, shall be promoted for environmentally friendly management.

Community-Based IPM Programs: Support community-based programs of integrated pest management that allow farmers to share knowledge, resources, and best practices among themselves related to pest management.

Promotion of Sustainable Pest Management: Reduced chemical use is to be promoted. Environmentally friendly options of pest management that safeguard biodiversity and soil health shall be promoted.

Resource Mobilization for the Small-Scale Farmer: It includes the mobilization of resources and finance for aiding small-scale farmers to have access to facilities that allow them to get access to affordable IPM tools, hence decreasing dependency on high-cost chemical treatments.

Fall Armyworm in Maize. Spodoptera frugiperda commonly called fall armyworm is a destructive insect that requires integrated pest management practices in terms of biological controls and chemical applications due to its sudden dispersal. The Government and I/NGOs should take the following implication regarding fall armyworm in maize:

Role of Government

Research and Development: Funds should be allocated with support to various research studies in order to decipher the biology and behaviour of the fall army worm. This will help in developing efficient biological control, resistant varieties, and safety in chemical application.

Monitoring and Following: Establish national monitoring systems to follow the dispersion process of the fall armyworm. Develop early warning systems that show farmers when the likely period of an infestation will be.

Regulation of Pesticides: Regulate the use of chemical treatments to ensure effective, safe, and environmentally friendly pesticides are available to the farmer for the control of the fall armyworm without causing ecosystem damage.

Farmer Education and Extension Services: Agricultural extension services to teach farmers IPM strategies for fall armyworm control, covering safe application of chemical treatments, biological controls, and practices that aid in crop management.

Financial Incentives: Subsidies and any other forms of financial incentives shall be accorded to farmers who shall have access to technologies for pest control, biological agents, and other materials that shall be necessary in the management of the fall armyworm.

Role of I/ NGOs

Training and Capacity Building: Training workshops along with awareness amongst farmers about IPM techniques in controlling the fall armyworm are necessary. Emphasis should be on integrated approaches, biological controls, and sustainable management of pests.

Community-Based Support: Enable community-level activities where farmers share experiences, best practices, and knowledge concerning the control of fall armyworm, thereby supporting one another in monitoring pest populations and strategies for control.

Promote Biological Control: Promote environmentally friendly biological control methods that will reduce dependence on chemical pesticides to ensure sustainability in the management of the pest.

Ensuring Access to Resources: Farmers ensure have affordable access to biological control agents and monitoring tools, while effectively disseminating information on the implementation of Integrated Pest Management (IPM) strategies.

Advocacy and Policy Influence: Advocate for improved policies and government actions related to integrated pest management and fall armyworm control, and ensure that resources and support are provided to smallholder farmers and their rural communities.

Salah Insect in Paddy. Salah insects create damage to crops, reduction in overall productivity, and economic loss to farmers. Some of the integrated pest management techniques would be in the form of crop rotation, biological controls, and insecticides that need to be resorted to. The Government and I/NGOs would take the following implication regarding salah insect in paddy:

Role of Government

Research and Development: Funding for and promotion of research into the biology of Salah insects and their respective methods for control in respect of development of efficient bio control agents and sustainable insecticides. Establish a pest surveillance system to monitor Salah insect infestations and provide farmers with early warnings of impending outbreaks. Ensure the regulation and availability of appropriate, effective insecticides that are environmentally safe and designed to minimize harm, even in cases of overuse.

Financial Incentives / Subsidies: To convince farmers to integrate into integrated pest management, give financial incentives or subsidy on farmers for adoption of integrated pest management practices, including buying of bio controls or insecticides.

Extension Services: Provide extension services regarding integrated pest management strategies including crop rotation and bio control methods for Salah insects.

Black Field Cricket in Potatoes. Black field crickets (Teleogryllus commodus), are known to impose crop damage and stunted growth on agriculture, translating into lower yields. The integrated management of insect pests using biological control, chemical treatments, and habitat management would reduce crop losses and ensure long-term productivity of crops. The Government and I/NGOs should take the following implication regarding Black field cricket in potatoes:

Role of Government

Research and Development: Fund research into understanding the life cycle and behavior of black field crickets, with respect to new, effective methods of managing the pest, including biological controls utilizing environmentally friendly chemical treatments.

Pest Monitoring and Early Warning Systems: Black field cricket population monitoring systems and an early warning system for outbreaks will be established to give farmer's sufficient warning of any impending cricket outbreaks.

Pesticide Regulation and Control: Regulate chemical treatments to ensure practical but safe products in the marketplace for farmers. Ensuring responsible use of pesticides precludes environmental damage.

Subsidies and Financial Incentives: Offering subsidies or financial incentives to farmers in obtaining IPM tools, such as biological control agents, pesticides, and habitat management approaches.

Extension Services and Training: Impart extension in agriculture comprising skills necessary for IPM practices of biological control, chemical treatments, and habitat management to effectively manage the cricket infestation.

Role of I /NGOs

Training and Education: In turn, training on integrated pest management strategies with more emphasis on the use of biological control methods, judicious use of pesticides, and habitat management to reduce cricket populations are to be informed among farmers through training programs.

Community-Based Pest Management: Facilitate community-based activities wherein farmers can share knowledge, strategies, and experiences in black field cricket and other pest controls without restraint.

Promotion of Sustainable Practices: The use of environment-friendly methods of pest control, such as biological control and habitat modification, would also be promoted to reduce dependence on chemical treatments. Ensure access to affordable bio control agents, monitoring tools for pests, and any other resources related to IPM by farmers, especially small-scale farmers.

Advocacy and Awareness: The farmers and the community will be educated about the use of IPM strategy and the importance of long-term population reduction in a sustainable manner.

Fungus in Potato. Fungi cause significant losses in agriculture and ecosystems through diseases like rusts, mildews, and blights, disrupting plant health and soil health. Managing infections requires resistant crop varieties, fungicides, and biological control methods. The Government and I/NGOs should take the following implication regarding fungus in potato:

Role of Government

Research and Development: Research funding on fungal diseases may be considered, with emphasis on resistant varietal development of crops and improvement in good crop management practices to prevent and control the disease. Research development on environmentally safe fungicides and the enhancement of methods for biological control can also be undertaken.

Fungicides: Ensure adequate use of fungicides in such a way that it is safe and effective, developing no resistance or causing deterioration in the environment. Ensure safe, efficient, and friendly-to-environment types are available to farmers.

Monitoring and Surveillance: This provides a system of surveillance across the nation in monitoring the build-up and spread of fungal diseases such as rusts, mildews, and blights across the board. This will be of importance in giving out early warnings to farmers, hence allowing timely interventions which may prevent widespread damage.

Education of Farmers and Extension: This would be done through the extension services in agriculture, with the farmers being educated on best practices concerning the management of fungal diseases.

Subsidies and Financial Support: Financial incentives/subsidies to those farmers adopting disease-resistant crop varieties, other pest management strategies inclusive of biological controls, and sustainable fungicide options.

Role of I /NGOs

Training and Capacity Building: Conduct training programs for farmers on the recognition of fungal diseases and management, resistant variety promotion, and biological methods for its control. NGOs can also create awareness among farming communities on the environmental and economic impacts of fungal diseases.

Biocultural Area Management-Biological Control: Enhance the use of methods of biological control, including natural predators or microbial agents useful in managing fungal infections in a sustainable manner with reduced chemical use.

Farmer Support Networks: Enhance farmer networks or cooperatives in knowledge and resource sharing on issues related to managing fungal diseases. It includes information sharing about resistant varieties, best practices to avoid or control fungal outbreaks.

Resource Distribution: Assist in the distribution process of resistant varieties, biocontrol agents, and knowledge concerning sustainable management practices among farming communities in affected areas.

Research Collaboration: This may involve working with other academic institutions, research centers, and any other organizations for advanced knowledge about the fungal disease and also the development of sustainable management approaches. Advocacy and Policy Influence: Advocate for the inclusion of sustainable management practices for fungal diseases in governmental policies and call for considerations toward methods that balance agricultural productivity with environmental health.

Black Spot Insect in Cauliflower. Black spot insects cause reduced photosynthesis, yield, and infection spread in crops like brassicas. Management involves crop rotation, biological controls, and resistant plant varieties, potentially leading to pesticide resistance. The Government and I/NGOs should take the following implication regarding fall armyworm in maize:

Role of Government

Research and Development: Provide funding and support to conduct research on black spot insects in developing resistance, understanding its life cycle, and searching for sustainable management options in order to reduce dependence on pesticides.

Pesticide Management: Regulate the use of pesticides to make sure that it is well-targeted, with minimum health and environmental risks and preventing pesticide resistance development. The government can also encourage, when necessary, the application of less harmful, more environmentally friendly types of pesticides.

Monitoring and Surveillance: Offer the country the ability to monitor the trend of black spot insects, intensity of an infestation, and risk to farmers of an outbreak of the pest. This shall be through agricultural extension services, which shall advise farmers on IPM strategies for the black spot insect in terms of crop rotation, biological controls, and use of resistant plant varieties.

Subsidies and Financial Support: The farmers need to be subsidized or provided with financial assistance in terms of buying resistant varieties, biological control agents, and other implements that ensure zero or minimal infestation of black spots. This would be of paramount importance in motivating the farmers to show more interest in its control.

Role of I/ NGOs

Training and Capacity Building: Training workshops and awareness campaigns have to be conducted among farmers regarding the losses due to black spot insects, besides promoting sustainable pest management practices like crop rotation, biological control, and resistant varieties.

Biological Control: Promote the use of biological controls and natural predators of black spot insects to assist in control, thereby reducing reliance on chemical pesticides and the risks associated with pesticide resistance.

Farmer Support Networks: Provide farmer networking and communities to share best practices in managing pests, thereby allowing farmers to share knowledge and work in unison in efforts toward combating infestation and improving yields.

Resource Distribution: Farmers help to access resistant varieties of plants, bio control agents, and crop management tools to afford them the ability to put into practice effective strategies for controlling pests.

Advocacy and Policy Influence: Advocate for stronger policies in regard to pest management and encourage the government to invest in research and adoption of sustainable farming practices that reduce reliance on chemical treatments and limits pesticide resistance.

Improved of Irrigation Systems. The study shows that farmers are increasingly adopting rainwater collection systems to address water shortages, a strategy particularly valuable during the dry season when water sources are unreliable. Government support could enhance the efficiency and reach of these systems. Subsidies can alleviate financial burdens by covering costs for rainwater harvesting equipment, encouraging wider adoption. Training programs are essential to educate farmers on installation, maintenance, and benefits, enabling independent management of these systems. Modern irrigation systems, such as drip and sprinkler systems, can enhance water use, increase crop yields, and conserve resources. Together, subsidies, training, and advanced irrigation can promote sustainable farming, bolstering agricultural resilience and productivity in dry regions. The improved irrigation systems are given below:

Drip Irrigation. Drip irrigation, a cost-effective method for delivering water directly to plant roots, promotes sustainable agriculture in dry seasons, but its high connection and maintenance costs can be a challenge. The Government and I/NGOs should take the following implications regarding drip irrigation:

Role of Government

Subsidize or help the farmers pay for the very high costs of connection and maintenance of drip irrigation systems. Put in place policies and infrastructure that will support the application of drip irrigation, mainly in water-scarce areas. Training and technical support will be provided to the farmers regarding proper operation and maintenance of drip irrigation in light of sustainable agriculture.

Role of I /NGOs

Awareness programs on the benefits accruing from drip irrigation concerning sustainable agriculture during the dry season. Arrange partnerships with the manufacturers or donors to profit the drip irrigation technology at cheaper costs for the small-scale farmers. Provide technical training and workshops for local communities on installing and maintaining drip irrigation systems.

Dig Holes for Irrigation. Irrigation involves digging holes near plants to capture and store water, conserving moisture, supporting crop growth with limited resources, and improving plant resilience. The Government and I/NGOs would take the following implications regarding digging holes for irrigation:

Role of Government

Provide financial support and subsidies for the encouragement of water-conserving irrigation methods by farmers, especially in water-scarce regions. Develop infrastructure and policies to promote water conservation techniques, such as creating water storage facilities for farmers. Offer training programs for farmers on efficient irrigation practices to optimize water usage and enhance crop resilience.

Role of I /NGOs

Conduct awareness campaigns on sustainable irrigation techniques, such as water storage near plants, to help conserve moisture and support plant growth with limited resources. Provide community training workshops on effective methods for digging and maintaining water capture areas near crops. Partner with local communities to implement water conservation projects, including low-cost methods for capturing and storing water.

Improving Canal for Irrigation. Improving irrigation canals enhances water distribution efficiency, reduces water loss, and supports larger cultivation areas; increases crop yields, minimizes waterlogging, conserves water, supports sustainable agriculture, and is crucial for managing water resources in irrigation-dependent regions. The Government and I/NGOs should take the following implications regarding improving the canal for irrigation.

Role of Government

Invest in upgrading and maintaining irrigation canal infrastructure to improve water distribution efficiency and reduce water loss across larger cultivation areas. Implement policies and funding programs focused on water conservation, supporting sustainable agriculture by minimizing waterlogging and managing water resources effectively. Design large projects upgrading irrigation systems to provide adequate water supplies for irrigation-dependent areas to ensure higher yields.

Role of I /NGOs

Educate farmers on the advantages accruing to them with improved irrigation canal systems to conserve water for sustainable agriculture.

Work with local communities on the construction or rehabilitation of minor, community-based irrigation channels to decrease water losses and make more water available for this resource. Provide technical training to farmers on best practices for canal maintenance and water management to support efficient use of available water resources.

Plastic Pond. Plastic ponds are used in agriculture for water storage, water conservation, and stable irrigation, but require proper maintenance and address environmental concerns regarding plastic disposal. The Government and I/NGOs should take the following implications regarding plastic pond:

Role of Government

Subsidize or provide grants for the connection of plastic ponds to improve water storage and conservation in agriculture.

Establish regulations and guidelines on the safe disposal and recycling of plastic materials used in ponds to address environmental concerns. Develop programs that promote eco-friendly alternatives to plastic ponds or improve the durability of materials used in agricultural water storage.

Role of I /NGOs

Educate farmers on proper maintenance techniques for plastic ponds to ensure long-term use and effective water conservation. Provide training on sustainable practices of disposing of plastic waste and introduce environmentally friendly alternatives where possible. Work with local communities to raise awareness on the impact that plastic waste has on the environment, besides encouraging initiatives of recycling or reusing them.

Develop Sustainable Adaptation Strategies. Local farmers are developing sustainable adaptation strategies to cope with rising temperatures and decreasing rainfall. They were trained on water conservation methods, including building reservoirs and using drip irrigation systems, after participating in climate change awareness programs. This knowledge helps in managing community-level small-scale irrigation projects and selecting climate-resilient crop varieties. Implementing a climate change education program can improve agricultural strategies in less irrigated areas like Panchkhal by optimizing water resource use. The following adaptation strategies' implications are given below:

Tunnel Farming. If the temperature is high enough that reduces the chance of harvesting, the strategies that protect direct sunlight. The Government and I/NGOs should take the following implication regarding tunnel cultivation:

Role of the Government

Temperature Mitigation Strategies: Endorse and implement policy decisions and programs that support temperature resilient agriculture, including the provision of subsidies or incentives to farmers on shade netting, greenhouses, and other cooling technologies.

Agricultural Research and Development: Invest in research deals with developing heat-tolerant varieties, soil moisture retention, and effective irrigation methods to help farmers adapt to high-temperature situations.

Improvement of Infrastructure: Community shared facility establishment for protected cultivation, such as a greenhouse or shade structure that would offer protection to plants from direct sunlight, thus giving more security of yields being consistent.

Education and Extension Services: Imparting appropriate training programs through agricultural extension services in protective strategies for crops, such as mulching, row covers, and agroforestry practices.

Financial Incentives and Subsidies: Offer vulnerable small-scale farmers subsidies or loans to implement heat-mitigation technologies such as shade systems or drip irrigation.

Role of I /NGOs

Farmer Awareness and Training: Train farmers in practical methods of securing crops against high temperatures, such as through the use of shade nets, mulching, and agroforestry.

Community-Based Solutions: Support community-level initiatives in constructing shared shade structures or cooling cooperative facilities that will help farmers act at the community level to mitigate extreme heat.

Provision of Resources: Link up with international and local organizations for provision of low-cost or donated resources that protect crops from the direct sun, such as shade netting or reflective material.

Research and Advocacy: To jointly conduct with the research institutions, construct, and test heat-resistant farming techniques for this area, and following the results, advocate for wider application of those techniques.

Financial Assistance and Microloans: Provide microloans or financial assistance to small-scale farmers to afford protective materials and technologies for high temperature and direct sunlight.

Organic Farming. Organic farming, despite potential good market prices, enhances environmental and human health by reducing chemical fertilizers, pesticides, soil fertility, biodiversity, and mitigating climate change. The

Government and I/NGOs should take the following implication regarding Organic farming:

Role of Government

Support from Policies and Incentives: Formulate and implement policies that provide incentives for organic farming practices, such as subsidies, tax exemptions, or grants to farmers who will eventually adapt to organic farming methods coupled with reduced chemical consumption.

Certification and Quality Control: Accreditation in the certification process of organic products in order for the quality to be assured, trust within the market to be developed, and better market prices probably achieved too.

Research and Development Fund: Allocate funds to research into organic farming methods tailored to local ecosystems, in particular, those techniques that improve soil fertility, biodiversity, and climatic resilience.

Market Development and Trade Support: Allow organic produce access to the local and international market through development of trade channels, opportunities for export, and making organic products reach more consumers.

Public Awareness and Education Campaigns: Funding and campaigns to promote the health and environmental benefits of organic products are crucial for increasing consumer demand and boosting organic farming incentives.

Role of I/NGOs

Training and Capacity Building: Train farmers in organic farming practices, including natural soil development and pest management, to enhance biodiversity and mitigate climate change's negative impacts.

Awareness and Advocacy: The goal is to raise community awareness about the environmental and health benefits of organic farming, advocate for reduced chemical use, and promote organic alternatives.

Provision of Resources and Inputs: Provide resources such as organic seeds, composting materials, or low-cost organic pest control options that help farmers move away from conventional to organic practices.

Market Linkages and Certification Assistance: Link farmers to organic markets while also assisting in the certification process so that farmers can sell their produce at better prices and reach out to environmentally conscious consumers.

Community-Based Research and Demonstrations: Establishment of model plots or pilot projects, which would help in developing confidence in the organic way of farming while offering a knowledge base to farmers who could be interested in switching over.

Crop Rotation. Crop rotation is crucial for sustainable agriculture as it enhances soil health by mitigating nutrient depletion and preventing erosion. Additionally, it also disrupts pest and disease cycles, manages weeds, and boosts crop yields. The Government and I/NGOs should take the following implication regarding crop rotation:

Role of Government

Policy Development and Subsidies: Formulate and execute policies to incentivize methods of sustainable agriculture, rotational crops especially, through the availability of subsidies, grants, or tax credits to those farmers who use these methods.

Research and Development: Fund and carry out research in establishing different kinds of crop rotation systems suitable for diverse local conditions but emphasize the promotion of healthy soil, erosion reduction, and natural reduction of weeds.

Extension Services and Training: Implying the provision of agricultural extension services, which could train farmers on the advantages of crop rotation, soil health, techniques of nutrient depletion reduction, and pest control. Support infrastructure and logistics for diverse crop marketing to make crop rotation easier by opening markets for a wide array of crops available to the farmer aside from staple crops.

Erosion Control and Land Management Programs: Implement erosion control and land management programs, including the promotion of crop rotation as the most effective approach that ensures soil erosion reduction and long-term land productivity.

Role of I/ NGOs

Farmer Training and Capacity Building: Hands-on training on crop rotation techniques and workshops that show how rotation serves in maintaining soil health, averting the decrease of nutrients, and breaking disease and pest cycles.

Sensitization Campaigns: These would create awareness in farming communities of the environmental advantages accruing from crop rotation, especially with reference to sustainable agriculture, soil fertility, and erosion control.

Provision of Resources and Technical Support: Avail farmers of various resources such as schedules for crop rotation, handbooks for management of farm pests, and soil-testing services for monitoring and enhancement of soil health.

Demonstration Plots and Field Trials: Establish demonstration plots for illustrating practical benefits of crop rotation in weed management, increase in crop yield, and sustainability of agriculture.

Community Mobilization and Advocacy: To create awareness and mobilization at the community level for sustainability practices, promote farmer groups in adopting crop rotation as a community strategy toward yield sustainability and soil conservation.

***Crop Diversification*.** Crop diversification enhances climate change resilience, reduces dependency on single crops, enhances food security, maintains soil humus, and provides stable incomes for farmers, promoting environmental sustainability. The Government and I/NGOs should take the following implication regarding Crop diversification:

Role of Government

Policy Incentization and Subsidies: Design policies to incentivize diversification by subsidizing or providing bounties or other forms of tax incentives to farmers who would use diversified crop systems.

Research and Development: Invest in research meant to determine the right combinations of crops that improve climate resilience, boost soil health, and meet local market demand.

Agricultural Extension Services: This involves extension services, which will help them in teaching ways for crop diversification with added benefits of increased soil humus for food security and dependable income generation.

Market Access and Infrastructure: Provide market infrastructure and logistics to ensure that farmers have easy access to stable markets for a variety of produce beyond traditional staple crops.

Climate Adaptation Programs: Impalement climate adaptation programs that integrate crop diversification to reduce dependence on a single crop with the aim of minimizing risks due to fluctuation in climate.

Role of I /NGOs

Farmer Training and Education: Training farmers on advantages accruing from crop diversification, also highlighting various techniques to be adopted for crop diversification in maintaining soil health, ensuring food security and realizing assured income.

Sensitization Campaigns: The necessity of crop diversification in light of climate resilience and environmental sustainability should be a subject of sensitization campaigns in rural communities, reducing reliance on single crop systems.

Provision of Resources and Technical Support: Make available resources like guides to crop planning, seeds of different crops, and technical support to support the farmers in diversifying their agricultural systems.

Demonstration Plots and Field Trials: Establishment of demonstration plots on effective models of crop diversification to show how this improves food security and stability of income and soil fertility.

Advocacy and Community Mobilization: Mobilize community groups in crop diversification for the advancement of collective strategies that reduce risks and enhance resilience against climate variability.

Mulching. Mulching in agriculture helps to improve soil fertility and yields through the conservation of water, regulation of temperature, control of weeds, and preventing erosion. Organic mulches decompose with time; enhance nutrient levels in the soil, while reducing the use of chemicals. The Government and I/NGOs should take the following implication regarding mulching:

Role of Government

Policy and Subsidies: Promote policies on mulching practices by providing subsidies or financial incentives to those farmers who apply organic mulch to enhance soil health through reduced chemical use.

Research and Development: Research effective materials of mulching and techniques for the best moisture retention, temperature regulation, and erosion control. Agricultural Extension Services: Ensure that the extended services and workshops reach farmers on the advantages accruable from mulching, including moisture retention, addition of nutrients, and weed suppression.

Infrastructure and Resources: Facilitate access to organic mulch materials through partnerships with local suppliers and ensure that mulching resources are made available at subsidized rates to smallholder farmers.

Environmental Programs: Integrate mulching into larger environmental conservation programs to enhance soil conservation and reduce dependence on chemical fertilizers.

Role of I /NGOs

Training and Education: NGOs will undertake a mulching techniques training program for farmers with the aim of making them fully aware of the benefits that organic mulches yield in enhancing soil fertility and controlling weeds through natural means.

Community Awareness Campaigns: The NGOs shall conduct campaigns on good farming practices like mulching to sensitize the community on environmental-friendly and inexpensive methods of soil management and moisture conservation.

Demonstration Projects: Setting up model farms to demonstrate good methods of mulching and how these ensure long-term benefits that accrue to soil fertility, crop productivity, and environmental health.

Selling Organic Mulching Materials: The Company will provide organic mulching materials, like straw or compost, to the farmers at an affordable price and support them in the initial phase of implementation so that the practice becomes more accessible.

Promotion of Sustainable Practices: Educate people on the reduction of chemicals in agriculture by advocating for mulching as a natural alternative in land fertility and crop yield, encouraging community-wide adoption.

Climate Smart Technologies. Climate Smart Technologies (CSTs) are revolutionizing agriculture by promoting efficient resource use, reducing greenhouse gas emissions, and increasing food security by integrating modern technology with traditional knowledge. The Government and I/NGOs should take the following implication regarding climate smart technology:

Role of Government

Policy Formulation and Funding: Incentivize policy formulation that addresses the development and dissemination of CSTs, promoting their use through economic incentives, such as grants or subsidy support for farmers to implement the CSTs in farming.

Research and Development: Encourage investment in research for the innovation or further optimization of CSTs by integrating the newest technology and methodology into traditional farming practices with higher efficiency in resource use and lower environmental impact.

Infrastructure and Access: Infrastructure for reliable internet and electricity access will ensure better access to digital CSTs and other technology-driven solutions, especially in relatively more rural areas.

Training and Extension Services: Regarding resource management, emission reduction, and resultant improved food security, training and extension services need to be imparted related to farming practices for CSTs.

Data and Monitoring Systems: Establishing systems to monitor the performance of CSTs, dissemination of data related to environmental and crop health trends in support of farmers for informed decision-making regarding resource utilization and climate adaptation.

Role of I /NGOs

Training and Capacity Building: holding workshops and practical trainings for farmers in using CSTs, integrating them into existing farming knowledge to raise productivity in ways that ensure environmental sustainability.

Demonstration Projects: These are pilot projects that will demonstrate the effectiveness of CSTs, thereby encouraging their adoption through practical experience in resource efficiency and emission reduction techniques. This also includes community awareness on the benefits of using CSTs in agriculture for various crops to garner local acceptance and commitment to the use of sustainable practices.

Technical and Financial Assistance: Offer technical, and where possible, financial assistance to smallholder farmers for access and adoption of CSTs; it could help bridge technology gaps in resource-limited regions.

Partnerships for Sharing Resources: Partner with technology developers, research institutions, and government agencies to bring CSTs into rural areas and further enhance the availability and appropriateness of those technologies through partnerships.

Indigenous Adaptive Strategies. Indigenous adaptation strategies, ingrained in local knowledge, challenge environmental challenges like climate change, promoting resilience, biodiversity conservation, and community empowerment, and integrating indigenous knowledge with modern technologies enhances adaptive capacities. The Government and I/NGOs should take the following implication regarding indigenous adaptation strategies:

Role of Government

Policy Support to Indigenous Knowledge: Direct policies that actually recognize and protect indigenous strategies of adaptation and integrate them into the national climate adaptation and conservation frameworks.

Funding and Incentives: Provide funds and incentives toward the documentation, research, and application of indigenous practices in climate resilience and biodiversity conservation.

Integration of indigenous knowledge into education: Developing the educational curriculum involving indigenous knowledge on adaptation and conservation and ensuring respect and awareness are taken into consideration by the younger generation towards traditional life.

Research Collaboration: Engage in research collaboration with indigenous communities and research institutions in regards to traditional practices through scientific studies and validation in complementing modern technologies for adaptation.

Knowledge-Sharing Infrastructure: Establish mechanisms for knowledge sharing amongst indigenous communities. These could also share practices amongst the communities, and best practices in resilience and conservation on regional levels.

Role of I /NGOs

Capacity Building and Training at Community Level: Organize workshops where indigenous communities are empowered, building on their traditional adaptation strategies. Conduct training on how to integrate these with the use of advanced technologies in improving resiliency. Documentation and advocacy involve the documentation of indigenous adaptation strategies for the conservation of traditional knowledge and its use in advocacy in environmental policies nationally and internationally.

Community-led Conservation: Supporting biodiversity conservation at a community level and community-driven processes that are centrally motivated by supporting locally initiated agendas with sustainable land and resource management elements.

Cross-Cultural Knowledge Exchange: Provide for exchanges among indigenous groups with other communities to help share adaptation strategies and technologies to foster broader resilience.

Support Technical and Financial Resources: provide technical resources and micro-grants to support traditional knowledge integration into modern approaches for capacity adaptation improvement and environmental sustainability at the community level.

Change in Cropping Calendar. This study provides crucial insights for adjusting the cropping calendar in Panchkhal Municipality in response to climate change. Farmers are adapting crop calendars to weather changes and optimizing planting and harvesting times to ensure agricultural productivity and adapt to shifting weather patterns. Provincial and national governments must provide accurate and timely weather forecasts to support farmers in planning their activities on a larger scale for effective implementation. Climate-smart agriculture training programs can enhance farmers' skills to adapt crop schedules effectively. Promoting research on climate-resilient crop varieties and raising farmers' awareness of climate trends is crucial for accessing best practices and innovations for cropping calendar adaptation.

By integrating cropping practices with real-time weather data and climate predictions, farmers can minimize crop losses, enhance yields, and optimize resource utilization. The knowledge provided empowers farmers and policymakers to work together to develop strategies that improve agricultural resilience in Panchkhal Municipality. The implications would of the following changes in the cropping calendar:

Food Crops (Paddy, Maize, Wheat and Others). As Paddy and maize is highly vulnerable to climate change during its growth and productivity stage, shifting in sowing dates, utilization of drought-resistant varieties and irrigation are advisable for farmers to achieve the objectives of food security and agricultural planning.

Role of Government

Research and Development: Invest money in agricultural research that would culminate in developing and providing drought-resistant food crops varieties that could resist climatic change.

Subsidies and Other Financial Assistance: Farmers are receiving subsidies or financial assistance to purchase drought-resistant seeds and renovate irrigation facilities to ensure adequate food supply amidst climatic challenges.

Irrigation Infrastructure: The project aims to enhance large-scale irrigation for food crops, enabling efficient water use, particularly in drought-prone regions.

Agricultural Extension Services: This includes establishing extension programs that can demonstrate the best practices in regard to the shifting planting times and resource management because of changing climatic conditions.

Climate Forecasting and Early Warning Systems: Forecasting of weather and climate conditions will help farmers properly plan times for planting and harvest with appropriate data.

Policy Formulation and Implementation: The policies need to be laid down that help in promoting climate-smart agriculture, focusing on long-term food security, resource management, and development of resilience against climate impacts.

Role of I /NGOs

Training and Capacity Building: Training on adapted planting time, drought-resistant varieties of paddy, maize, and improved irrigation practices for optimum yield under changed climatic conditions.

Resource Distribution: Assured mainstream access to resources like drought-resistant seeds, efficient irrigation equipment, and any other resource that can help farmers adapt to the change in climate.

Local Adaptation Programs: Design community-oriented adaptation programs wherein farmers can share knowledge and take collective actions on adaptation practices.

Advocacy and Policy Support: Support the realization of government policies that address sustainable agriculture, food security, and climate resilience, giving voice to farmers' perspectives at the local level.

Research and Collaboration: Communicate with research institutions to study the impact of climate change on maize farming and implement evidence-based practices in supporting adaptation.

Conservation and Sustainability: Promote water-saving techniques with soil conservation that can sustain productivity along with environmental health.

Cash Crops (Potato, Tomato, Cauliflower, Mango, Lychee and others). Changing the cropping calendar for cash crops is crucial due to climate change and market demands.They require best planting and harvesting times, requiring farmers to adjust sowing times, choose flexibility varieties, and improve irrigation management.

Role of Government

Research and Development: Support the development of climate-resilient and adaptable cash crop varieties to suit the changing weather conditions with market requirements.

Extension Services and Training: Inform knowledge about proper sowing and harvesting dates according to prevailing climate conditions, along with advice on better market opportunities.

Irrigation Infrastructure Development: Promotion and development of irrigation services to ensure reliable water supplies during critical growth of cash crop stages.

Subsidies and Financial Incentives: Subsidies or grants aid farmers in acquiring adaptive tools like high-quality seeds and irrigation equipment, alleviating financial burden.

Climate Monitoring and Early Warning Systems: Implement climate monitoring to provide farmers with timely information to reschedule planting based on prevailing weather forecasts.

Policy Incentives for Crop Flexibility: Pursue the use of policies that support flexible, climate-adapted of varieties of cash crop together with farming practices that suit contextual communities.

Role of I /NGOs

Training of Farmers and Sensitization: Farmers will be trained in adjusting sowing dates, selection of cash crop varieties that would bear the weather changes and irrigation management that will be compatible with weather and market conditions.

Seed and Resource Distribution: Drought-tolerant, flexible seeds of cash crop will be distributed with appropriate irrigation systems at an affordable cost to the small-scale farmers.

Community-Based Adaptation Programs: Facilitate the sharing of best practices, coordination of planting schedules, and collaboration on water management across local farmer networks.

Advocacy for Farmer Support: Support policies that prioritize adaptive resources and support to the cash crop in light of challenges in both climate and markets.

Research Partnerships: Partner with research institutions on local studies of the most viable adaptive practices for cash crop farming and share findings with farmers.

Promote Sustainable Irrigation: The goal is to promote the use of water-saving irrigation methods to enhance resilience against unpredictable weather conditions.

Education plays an Important Role in Adopting Adaptive Strategies. The research shows how education helps farmers adapt to climate change by providing essential knowledge, modern technologies, and climate-resistant crops. Education policies promote sustainable farming and modern practices through collaboration between governments, NGOs, and local authorities. Local farmers use short-term training in water conservation, while long-term efforts focus on sustainable farming, soil management, and advanced irrigation methods like the lifting system. Governments offer training and subsidies, while NGOs provide additional support, helping farmers transition to more resilient, climate-smart agricultural practices.

Formal Education. Formal education helps farmers understand the impact of climate change, modern irrigation techniques, and to keep the soil fertile, respecting cultural practices, and empowering future generations to innovate while preserving heritage. The Government and I/NGOs would take the following implications regarding formal education:

Role of Government

Curriculum Development: Include climate change, sustainable agriculture, and soil management in the formal education system to prepare the future generation right from the level of primary, secondary, and higher education.

Agricultural Extension Services: The government would initiate agricultural extension services that will inform climate-smart practices and modern irrigation techniques among the farmers, especially in the rural areas.

Access to Education Subsidies: Provide scholarships or subsidies for farmers and their families to pursue formal education in agriculture and environmental sciences, thus enabling innovative practices while respecting culture.

Nationwide Sensitization: Run national awareness campaigns on the effects of climate change, soil fertility, and sustainable agriculture to make farmers appreciate these concerns.

Supporting Agricultural Schools and Vocational Training: Invest in agricultural schools and vocational training centers with a focused curriculum of climate resilience and sustainable practices that help build a skilled workforce able to innovate with heritage.

Role of I/ NGOs

Community-Based Education Programs: Provide programs in the communities on climate change awareness, modern irrigation techniques, and sustainable soil management adapted to the local needs and cultural practices.

Workshops and Field Demonstrations: Training workshops will be conducted in climate-resilient agricultural methods, including the maintenance of soil fertility and efficient irrigation methods.

Cultural Heritage and Innovation Programs: Design programs that ensure cultural farming traditions are preserved while introducing innovative farming methods to the next generation; further the cause of innovation and heritage.

Educational Resource Provision: Provide education through guide books and manuals on climate change, irrigation, and soil fertility methods that are understandable and accessible to local farmers.

Capacity-Building for Young Farmers: Enable young farmers to build their leadership and knowledge through mentorship programs, a new crop of educated farmers with innovative sustainable practices.

Non-formal Education. Non-formal education enhances farmers' and locals' agricultural skills, like water conservation and mitigation of climate change adaptation strategies, respecting local traditions, and introducing modern ideas. The Government and I/NGOs would take the following implications regarding non-formal education:

Role of Government

Develop Non-Formal Education Programs: Develop community-based non-formal education in agricultural skills, water conservation, and climate adaptation initiatives, considering local needs.

Resource Allocation: Provide resources and funding to establish non-formal education centers among rural areas in order to increase access by farmers and locals.

Water Conservation Technical Training: Train farmers in water-saving technologies and irrigation management practices through local agricultural extension offices.

Cultural Practices and Partnerships: Engage with elderly community members at the local level to gather cultural practices and integrate them into modern agricultural methodologies. This ensures that the programs have respect and are relevant culturally.

Climate Information Dissemination: Establish channels for periodically providing farmers with climate information, forecasts, and strategies on adaptation to support informed decision-making by farmers.

Role of I /NGOs

Workshops and Training at Community Level: Organize practical workshops and hands-on training in water conservation, soil health, and adaptation strategies relevant to climate variations.

Indigenous Knowledge Promotion: Stress and promote traditional agriculture practices and knowledge that align with sustainable methods as a way of respect for the culture while introducing new techniques.

Preparation of Educational Tools: Design educational tools in modes that are easy to understand, such as booklets, videos, and posters, on climate adaptation and conservation practices that attend to the diverse literacy levels in the community.

Capacity Building for Local Leaders: Train community leaders in order for them to become educating leaders in sustainable farming practices, efficient ways of water management, and in climate resilience strategies that support local farmers.

Demonstration Sites: The idea is to set up demonstration farms or model sites where farmers within the locality can visit to see for themselves methods of water conservation and adaptation to climate change amidst continuity with traditional practices.

In-formal Education. Informal education, involving everyday experiences, traditions, and cultural practices, is crucial for preserving local knowledge, resource management, and survival in changing environments by combining informal learning with practical experiences. The Government and I/NGOs would take the following implications regarding informal education:

Role of Government

Encourage Cultural Preservation Programs: Designate and fund programs aimed at the documentation and preservation of traditional knowledge and practices related to natural resource management and adapting to the environment.

Transfer Local Wisdom into Policy: Give proper recognition to the role of informal education in integrating traditional knowledge into local and regional environmental policies

Organize Community Events: Organize and support festivals, events, or forums where communities will share and celebrate cultural practices, while encouraging knowledge transmission between generations.

Community-Based Resource Management: This would involve the promotion of community-led resource management programs dependent on traditional knowledge and practices concerning land and water use.

Training Local Educators: The training of community leaders to act as informal educators for their respective communities would be an important way of communicating traditional lifestyles and ways in which resources are conserved.

Role of I /NGOs

Traditional Practices Workshops: Hands-on workshops and training for the community on traditional skills and practices.

Knowledge Documentation and Sharing: The traditional knowledge is documented in video, story, and booklet forms and supports its sharing within and outside of the community.

Youth Education Programs: Support the development of youth education programs in communities which include traditional practices along with practical experiences. This can help to bring out the applicability of traditional cultural knowledge in understanding the environmental situation that exists today.

Community Exchange Programs: Establish mechanisms for exchange amongst communities on local resource management methodologies to enhance local resilience.

Support Learning by Doing: Facilitate projects that involve hands-on learning by doing, such as farming, water conservation, or forest management, to acquire experience with the traditional methods by the younger generations themselves.

Link to School to Farm: This study offers valuable insights for Panchkhal Municipality's climate change education strategy, suggesting the need to connect schools with farms. The integration of local agricultural practices and climate change education into school curricula equips students with practical knowledge about sustainable farming techniques and climate adaptation strategies.

This method not only enhances students' comprehension of agriculture and climate change but also promotes a climate-aware culture among the youth. Farm-based learning helps students understand the significance of resilient agricultural practices like crop diversification, water conservation, and the use of climate-resistant crops. Schools will foster a generation of climate-conscious farmers who are better equipped to tackle the challenges of climate change by promoting these practices.

School education integrating farm practices fosters communities, preserving traditional agricultural wisdom and adapting to modern climate challenges by passing local knowledge to younger generations. The knowledge provided empowers students to actively contribute to sustainable agricultural development in Panchkhal Municipality, thereby enhancing long-term resilience and food security in the region.

In conclusion, climate change education significantly helps improve farmers' adaptation strategies in Panchkhal Municipality. Linking school education to farm practices provides an effective transfer of knowledge that enhances their capability for adapting to changing environmental variables. The main adaptation strategies developed are improved irrigation system development and management, adjustment in cropping calendars, and effective pest and disease management practices. The other strategies for sustainable adaptation include land use planning, adding to the proper management of natural resources that help in strengthening the farmers' resilience by sustaining agricultural productivity and the sustainability of agriculture. Overall, these measures strengthen farmers' resistance to climate change pressures while realizing food security, with the sustainability of local ecosystems maintained.

Knowledge Contribution

Climate change education is essential to empower farmers in Panchkhal Municipality to take positive events rather than merely react to changing circumstances. Although they recognize its impacts, farmers still lack the knowledge needed to effectively address climate change. It would be noted that farmers are provided with knowledge of relevant methods used to adapt to the impacts of climate change through training. Training on climate change is essential to ensure the farmer is empowered to respond using the relevant knowledge acquired from a workshop, which is a critical approach to ensure the farmer adapts to climate change. The following contribution of this research as below:

i. Although the farmers of Panchkhal Municipality were aware of climate change, they had little knowledge of how to cultivate according to its impacts. This research seeks to assist them by demonstrating the need to adopt adaptation strategies that ensure climate resilient farming practices.

ii. Formal, Non-formal, and Informal education helps in the process of strategy adoption. Through formal, non-formal, or informal education, the farmer understands the use of hybrid seeds, chemical fertilizers, and pesticides.

iii. This research seeks to fill the knowledge gap and empower farmers through effective adaptation strategies provided by climate change education.

iv. This research shows that adoption of agricultural strategies through formal, non-formal and informal education plays an important role in increasing agricultural production. The adoption of climate flexibility in agriculture is encouraged by conducting workshops, seminars, and interacting with experts by the farmers.

v. The farmers are made aware of how to use the hybrid seeds, fertilizers, and pesticides for the crops in an integrated manner in relation to climate change. It emphasizes the significance of knowledge distribution in the community in making the adaptive measures more effective by learning from each other.

These points indicate that while farmers are aware of the effects of climate change, they lack the educational knowledge needed for climate-adaptive cultivation practices.

Therefore, the purpose of the study is to empower the people of Panchkhal Municipality through the knowledge of climate change. Even if education can help the people adopt the techniques related to climate change adaptations such as the use of hybrid seeds, fertilizers, and pesticides in the people of the study area, conducting the study through workshops/seminars and even meetings with the experts can help the people adopt the techniques of 'flexible farming related to climate change.

REFERENCES

Adams, J. (2009). Education for climate change adaptation: Knowledge, capacity, and behavioral change. *Journal of Climate Change and Education*, *14*(2), 103-120.

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies, 3*(3), 179–195. https://doi.org/10.1191/1464993403ps060oa

Adger, W. N., Arnell, N. W. & Tompkins, E. L. (2003&2005). Successful adaptive to climate change across scales. *Global Environmental Change*, *15*, 77-86.https://doi.org/10.1016/j.gloenvcha.2004.12.005

Adhikari, B., & Shrestha, R. (2019). The role of education in climate change adaptation: A case study of rural Nepal. *Journal of Environmental Education and Adaptive Strategies*, *5*(3), 189-205.

Adhikari, B., Shrestha, R., & Paudel, S. (2019). Education for climate change adaptation strengthening community resilience through knowledge and practice. *Climate Change and Adaptive Journal*, *9*(1), 34-50.

Adhikari, S., Baral, H., & Nitschke, C. (2018). Adaptation to climate change in Panchase Mountain ecological regions of Nepal. *Environments, 5*(3), 2-18. https://doi.org/10.3390/environments5030038

Agrawala, S., Raksakulthai, V., Aalst, M., Larsen, P., Smith, J., & Reynolds, J. (2003). *Development and climate change in Nepal: Focus on water resources and hydropower.* Organisation for Economic Co-operation and Development (OECD). https://www.oecd.org/environment/cc/19742202.pdfAgriculture.

Alonso, W. (1964). *Location and land use: Toward a general theory of land rent*. Harvard University Press.

Anderson, A., & Williams, M. (2019). Climate change education for sustainable development: Practices and perspectives. *Educational Studies Journal, 45*(3), 234–248.

Aryal, K. P., Cockfield, G., & Maraseni, T. N. (2014). Climate change vulnerability and adaptive strategies in the agricultural sector: A case study of indigenous and migrant farmers in Nepal. *Environmental Science & Policy*, *43*, 123–135.

Asongwe, G. A., Yerima, B. P. K., & Tening, A. S. (2014). The impacts of climate change on crop farming in Cameroon. *Agricultural Science Research Journal*, *4*(3), 80-88.

Barbieri, C. &Mahoney, E.(2009). Why is diversification an attractive farm adjustment strategy? Insights from Texas farmers and ranchers. *Journal of Rural Studies, 25*(1), 58-66.

Bebber, D. P., Ramotowski, M. A. T., & Gurr, S. J. (2013). Crop pests and pathogens move polewards in a warming world. *Nature Climate Change*, *3*(11), 985–988.

Bell, A.C., West, A. G. &Felsenfeld, G. (2001&15). Insulators and boundaries: versatile regulatory elements in the eukaryotic genome. *Science, 291*(5503), 447- 450.

Benbrook. C., Kegley, S., & Baker, B.(2021). Organic farming lessens reliance on pesticides and promotes public health by lowering dietary risks. *Multidisciplinary Digital Publishing Institute. Agronomy, 11*(7), 1266. https://doi.org/10.3390/agronomy11071266

Best, K., & Kahn, B. (1999&2004). *Research in education (7th.ed.).* Prentice Hall.

Bhandari, G., Sharma, M., & Dhakal, S. (2017). Community-based adaptive strategies for climate resilience: A case study from rural Nepal. *Journal of Climate Adaptive and Sustainability*, *12*(3), 45-62.

Bhatta, G. D., & Doppler, W. (2010). Socio-economic and environmental aspects of farming practices in the peri-urban hinterlands of Nepal. *Journal of Agriculture and Environment,11*, 26-39.

Bibi, F., & Rahman, A. (2023). An overview of climate change impacts on agriculture and their mitigation strategies. *Agriculture*, *13*(8), 1508. https://doi.org/10.3390/agriculture13081508

Birks,H.H.(2014).South to North: Contrasting late-glacial and early-Holocene climate changes and vegetation responses between south and north Norway. *Sage Journal, 25*(1), 117-129. https://doi.org/10.1177/0959683614556375

Bogdan, R. & Biklen, S. (1998). *Qualitative research for education: An introduction to theory and practice (5th ed.).* Pearson Education, Inc.

Boserup, E. (1965). *The conditions of agricultural growth: The economics of agrarian change under population pressure.* Allen & Unwin.

Bryceson, D. F. (1996). Deagrarianization and rural employment in Sub-Saharan Africa: A sectoral perspective. *World Development*, *24*(1), 97-111.

Burton, L. (2007). *Survey research: Choice instruments, sample*. John Hopkins University

Central Bureau of Statistics [CBS]. (2011). *Population census data.* National Planning Commission Secretariat, Government of Nepal.

Chae, S. & Kim, D. (2020). Research trends in agenda-setting for climate change adaptive policy in the public health sector. *Med Public Health*, *53*(1), 3–14. doi: 10.3961/jpmph.19.326.

Chakraborty, S., & Newton, A. C. (2011). Climate change, plant diseases and food security: An overview. *Plant Pathology*, *60*(1), 2–14. https://doi.org/10.1111/j.1365-3059.2010.02411.x

Chaloner, T. M., Gurr, S. J., & Bebber, D. P. (2021). Plant pathogens in a changing world. *The New Phytologist*, *229*(4), 1894-1906. https://doi.org/10.1111/nph.17020

Chazdon, R. L. (2008). Beyond deforestation: Restoring forests and ecosystem services on degraded lands. *Science*, *320*(5882), 1458-1460.

Chhetri, N. (1999). Institutional adaptive to climatic risks: Insights from a study of the livelihoods of migrant communities in Nepal. *Mountain Research and Development*, *19*(2), 94-101. https://doi.org/10.2307/3674392

Chikaire, J., Nnadi, F. N., Orusha, J. O., Nwoye, E. O., & Onogu, B. (2011). The role of agricultural extension in climate change adaptation and mitigation in agriculture. *World Rural Observations, 3*(4), 1-8. http://www.sciencepub.net/rural

Christaller, W. (1966). *Central places in Southern Germany* (C. W. Baskin, Trans.). Prentice-Hall. (Original work published 1933).

Cohen, L., & Morrison, K. (2013). *Research methods in education* (7th ed.). Routledge.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research method in education* (6th ed.) Taylor & Francis Group.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Sage Publications.

Daldeniz, B., & Hampton, M. P. (2013). Dive tourism and local communities: Active participation or passive impacts? Case studies from Malaysia. *International Journal of Tourism Research*, *15*(5), 507-520. https://doi.org/10.1002/jtr.1898

Department of Forest Research and Survey (DFRS), & Forest Resource Assessment Nepal (FRA). (2015). *State of Nepal's forests*. Government of Nepal, Ministry of Forests and Soil Conservation.

Department of Hydrology and Meteorology [DHM]. (2016). FNEP: Finnish-Nepalese project for improving the meteorological readiness in Nepal. *Journal of Hydrology and Meteorology, 8*(1), 71–75. https://doi.org/10.3126/jhm.v8i1.15575

Department of Hydrology and Meteorology [DHM]. (2017).*Observed climate trend analysis of Nepal (1971-2014).* Ministry of Population and Environment.Government of Nepal.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptive methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, *19*(2), 248-255. https://doi.org/10.1016/j.gloenvcha.2009.01.002

Deutsch, C. A., Tewksbury, J. J., Tigchelaar, M., Battisti, D. S., Merrill, S. C., Huey, R. B., & Naylor, R. L. (2018). Increase in crop losses to insect pests in a warming climate. *Science*, *361*(6405), 916-919. https://doi.org/10.1126/science.aat3466

Devkota, R. P., Paudel, B., & Subedi, A. (2011). Climate change and its impacts on agriculture: Farmers' perception in mid-hills of Nepal. *Journal of Agriculture and Environment*, *12*, 69-76.

Dhakal, S., Sedhain, G. K., & Dhakal, S. C. (2016). Climate change impact and adaptation practices in agriculture: A case study of Rautahat District. *Sustainability*, *8*(12), 1-22. https://doi.org/10.3390/su8121319

DHM. (2021). *Observational records of climate data*. Department of Hydrology and Meteorology, Government of Nepal.

Dhungana, H. P., Bista, S., & Shrestha, R. (2020). Community adaptive strategies to climate change in rural Nepal: A case study of agricultural practices. *Journal of Climate Change and Resilience*, *8*(2), 122-135.

Díaz-Álvarez, E. A., Martínez-Zavaleta, J. P., López-Santiz, E. E., & de la Barrera, E. (2023). Climate change can trigger fall armyworm outbreaks: A developmental response experiment with two Mexican maize landraces. *International Journal of Pest Management, 69*(2), 184–192. https://doi.org/10.1080/09670874.2020.1869347

Diffenbaugh, N. S., & Field, C. B. (2013). Changes in ecologically critical terrestrial climate conditions. *Science*, *341*(6145), 486-492.

Dlamini, M. N. (2016). *Understanding and teaching climate change in the Secondary Education Geography curriculum in Swaziland*. https://repository.up.ac.za/items/3862bbc8-bad0-4a11-b914-32843d99b0a3

Easterling, D. R., Meehl, G. A., Parmesan, C., Changnon, S. A., Karl, T. R., & Mearns, L. O. (2000). Climate extremes: Observations, modeling, and impacts. *Science, 289*(5487), 2068–2074. https://doi.org/10.1126/science.289.5487.2068.

Education Policy. (2019). *National education policy 2019*. Ministry of Education, Science, and Technology, Government of Nepal.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *Journal of Development Studies*, *35*(1), 1-38. https://doi.org/10.1080/00220389808422553

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press.

El-Solh, M. (2003). Integrating climate change education into development programs. *Environmental Education Research*, *9*(2), 175-191. https://doi.org/10.1080/13504620303434

European Commission. (2020). Forging a climate-resilient Europe: The new EU strategy on adaptation to climate change. *European Green Deal Policy, 14(*5), 28–42.

Famiglietti, J. S. (2014). The global ground water crisis. *Nature Climate Change*, *4*(11), 945-948.

Field, C. B., Barros, V., Stocker, T. F., & Qin, D. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation*. Cambridge University Press.

Food and Agriculture Organization [FAO]. (2009). *Climate change and food security: A framework document*. Interdepartmental Working Group on Climate Change.of the United Nations.

Food and Agriculture Organization. (2019). *The state of food security and nutrition in the World 2019: Safeguarding against economic slowdowns and downturns*. FAO. https://www.fao.org/3/ca5162en/ca5162en.pdf

Fróna, D., Szenderák, J., & Harangi-Rákos, M. (2021). Economic effects of climate change on global agricultural production. *Nature Conservation*, *44*, 117–139. https://doi.org/10.3897/natureconservation.44.64296

Funk, C., Dettinger, M. D., Michaelsen, J. C., Verdin, J. P., Brown, M. E., Barlow, M., & Hoell, A. (2008). Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. *Proceedings of the National Academy of Sciences*, *105*(32), 11081-11086.

García-Feced, C., Weissteiner, C. J., Baraldi, A., Paracchini, M. L., Maes, J., Zulian, G., Kempen, M., Elbersen, B., & Pérez-Soba, M. (2015). Semi-natural vegetation in agricultural land: European map and links to ecosystem service supply. *Agronomy for Sustainable Development*, *35*(1), 273-283.

Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science & Policy*, *12*(4), 491-503.

Garrigus, J. (n.d.).*Climate change adaptive strategies for agriculture in Southeast Asia* [Unpublished manuscript]. Springer.

Gautam, M., Timilsina, R., Govinda, R., & Acharya, K. (2013*).* Climate Change in the Himalayas : Current State of Knowledge. *Policy Research Working Paper;No. 6516.* World Bank, Washington, DC. https://openknowledge.worldbank.org/

Gautam, S., & Thapa, G. B. (2018). Climate change, agriculture, and rural livelihoods in the Himalayas. *Asian Journal of Environmental Science*, *13*(1), 88-103. https://doi.org/10.21608/ajes.2018.29920

Gerretsen, I. (2021). The impact of climate change on agricultural practices in developing countries: a focus on education and training. *Global Environmental Change*, *67*, 102-118. https://doi.org/10.1016/j.gloenvcha.2021.102118

Giri, S., Prabhakar, A., Malla, R. B., Oli, S., Poudel, S., & Khanal, A. (2023). Climate change mitigation and adaptation in Nepal and South Asia: Challenges, progress, and recommendations. *Journal of Sustainability and Environmental Management, 2*(2), 133–140. https://www.nepjol.info/index.php/josem/article/view/55589

Gopal, R. (2017). Adapting agriculture to climate change: regional strategies for sustainable development. *Agriculture and Climate Change Journal*, *9*(3), 45-63.

Government of Nepal, Ministry of Environment. (2010). *National adaptation programme of action (NAPA) to climate change*. Ministry of Environment, Government of Nepal.

Government of Nepal, Ministry of Environment. (2011). *Climate change policy*. Government of Nepal. https://faolex.fao.org/docs/pdf/nep143050.pdf

Government of Nepal, Ministry of Environment. (2011). *National framework on local adaptation plans for action*. Climate Change Management Division. https://www.moenv.gov.np

Gurung, G. (2018). *Educational perspective of indigenous knowledge and practice of plant management of Gurung community*. Faculty of Education, Tribhuvan Unuversity.

Han, H., Li, J., & Zhang, X. (2022). Climate change adaptive strategies: Education and policy recommendations. *Environmental Policy and Governance,32*(2), 100–115. https://doi.org/10.1002/eet.2001

Heintz, J. (2007).*Globalisation, economic policy and employment: Poverty and gender implications*. International Labour Office, Employment Policy Unit, Employment Strategy Department. https://doi.org/10.1016/j.agsy.2021.103408

Intergovernmental Panel on Climate Change (IPCC). (2014). Climate change 2014: impacts, adaptation, and vulnerability. *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. (2007). *Impacts, adaptation, and vulnerability*. Contribution of Working Group II to the Fourth Assessment.

Intergovernmental Panel on Climate Change. (2006). *Climate change 2007: Impacts, adaptation, and vulnerability.* Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change. Summary for policymakers. Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. World Meteorological Organization (WMO); United Nations Environment Programme (UNEP). https://www.ipcc.ch/report/ar6/wg3/

International Center for Tropical Agriculture (CIAT), World Bank, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), & Local Initiatives for Biodiversity, Research and Development (LI-BIRD). (2017). *Climate-smart agriculture in Nepal* (CSA Country Profiles for Asia Series, 26 p.). CIAT; World Bank; CCAFS; LI-BIRD. https://hdl.handle.net/10568/83339

IPCC. (2006). *Climate change 2007: The physical science basis*. Intergovernmental Panel on Climate Change.

IPCC. (2021). *Climate change 2021: The physical science basis*. Intergovernmental Panel on Climate Change).

IUCN. (2013).*Enhancing ecosystems and livelihoods, delivering nature-based solutions to development challenges: IUCN Nepal Programme framework 2013-2016.* International Union for Conservation of Nature.

Jarvis, A.,Lane, A., & Hijmans,R.(2008). The effect of climate change on crop wild relatives.*Agriculture Ecosystems & Environment, 126*(12), 13-23.

Jones, A., & Miller, R. (2021). *Geographic information systems in climate change research: A focus on agricultural adaptation*. Springer.

Juroszek, P., & von Tiedemann, A. (2013). *Climate change and agricultural plant Diseases*. *Environmental Science & Policy*, *33*, 45-58. https://doi.org/10.1016/j.envsci.2012.10.009

Karki, R., Gurung, A., & Shrestha, S. (2020). Impacts of climate change on agriculture and water resources in the mountains of Nepal: Adaptive strategies for resilience. *Journal of Mountain Research, 15(*2), 234-250.

Kellerman, A. (1989). Agricultural location theory. *Environment and Planning, 21*(10), 1381-1396.

Kemp, R. (1994). Technology and the transition to environmental sustainability: The problem of technological regime shifts. *Futures, 26*(10), 1023-1046. https://doi.org/10.1016/0016-3287(94)90071-X

Khanal, N. R. (2018). *Adaptive strategies in agriculture for climate change: A Review of Policies and Practices*. *Journal of Climate and Weather*, *6*(1), 12-23. https://doi.org/10.2174/2585753X06618010001

Khanal, P. (2012). Policy *as a practice of power: an analysis of the policy to decentralize school education in Nepal*. Canterbury Christ Church University.

Kimole, S. (2012). *The adoption of mushroom farming among smallholder farmers: A case of women mushroom farmers in Makuyu, Kenya*. Vanhall, Larenstein.

Klein, R. J. T., Schipper, L., & Dessai, S. (2005). Integrating climate adaptive into development planning. *Climate Policy*, *5*(3), 320-338. https://doi.org/10.1080/14693062.2005.9685561

Kramer, R., Richter, D., Pattanayak, S., & Sharma, N. (2008). Adaptive to climate change: integrating local and institutional knowledge in developing countries. *Environmental Economics and Policy Studies*, *10*(2), 57-74.

Krejcie, R.V., & Morgan, D.W., (1970). *Determining sample size for research activities*. Educational and Psychological Measurement.

Kripalani, R. H., Kulkarni, A., & Sabade, S. (2003). South Asian climate and climate change. *International Journal of Climatology*, *23*(4), 583-601. https://doi.org/10.1002/joc.887

Kundzewicz, Z. W. (2015). Climate change track in river floods in Europe. *Proceedings of the International Association of Hydrological Sciences*, *369*, 189–194. https://doi.org/10.5194/piahs-369-189-2015

Laderach, P., Jarvis, A., & Ramirez, J. (2017). Climate change and coffee: A review of impacts and adaptive strategies. *Agricultural Systems*, 152, 50-64. https://doi.org/10.1016/j.agsy.2017.01.003

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G., Folke, C., George, P. S., Homewood, K., Imbernon, J., Leemans, R., Li, X., Moran, E. F., Mortimore, M., Ramakrishnan, P. S., Richards, J. F., Skånes, H., ... Xu, J. (2001). The causes of land-use and land-cover change: Moving beyond the myths. *Global Environmental Change*, *11*(4), 261–269. https://doi.org/10.1016/S0959-3780(01)00007-3

Lincoln, Y. S., & Guba, E.G. (1985). *The naturalistic inquiry*. Sage Publication.

Lindwall, C.(2022).*What Are the Effects of Climate Change?* https://tinyurl.com/3fcwxxzm

Ling, H. Y., Deng, S. Z., ChakHo,H., Chen,Y. Hajat,S., QuanZhou, C.R.B,Cheng,J. Wen, W., & RuiHuang, J. C. (2021). The half-degree matters for heat-related health impacts. *Advances in Climate Change Research*, *12*(6), 628-637. https://doi.org/10.1016/j.accre.2021.09.001

Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., Lubchenco, J., Seto, K. C., Gleick, P., Kremen, C., & Li, S. (2015). *Systems integration for global sustainability*. Science, *347*(6225) https://doi.org/10.1126/ science.1258832

Lobell, D. B., & Field, C. B. (2007). *Global scale climate impacts on agriculture and food security*. *Global Environmental Change*, *17*(1), 96-106. https://doi.org/10.1016/j.gloenvcha.2006.08.002

Lobell, D. B., Burke, M. B., Tebaldi, C., et al. (2008). Prioritizing climate change adaptive needs for food security in 2030. *Science*, *319*(5863), 607-610. https://doi.org/10.1126/science.1152339

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). *Climate trends and global crop production since 1980*. *Science*, *333*(6042), 616-620. DOI: 10.1126/science.1204531

Local Adaptive Plan for Action (LAPA) (2010). *LAPA guidelines for developing local adaptive plans of action*. Government of Nepal, Ministry of Environment.

Malik, A., & Ford, J. (2024). *Education and climate adaptation: Bridging the gap between knowledge and action*. *Climate and Development*, *16*(2), 145-156. https://doi.org/10.1080/17565529.2023.2174943

Malla, G. (2008). Climate change and its impact on Nepalese agriculture. *The Journal of Nepalese Agriculture*, *9*, 62-71.

Marhatta, S. B., Sharma, A., & Thapa, G. B. (2009). *Climate change adaptive strategies in agriculture: A case study in Nepal*. *Journal of Environmental Management*, *90*(1), 67-79. https://doi.org/10.1080/17565529.2023.2174943

Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (2000). The impact of climate change on agriculture: A Ricardian analysis. *The American Economic Review*, *84*(4), 753-771.

Mersha A.A., & Van Laerhoven, F. A. (2016). Gender approach to understanding the differentiated impact of barriers to adaptive responses to climate change in rural. *Reg. Environ. Chang,16* (6),1701–1713.

Ministry of Water Supply, Nepal (2019). *Climate resilient water safety plans*. Kathmandu: Government of Nepal.

Ministry of Water Supply, Nepal (2019). *Water supply sector development plan 2016-2030*. Government of Nepal, Ministry of Water Supply. https://mwsd.gov.np

Minoli, S., C., Müller, J, Elliott, A.C., Ruane, J., Jägermeyr, F., Zabel, M., Dury, C., Folberth, L,. Francois, T., Hank, I., Jacquemin, W., Liu, S. O., & T.A.M. Pugh, T.A.M. (2019). Global response patterns of major rainfed crops to adaptive by maintaining current growing periods and irrigation. *Earth's Future*, *7*(12), 1464-1480. https://doi.org/10.1029/2018EF001130

Mochizuki, Y., & Bryan, A. (2015). Climate change education in the context of education for sustainable development: Rationale and principles. *Journal of Education for Sustainable Development*, *9*(1), 4-26. https://doi.org/10.1177/0973408215569109

Molden, D., Oweis, T., Pasquale, S., Kijne, J., & Barker, R. (2007).*Water for food, water for life: A comprehensive assessment of water management in agriculture.* Earthscan/International Water Management Institute (IWMI).

NAP (2021). *National adaptive plan (NAP) for climate change*. government of Nepal, ministry of forests and environment. https://www.mofe.gov.np

National Aeronautics and Space Administration (NASA) (2021). *Climate change: How NASA monitors climate change*. National Aeronautics and Space Administration. https://climate.nasa.gov/

National Climate Change Policy (2019). *Nepal's national climate change policy*. Government of Nepal, ministry of forests and environment. https://www.mofe.gov.np

Ndamani, F., & Watanabe, T. (2016). Determinants of farmers' adaptive to climate change: A micro-level analysis in Ghana. *Scientia Agricola*, *73*(3), 201-208. https://doi.org/10.1590/0103-9016-2015-0163

Ndamani, F., & Watanabe, T. (2016). Determinants of Farmers' Adaptation to Climate Change: A Micro Level Analysis in Ghana. *Scientia Agricola, 73*, 201-208. https://doi.org/10.1590/0103-9016-2015-0163

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T. & Zhu, T. (2009). *Climate change impact on agriculture and costs of adaptation*. https://www.ifpri.org/cdmref/p15738coll2/id/130648/filename/130821.pdf.

Nepal Health Research Council [NHRC]. (2018).*Country reports on human rights practices*. United States Department of State Bureau of Democracy, Human Rights and Labor.

Neupane, R. (2019). *PMAMP-PIU Potato superzone kavrepalanchok assessment of organophosphate and carbamate residues in the potato of Kavre, prime minister agriculture modernization project*. https://doi.org/10.13140/RG.2.2.30342.52809.

Newman, I. (2004). *Mixed methods research: Exploring the interactive continuum*. Southern Illinois University Press.

Nightingale, A. J. (2011). Community-based climate adaptive planning: Processes and learning from community forestry in Nepal. *Technical Report*. https://www.researchgate.net/publication/313164234

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., & West, J. (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India. *Global Environmental Change*, *14*(4), 303-313. https://doi.org/10.1016/j.gloenvcha.2004.01.001

Oerke, E.-C. (2006). *Crop losses to pests. Journal of Agricultural Science*, *144*(1), 31-43. https://doi.org/10.1017/S0021859605005708

Ojha, H., Persha, L., & Chhatre, A. (2009). *Community forestry in Nepal: A policy innovation for local livelihoods* (IFPRI Discussion Paper No. 00913). International Food Policy Research Institute. https://www.ifpri.org/publication/community-forestry-nepal-policy-innovation-local-livelihoods.

Olmsted, L. J. (2007). *The global warming crisis: An analytical framework to regional responses*. University of California.

Oxfam, N. (2013). *Agro-biodiversity and food security: Scaling up innovations for building people's capacities to respond to climate change: Conceptual and Methodological Development for a Baseline Survey*. https://sdhsprogram.org/assets/2016/07/Technical-Report_Baseline_Bioversity-International.pdf.

Panday, D. (2012). Adapting climate change in agriculture. The Sustainable Way in Nepalese context. *Hydro Nepal Journal of Water Energy and Environment, 11*(1), 91-94. https://doi.org/10.3126/hn.v11i1.7222

Pant, K. P. (2013). Effects of labour migration on poverty and agricultural growth in Nepal. *The Journal of Agriculture and Environment, 14*, 87–101. file:///C:/Users/NB%20HIMALAYA/Downloads/admin,+JAE_14_87-101.pdf

Park, N.E., Choe, S.U., & Kim, C.J. (2020). Analysis of climate change education programs: focusing on cultivating citizen activists to respond to climate change. *Asia-Pacific Science Education, 6*(1), 1–26. file:///C:/Users/NB%20HIMALAYA/Downloads/Analysis_of_Climate_Change_Education_CCE_Programs_.pdf.

Paudel, N. & Andersen, S. (2010). Climate change adaptive and agriculture in Nepal: A review. *Journal of Agricultural and Environmental Sciences*, *4*(2), 1-12. https://www.jaes.org

Petley, D. N. (2010). Global patterns of loss of life from landslides. *Geology*, *38*(4), 353-356. https://doi.org/10.1130/G30750.1

Pokhrel, D. M. & Pandey, B. (2011). Climate change adaptation: strategic vision in agriculture. *The Journal of Agriculture and Environment*, *12*, 104-112.

Practical Action Nepal (2009). *Climate change adaptive and disaster risk reduction: practical action's experience in Nepal*. Practical Action Nepal. https://practicalaction.org

Rai, R. (2011). Climate change impacts and adaptive strategies in Nepal. *Journal of Climate Change and Sustainable Development*, *4*(2), 45-57. https://doi.org/10.1016/j.jcsd.2011.05.004

Regmi, B. R., & Paudel, N. S. (2019 &2021). Climate change and rural livelihoods in Nepal: Adaptive strategies in practice. *Climate and Development*, *11*(1), 45-57. https://doi.org/10.1080/17565529.2018.1442789

Regmi, B., & Adhikari, A. (2007). *Human development report: Climate change and human development – Risk and vulnerability in a warming world. Country case study–Nepal*. United Nations Development Programme. https://www.undp.org.

Reid, H., Sahlen, I., Stage, J., & MacGregor, J. (2008). Climate change impacts on Namibia's natural resources and economy. *Climate Policy*, *8*, 452-466. https://doi.org/10.1080/14693062.2008.9685709

Rodell, M., Velicogna, I., & Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature*, *460*(7258), 999-1002. https://doi.org/10.1038/nature08238

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Rudel, T. K. (2009). Tree farms: Driving forces and regional patterns in the global expansion of forest plantations. *Land Use Policy*, *26(*3), 545-550. https://doi.org/10.1016/j.landusepol.2008.08.003

Samson, I. (2023). *Climate change education. An analysis of the secondary schools curriculum in Nepal*.UNESCO. https://unipd-centrodirittiumani.it/en/schede/Climate-Change-Education-An-analysis-of-the-secondary-schools-curriculum-in-Nepal/502.

Satterthwaite, D. (2007). *The transition to a predominantly urban world and its underpinnings*. Human Settlements Discussion Paper Series. International Institute for Environment and Development (IIED).

SDGs. (2017). *Sustainable development goals report 2017*. United Nations. https://unstats.un.org/sdgs/report/2017/

Sen, A. (1981). Poverty and famines: An essay on entitlement and deprivation. Oxford University Press.

Seto, K. C., Gunslay, A., & Kaufmann, R. K. (2011). The role of urbanization in climate change. *Global Environmental Change*, *21*(1), 248-259.

Shackleton, C. M., McGarry D., Fourie, S., Gambiza, J., & Fabricius, C. (2007). Assessing the effects of invasive alien species on rural livelihoods. Case examples and a framework from South Africa. *Human Ecology*, *35*,113– 127. https://doi.org/10.1007/s10745-006-9095-0

Shrestha, M. K. (2020). Buddhist attitude towards health-related physical fitness and physical education. Lumbini Buddhist University.

Shrestha, R., & Devkota, S. (2020). *Agricultural adaptation to climate change in Nepal: strategies and challenges*. *Journal of Agricultural Science and Technology, 22*(4), 117-126.

Shrestha, S. & Devkota, S. (2010). Climate change adaptive strategies in agriculture: A case study in Nepal. *Journal of Climate Change and Agriculture*, *8*(1), 23-34. https://www.jccag.org

Shrestha, S. K. (2023). Climate change and adaptive strategies for agriculture in Panchkhal Municipality. *The Third Pole: Journal of Geography*, *23*, 47–65. https://doi.org/10.3126/ttp.v23i01.61907

Shrestha, S., & Paudel, N. (2020). *Climate change and agriculture: An overview of*

Shrestha, S., Adhikari, K., & Bhattarai, R. (2020). *Effects of climate change on agricultural practices in Nepal: A study of adaptive measures*. *Agricultural Economics Review*, *mountainous regions: Understanding and adaptive strategies*. *Earth Surface Processes and Landforms, 41*(5), 581-598.

Shreya. (2023, June 4). The need for climate education in Nepal and beyond. *Mock COP*. https://mockcop.org/the-need-for-climate-education-in-nepal-and-beyond/

Sidle, R. C., & Bogard, K. V. (2016). Climate change impacts on hydrological hazards in adaptive strategies in Nepal. *Climate Change Economics*, *11*(2), 45-60.

Silveira, S., & Matosas, R. (2003). Educational strategies for climate change adaptation. *Journal of Climate Education*, *4*(1), 55-68.

Skendzic,S. Zovko,M.' Zivkovic,P.I.,Lesic,V. & Lemic, D. (2021). The impact of climate change on agricultural insect pests. *Insects,12*(5), 440. https://doi.org/10.3390/insects12050440

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Smith, J. (2020). *Landscape ecology and environmental change*. Oxford University Press.

Stern, N. (2006). *The stern review on the economics of climate change*. HM Treasury, London.

Strauss, A., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Sage Publications, Inc.

Sujakhu, N. M., Ranjitkar, S., Niraula, R. R., Salim, M. A., & Schmidt-Vogt, D. (2018). Farmer's local knowledge and perception of climate change and adaptive epractices in the mountain region of Nepal. *Sustainability*, *10(*2), 403. https://doi.org/10.3390/su10020403

Tashakkori, A., & Teddlie, C. (2008). *Mixed methodology: Combining qualitative and quantitative approaches*. Sage Publication.

Teddlie, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. *Journal of Mixed Methods Research*, *1*(1), 77-100. https://doi.org/10.1177/1558689806292430

Thakuri, S. (2017). Climate change and its implications for agricultural systems in Nepal. *Nepal Journal of Environmental Science*, *6*(1), 15-25. www.njes.org

Thapa, G. B., & Weber, K. E. (1990). Managing mountain watersheds: The case of Nepal. *Environmental Conservation*, *17*(3), 247-256. https://doi.org/10.1017/S0376892900032676

Thapa, G. B., Subedi, S., & Bhandari, R. (2021). Agriculture and climate change: assessing adaptive strategies in Nepal. *Environmental Management*, *67*(4), 589-600. https://doi.org/10.1007/s00267-021-01450-2

Thapa, R., & Regmi, R. (2018). Climate change impacts and adaptive strategies in agriculture: A case study of Nepal. *Journal of Agriculture and Environment*, *19*, 27-34. https://doi.org/10.3126/aej.v19i0.19864.

Thornton, P. K., Jones, P. G., Ericksen, P. J., & Challinor, A. J. (2009). Agriculture and food systems in sub-Saharan Africa in a 4°C+ world. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1934), 117-136. https://doi.org/10.1098/rsta.2009.0189

Thornton, P., Dinesh, D., Cramer, L., Loboguerrer, A. & Campbell, B. (2018). Agriculture in a changing climate: Keeping our cool in the face of the hothouse. *Outlook agriculture*, *47*(4), 283–290. https://doi.org/10.1177/0030727018815332

Thunen,J.H. (1810). *Location theory*. Encyclopaedia Britannica.

Tiwari, K. R., Awasthi, K. D., & Balla, M. K. (2018). Local adaptation plans of action (LAPA) as a mechanism for enhancing climate resilience: A case from Nepal. *Environmental Development*, *25*, 23-33.

Tiwari, K. R., Awasthi, K. D., Balla, M. K., & Sitaula, B. K. (2014). Local people's perception on climate change, its impact and adaptive practices in himalaya to terai regions of Nepal. *Himalayan Journal of Sciences*, *9*(9), 67-75. https://doi.org/10.3126/hjs.v9i9.5172

Trenberth, K. E. (2011). Changes in precipitation with climate change. *Climate Research*, *47*(1), 123-138. https://doi.org/10.3354/cr00953

Tshiningayamwe, S. A. N. (2018). Integration of climate change into the Namibian school geography curriculum. *Alternation Special Edition*, *21*, 234–257. https://doi.org/10.29086/2519-5476/2018/sp21a11

Turner, B. L., Kasperson, R. E., Matson, P. A., & et al. (2003). *A framework for vulnerability analysis in sustainability science. proceedings of the national Academy of Sciences*, *100(*14), 8074-8079. https://doi.org/10.1073/pnas.1231335100

UIS. (2012). *International standard classification of education: ISCED 2011*. UNESCO Institute for Statistics.

UNESCO. (2020). Education for sustainable development: ESD for 2030 Framework. https://unesdoc.unesco.org/ark:/48223/pf0000374049.

UNFCCC. (2007). *National adaptive programmes of action (NAPA) - Overview*. United nations framework convention on climate change. https://unfccc.int/topics/adaptation-and-resilience/resources-for-adaptation

United Nations [UN]. (2017). *Sustainable development goal report*. Statistics Division Development Data and Outreach.

United Nations Department of Economic and Social Affairs (2017) *Climate change and the sustainable development goals: An overview*. United Nations. https://www.un.org.

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2015). Rethinking education towards a global common good. www.unesco.org

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2006). *Education for sustainable development and climate change adaptation*. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000146096

United Nations Framework Convention on Climate Change [UNFCCC]. (2006, 2007). *Climate change: Impacts, vulnerabilities and adaptive in developing countries*. United Nations Framework Convention on Climate Change.

United State Agency for International Development [USAID]. (1996*). Conducting key informant interviews*(1st.ed., 2004). http://www.dec.org/pdf_docs/pnabs541.pdf

University of Illinois Extension (n.d.). *Climate change and agriculture: Adaptive strategies*. https://extension.illinois.edu

Upadhyay, D. P. (2019). Climate change and adaptive strategies: A study of agriculture and livelihood adaptive by farmer in Bardiya district. *Advances in Agriculture and Environmental Science, 2(1),* 47-52. https://doi:10.30881/aaeoa.00022

Urban Water Supply and Sanitation [Sector] Project. (2018). *Sectoral assessment of climate change impacts and adaptive needs*. Government of Nepal. https://www.uwssp.gov.np

Varshney, R., Sharma, S., & Kumar, S. (2011). Climate change adaptive strategies: An overview. *Journal of Environmental Management*, *92*(4), 1230-1239.

Von Thünen, J. H. (1826). *The isolated state*. English translation by Peter Hall, 1966. Economic Geography. Pergamon Press.

Vörösmarty, C. J., Lévêque, C., & Revenga, C. (2000). *Global water resources and climate change: A new perspective*. *Global Environmental Change*, *10* (2), 107-119. https://doi:10.1016/S0959-3780(00)00005-8

WFP (2009). *Food security and climate change: The role of world food programme*. World Food Programme. https://www.wfp.org

Wigley, T. M. L. (2005). *The climate system: past, present, and future. Journal of Climate*, *18*(12), 2267-2296. https://doi.org/10.1175/JCLI3456.1

Wilby, R. L., & Keenan, R. J. (2012). *Adapting to climate change: A systematic literature review of approaches and practices*. *Environmental Management*, *49*(1), 1-19. https://doi.org/10.1007/s00267-011-9755-6

WMO (2004). *Weather and climate extremes in a changing climate*. World Meteorological Organization. www.wmo.int

Xaba, M., Nkabinde, J., & Zulu, N. (2002). *Climate change education in southern Africa*. *African Journal of Environmental Studies*, *5*(2), 33-47. https://doi.org/10.4314/ajes.v5i2.29388

Yin, J. (2014). Impacts of climate change on agriculture and adaptive strategies: A case study in china. *Climate Policy*, *14*(6), 734-749. https://doi.org/10.1080/14693062.2014.906436

Zomer, R. J., Trabucco, A., & Bossio, D. A. (2014). Soil organic carbon and soil health: *An overview. Global Change Biology, 20*(3), 1173-1185. https://doi.org/10.1111/gcb.12454

APPENDICES

Appendix A: Questionnaire for Household Survey

Section A (I): Socio-Economic and Demographic Conditions

1. Name.....................Age...........sex………….Contact no……………

2. Permanent addresses District: ....

Municipality/ rural municipality............. Tole............

3. Religion.......Caste........ Mother language……….

Mrital status: 1.Unmarried ☐ 2. Married 3. Separated living

4. Divorce ☐ 5.Widows ☐ 6. Others……………………

5. Tell me your mother tongue……………………………….

6. Academic qualification

Qualification …………………….. Subject………………

7. How many members do you have in your family? Fill in the details below

Age group	Male	Female	Total
Below 15 yrs			
15-64 yrs			
65 or above yrs			

8. State the educational qualifications of your family

Educational level	Male	Class/Semester	Female	Class/Semester	Remarks
1	Primary level				
2	L.Secondary level				
3	Secondary level				
4	Proficiency certificate/10+2				
5	Bachelor level				
6	Masters level				
7	Other				

9. Are your children going to school / college?

Yes ……………….. No…………………..

If yes mention, the given below

Categories	Son	Daughter	Class/level	Remarks
Government school				
Community school				
Private school				
Government college				

10. Annual family income

Categories	Nrs
Agriculture	
Commercial agriculture	
Service	
Remittance	
Trade	
Labour	
Others(Specify)	
Total	

11. Annual family expenditure

Agriculture	Nrs	Non-agriculture	Nrs
Food		Education	
Lentils		Heath	
Vegetables		Cultural functions	
Fruits		Travel and tourism	
Oil		Tobacco	
Spice		Drinking	
Meat/Eggs/Fish		Tax land	
Dairy products		Rental land	
Others		Others	

12. The trend of agricultural production and income based on livelihood.

Category	Prod. 2071	Inco. 2071	Prod. 2072	Inco. 2072	Prod. 2073	Inco. 2073	Prod. 2074	Inco. 2074	Prod. 2075	Inco. 2075
Food crops										
Cash crops										
Livestock										

Bird rearing

others

13. Describe the materials used in your home.

1. Wood and zinc □ 2. Stone and Clay □ 3. Cement, sand, brick and rod (concrete)

4. Other (mention)

14. What are the items do you use in your home?

1. Telephone □ 2. Mobile □ 3. Computer □ 4. Laptop □ 5. Tap □

6. Fridge □ 7. Inverter □ 8. Solar □ 9.Clock □ 11 Fan □ 12. Chair □ 13. Sofa□

14 others (mention).........

Means of transportation: 1. Bicycle □ 2. Cart □ 3. Motorcycle / Scooter□ 4. Car / truck□

5. Three Wheel Tempo□ 6. Other (Mention)

15. Do you / does any member of the family have land in the name of Lalpurja?

1. Yes□ 2. No□

If yes, give the details below:

Resource Access

Types of land	Area(in ropani)	1. Male owned □ 2 Female owned □ 3 .Joint ownership of both□	Current estimated value
1.Farm			
2. Pakha/Bari			
3.House/Ghaderi			
4.Other (disclose).			

16. Do you have any land in the name of any member of your family without Lalpurja?

1. Yes □2. No □

If yes, give the details below

Types of land	1. Male owned □ 2 Female owned □ 3 .Joint ownership of both□	Area (in ropani)	Current estimated value
1.Farm 2. Pakha/Bari 3.House/Ghaderi			
4. Other (disclose).			

17. Mention the details of the land used for agricultural work with your family.

18. How many months does your product feed your family?

1. Below 6 months □2. 6-9 months□

3. 9- 12 months □4. Above 12 months□

19. How many years have you been involved in agriculture?

1. 1-5 years □ 2. 6-10 years □ 3. 10-15 years □ 4. Above 15 years□

20. What are the main sources of energy (cooking and lighting) in your home?

1. Firewood □ 2. Electricity □ 3. Kerosene □ 4 Biogas □ 5 Solar □

6. Inverter / Generator □ 6.Other (mention) .

21. Have any of your members have gone foreign country for employment?

1. yes □ 2. No□

If yes, fill in the details below:

Name of country	Male	Female	Year

Section-B Climate related Variables

A. Knowledge level questionnaire related to climate change

22. Do you know anything about climate change?

1. Yes □ 2. No□

If yes, mention it.................

23. Do you know about carbon emissions?

1. Yes □ 2. No□

If yes....................

24. Do you know about global warming?

1. Yes □ 2. No□

If yes …

25. Does Carbon Emissions Increase Global Warming?

1. Does□. 2. Doesn't□

26. Is global warming the cause of climate change?

1. Yes□ 2. No □

If yes how...............

27. How do you know the main information about climate change?

1. Internet □ 2. Radio / TV □ 3. Neighborhood □4. Enlightened people□

4. Letter Magazine□ 6. Other (mention)..........

28. Do you know what policies and regulations the state should implement to mitigate the effects of climate change?

1. Yes □ 2. No □

If yes, I. Plantation □ ii. Increase investment in education □ iii. Increase investment in agriculture iv. Promoting Sustainable Development v .Other (mention)....................

29. How do you feel about climate change?

1. Permanent □ 2. Temporary □ 3. Both □ 4. Undecided □

30. Have you experienced climate change for the last 10 years?

1. Yes □2. No. □ If yes, 1. Winter □ 2. Summer □ 3. Winter and summer □

31 Have you listen about future effects of climate change?

1. Yes □ 2. No □, if yes

I. Heavy rain □ ii. Sea level rise □ iii. Increasing decay □ iv. Low rainfall □ v. Temperature rise □ vi. Decreased temperature □ vii. The trees will die □ viii. Sea temperature rises □ ix. Losses on animals and plants □ x. Indecision □ xi. Other (mention)........................

C. Perceptions of the Respondent on Climate Change

Have you used the following perception for climate change? Tick (√) the given sentence.

Where, SD= Strongly Disagree, D = Disagree, DK= Don't Know, A= Agree, SA= Strongly Agree

S.N	Statements	SD	D	DK	A	SA
32	Climate is Changing.					
33	Climate change is caused by human activities					

34	A climate change is the issues of the world.
35	Global warming is increasing due to climate change
36	Climate change is the change in average weather conditions
37	Climate change is making holes in the weight layer.
38	Deforestation is a cause of climate change.
39	Excessive use of organic fertilizers is due to climate change
40	Pollution from industry causes climate change
41	Climate change is caused by poor management of waste

D. Trends of climate change

42. Do you know, what is a hot wave?

1. yes □ 2. No□

if yes Mention ....

43. In what season does it flow?

1. Summer□2. Winter □ 3.Both□

44. Do you feel that agriculture has been affected by the heat wave?

1. Yes □ 2 No□

if yes, mention i. Little □ ii medium □ iii. Lots□

45. Do you know that cold air waves?

1 □ 2. No□

If yes mention ………………………………

46. In what season does it flow?

1. Summer □ 2. Winter □ 3. Both□

47. In your experience, cold wave has affected to agriculture?

1. Yes □ 2. No□

If yes, mention any i. Little □ ii medium □ iii. Lots

48. In your experience, the temperature is increasing for last 10 years?

1. yes □2. No□

If yes, mention any i. Little□ ii. Medium □ iii. Lots □

49. In your experience, the rainfall is increasing for the last 10 years?

1.yes□2. No□

If Yes, mention any i. Little□ ii. Medium □ iii. Lots□

Section - C. Agricultural Support Services

A. Priority investments for agricultural development

50. How many types of roads available in this municipality? i. Highway □ ii Gravell road □ iii. Agricultural road □ IV. Trekking road

v. Other (mention)................

51. Is there an agricultural road?

1. yes□ 2. No□

If yes, how long (km)...........................?

52. What type of irrigation facility is available here?

1. Permanent □ ii.Temporary □ iii. Seasonal □ iv all kinds

Source: 1. Canal □ 2. Kulo / Paini 3.Boaring □ 4.Inar / Kuwa

5. Sky water □ 6. Other.

53. Have you used modern inputs?

1.yes □ 2. No□

If yes, mention i. Little□ ii. Medium □ iii. Lots□

54. Have you changed your working season due to temperature for a long time (10 years)?

1.yes □2. No□

If yes i. winter □ ii. cold □ iii. winter and cold□

55. Have you changed the time of agricultural work due to rainfall for a long time (10 years)?

1. Yes□2. No□

If yes i. Dry □ ii. wet □ iii. Dry and wet□

B.Agricultural Production Practices

56. How do you arrange labor for agricultural production?

i. Within the family □ ii. Out of family □ iii. both□

57. Give the following details regarding water, irrigation, fertilizer and pesticide

C. Agriculture Financing

58. Have taken a loan for the operation of an agricultural farm?

i. Yes□ ii. No□

If yes, give the details

Categories	Nrs	Interest rate
Bank		
Microfinance		
Cooperatives		
Landlords / Relatives		
Total		

59. Challenges of crop production caused by climate change

S.N.	Statements	SD	D	DK	A	SA
1	Illiterate farmers					
2	Inadequate training on crop production expansion					
3	Inadequate access to information on crop adjustment strategies for farmers					
4.	Government's limited plan for climate risk management					
5	Farming land far away from farmers' houses					
6.	Inadequacy of climate projection technology					
7.	Lack of supportive institutional facilities such as: cooperatives, education programs.					
8.	Weak information system to provide advance notice of climate change					
9	Not getting agricultural workers on time					
10.	High prices of fertilizers, seeds and agricultural commodities					
11	High price has to be paid for irrigation					
12.	The high price of buying land or renting land					
13.	Traditional perceptions of climate change					
14.	Not knowing the institutional source for agricultural production					
15.	Farmers' religious beliefs about agriculture					

16. Lack of warehouse for storage of agricultural inputs

60. Who determines the market price of agricultural produce?

1. Cooperatives □ 2. Brokers □ 3. Wholesalers 4. Retailer 5.Other ......

61. Is there an arrangement to collect agricultural produce in one place for sale?

1. Yes □ 2 No □

62. How are agricultural products distributed?

1. Individual □ 2. In group □ 3. Cooperatives □ 4. Wholesalers □ 5. Retail Traders

6. Broker □ 7. Other (mention).......

63. Does any organization help sell your product?

1. Does □ 2. Does not□ 3. little□

64. Have you received any financial or technical help for agricultural ?

1. Yes□2. No□

If so, mention i. Government organization □ ii. Co-operative □

iii. Non-governmental organization □ IV. commercial institution

v. Other (mention).......................

65. Have you visited for any kind of information or advice to expand an agricultural firm?

1. Yes □2. No□

If so, mention how many times have you visited......................

66. Did you change the agricultural techniques after the visit?

1. Changed□ 2. Not changed□

If so, specify............................

A. Impact of Climate Change on Agriculture

67. Are you aware of climate change?

1. Yes □ 2. No □ if yes, i. High temperature□ ii Low temperature □

iii. Increase of temperature □ iv Decrease of rainfall □ v. erratic rainfall □

68. Which area of the region is being most affected by the current climate change?

1. Drought □ 2. Landslide □ 3.Increase in temperature □ 4. Desertification

5. Deforestation □ 6. Other (mention) .....

69. Have you ever encountered any seasonal effects in your life / time?

1. Yes □ 2. No □ if yes, i. Drought □ ii. Flood □ iii. Increase in temperature

iv. Desertification □ v. Deforestation □ vi. Other (open).....

70. Have you seen any new diseases affecting in livestock and crops for last 10 years?

1. Saw □ 2. Did not see□

If so, when did it first appear and what is it..................

71. Crop production has changed for last 10 years

1. Yes□ 2. No □3. I don't know□

72. Have you found any crops in this area that are missing now?

1. Yes □2 No □3. I don't know□

If yes, mention you know.................................

73. Can you predict the next season?

1. Yes □2. No □ If you predict,

1. Looking at the past season (time)□.2. Consulting a weather expert □

3. Radio / TV Also.□4. Internet□5.Other (mention)………..

74. Have you seen catastrophic events due to climate change?

1. Yes □ 2. No□ If so, specify.......................

75. Due to climate change, people have migrated from this municipality?

l Yes □ 2. No □ If yes, i. Very □ ii medium□ iii. A little□

76. Have you experienced extreme / unusual weather events, such as: floods, waves, droughts? 1. yes □2. No□

If yes, i. Heavy rains caused flood□ ii. The ground was inundated due to heavy rains□ iii. Drought□ iv. Don't know □ v. Other (mention)………..

77. Have you been told by an official about the event of a flood or drought?

1. Yes □. 2. No□

78. How climate change has affected to you?

i. Damage to property □ii. Damage to livestock □ iii. Deficit in agricultural production□ iv. Decrease in remittance□ v. increase in health risks □vi. Lack of drinking water □

vii. Do not know□ viii. Other (mention)........................

79. Have you ever attended consultations, meetings, seminars on climate change?

1. Yes□2. No□ If yes i. Government level □ ii. NGO level □ iii. United Nations □ iv. European Union □ v. Don't know □ vi. Other (mention) ………

80. How would you like to get information about climate change?

i .Radio / TV □ ii. Educational Institutions □ iii .News □ iv .Internet

v. Religious Institutions □ vi. Neighbors / friends □ vii. Posters / pamphlets / brochures viii. People who lead society □ ix. Other (open)................

Section D: Climate Change Adaptive Strategies

81. People can change themselves according to the climate change.

1. Yes □ 2. No □ 3. I don't know□

82. Have you participated in trainings for capacity and skill development?

1.Yes □2. No□ If yes , fill in the details below:

Training / Workshop / Risk Reduction Duration of Training

Training Name

83. Do you have traditional knowledge of adaptive to climate change?

1.Yes□2. No□ If yes mention it............................

84. Do you have the technical knowledge to produce crops according to time?

1. Yes□2. No□ If yes, mention how:

85. How do you adaptiveto climate change for long-term?

1. By changing the planting time □ 2. By changing the species of plants □

3. By additional irrigation □ 4. Other (mention) ....

86. Are you insured to reduce the damage caused by climate change?

1. Yes□ 2. No□ If yes, give the details below:

Category	Time of period	Nrs	When	Remarks
Food crops				
Cash crops				
Poultry farming				
Livestock				
Floriculture				
Mushroom				
Others (specify)				

87. Have you used cope with climate change in the past?

1. Yes 2□. No□

If yes, mention: i. By planting □iii. By cutting down trees□ iii. By constructing wells / or other water sources□ iv By closing water taps / pipes when not in use □ vi. By helping to create green spaces like parks or gardens□ vii. Nothing□ viii. Other (mention) ……………..

88. Have you helped any organizations for agricultural production?

1.Yes □ 2. No□ If yes , i. Federal government □ ii. Province government □ iii Local government □ iv Non-governmental organization □ v. International non-government organization □ vi. Other (mention)……

89. Do you think the practice of agricultural production has changed for past (10 years) to till?

1. Yes □ 2. No□ If yes, mention…………………………………

90. Do you produce different crops in at a time?

1. Yes □ 2. No □ If yes, mention crop type...........................

91. Do you know what is a commercial farming system ?

1. Yes□ 2. No□ If yes , what is ?................................

92. Have you experienced in tunnel farming.

1. Yes□ 2. No□ If yes, mention it.................

93. Do you know about organic farming products?

1.Yes □2. No□ If yes, mention.................

94. Did you know that off-seasonal agricultural products?

1. Yes□2. No□ If so, what? ....

95. Do you use any new strategies at a present time to adapt to climate change?

1. Yes □ 2. No □ 3. I don't know□ If you do, open...................

96. Which of the following organizations do you think should help in future for adaptive of climate change?

1. Government of Nepal □ 2. Non-governmental organizations □ 3.European Organization 4. United Nations □ 5. Other (open)....

97 . What strategies do you use to mitigate the effects of climate change?

1. To change the type of crop. 2. To change the seed of animal 3. Greenhouse □ 4. agroforestry□ 5. Change the animal species 6. Water collection □ 7. Other ..

98 . Have you planted new plants to adjust to the climate change?

1. Yes □2. No□ If yes, how many plant have you planted? ....

99. Now you have made the shadow of the tree to save the plants?

1. Yes□2. No□ If yes , when did you start?..........................

100. Have you changed the land of planting crops

1.Yes □ 2. □ If yes, when and how many areas ? ....

101. Have you fragments the land?

1.Yes □ 2. No □ If yes, how many pieces.............

102. Adaptation strategies of Panchkhal Municipality Tick (√) in the appropriate

S.N.	Practices	SD	D	U	SA	A
102.1	Multiple crops types					
102.2	Divide the land into small pieces					
102.3	Practice of multiple alternative land use					
102.4	Increase of irrigation system					
102.5	Employment other than farming					
102.6	To increase the productivity of agriculture					
102.7.	Use of chemical fertilizers					
102.8.	To use of organic fertilizers					
102.9	To use of organic crops					
102.10	Planting new plants					
102.11	Shading the plants					
102.12	Mulching					
102.13.	Changing the size of land for crop production					

103. Are you trying to adapt to the current climate change?

1. Yes □2. No□ If yes, mentions 1. By changing the planting date □ 2. By changing the crop types

3. By changing the species □ 4. By changing from crop to animal husbandry

5. By converting livestock to crops □ 6. By reducing the number of livestock

7. By cutting down the cultivated land. 8.By increasing the cultivated land

9. Use of water conservation technology. 11. Change the irrigation method

12. By shading the plants □ 13. By religious beliefs or prayers

14. By changing the use of chemical fertilizers and pesticides

104. Fill in the details of the main crop before and after using pesticides in agricultural production (give details of at least 5 years).

Crop type	Agricultural production before application of pesticides (KG, Ropani)	Agricultural production after application of pesticides (KG, Ropani)

105.Do you know what causes insects to infest crops?

1. Yes □2. No□ If yes, 1.High rainfall □ 2. Low rainfall □ 3. High temperature □ 4.Low temperature □ 5.Irregular rainfall □ 6.Drought □ 7. Other (open).....

106. What is the tendency of insects to infest in agriculture production?

1. Decreasing □2.Increasing 3.No change □4. Don't know □

107. Do you know about urbanization?

1. Yes □ 2.No□ 3. Don't know□ If yes, mention..

108. How many small industries are there in this area now?

1. 1-5 □ 2. 6-10 □ 3. More than 10 □

109. How many medium industries are there in this area?

1. 1 - 5 □ 2. 6-10 □ 3. More than 10 □

110. How many large scale industries are there in this area?

1. 1 - 5 □ 2. 6-10 □ 3. More than 10□

111. What is the condition of agricultural land now than 10 years ago?

1. Agricultural land has not changed □ 2. Agricultural land has changed

3. I don't know□

112. What is the number of people engaged in agriculture and non-agriculture in this area?

1. Agriculture □ 2. Non-agriculture □ 3. I don't know □

113. What is the condition of agricultural production for10 years ago and till?

1. Decreased □2. increased □ 3. stable □ 4. Don't know□

114. What are the problems that increased due to changing from rural to urban areas?

1. Yes □ 2. No □ 3. Undecided □

If yes, i. Road □ ii. Electricity □ iii. Education □ iv. Water □ v. Garbage management vi. Administrative work □ vii. Other (open) ......

115. Have you sold land for urbanization?

1.Yes□2. No□3. Undecided □

116. What is the condition of your land 10 years ago and now?

1. Decreased 2. Increased □ 3. Constant □ 4. Don't know□

Appendix B: Key Informant Interview Guideline

Name………………………………Wardno………Contact No……………………

Gender: ……………Age: …………Occupation…………..

Educational Qualification: ……………………Marital Status………………….

Number of families: male: female:

1. Do you have any other source of income besides agriculture?

1.yes□2. No□

If yes, what....................?

2. What percentage do you spend per year on agriculture? (Estimated)

....

3. Do you have your own land?

1. Yes □ 2. No□

If yes, mention it......................

4. How many months does your product last?

....

5. How much livestock do you have?

1. Buffalo □ 2. Cow 3. Goat □ 4. Chicken □ Other (Open)..................

6. Have you faced problems related to climate change?

1.Yes□ 2. No□ If yes , specify ....

7. Have you observed any new diseases in crops and animal husbandry for the last 10 years?

1. Yes □ 2. No□ If yes, when did you see first time? ....

8. What types of seeds (hybrid and traditional) do you use in agriculture and where do you get them
from? ………………………………………………………………………..

9. What are the main risk factors for climate change in agriculture?

....

10 What kind of effects do you see on climate change?

………………………………………………………………………

11What strategies have you used to mitigate the effects of climate change?

…………………………………………………………………

11. Do you know how the government organization and NGOs are playing a role in mitigating the effects of climate change?

....

12. Have you experienced any types of catastrophic climate change?

1. Yes□2.No□ Mentio if...

13 Do you have any major problems / obstacles in agricultural production related to production technology?

1. Yes□2.No□ Mention if...................

14. In your opinion, what are the reasons for selling agricultural land?

....

15. Do you have any plans to increase agricultural production?

....

16. What are the main barriers to agriculture in the municipality?

....

17. What is the impact of migration from rural areas to urban areas on agriculture?

....

18. Has land production changed since you started farming for 10 years?

....

19. What are obstacles you face in managing your land?

....

20. What is the effect of the supply of fertilizer, seed, and pesticides/ insecticides on agriculture production ?

....

KII for Agricultural Service Providers

Name……………………………………………Organization…………………………..:

Occupation…………………. Contact No……………………………..

1. How do you see the effect of climate change?

....

2. What is the effect of climate on agriculture?

....

3. What are the effects of climate change on livelihood in Panchkhaal municipality?

....

4. What are the main challenges farmers' faces, and how can these be solved?

....

5. What efforts is your organization making at the local level to address issues related to social and economic change caused by climate change?

....

6. In your experience, what practical actions can help address climate change?

1. Extension of service 2. Transfer of knowledge 3. Technical Assistance □
4. Increase in income opportunities □ 5. Debt Management □ 6. Other ..

7. What kind of farmers are benefiting from the services of your organization?

....

8. What are farmers doing to adapt to climate change?

....

9. What kind of improved adaptive strategies has your organization adopted in area?

....

10. In your experience, what is the perception of local farmers on climate change?

....

11. Based on your experience, how are local farmers tackling climate change issues?

....

KII for Local Government Representatives

Name: .... Position……….. Profession: ....

1. In your experience, what are the elements of climate change affecting agriculture?

....

2. Do you see any signs of climate change in this area?

   1. Yes ☐ 2 No ☐ Mention if yes..

3. What are the effects of variability and climate change on agriculture in this region?

....

4. In experience, what is a more responsible for climate change in this municipality?

....

5. What local adaptation strategies help reduce the impact of climate change on agriculture?

....

6. Which organizations are working to reduce the impact of climate change on the future?

....

7. In your experience, how are local governments tackling issues related to climate change?

....

8. Do you have any plan to protect agricultural land from urbanization?

....

9. What is the impact of agricultural land shifting from rural to urban area? ....

10. In your experience, how is rapid urbanization affecting natural resources?

....

11. Any organization has made any management to give some grants or loans to the farmers here?

....

12. In your experience, how does construction affect agricultural production? ....

13. What are the main obstacles in the agricultural sector of this municipality?

....

14. Are you thinking about the urbanization plan? |

....

15. Which wards are rapid urbanization and Why...

Appendix C: FGD Guideline

Name: ....Ward no.....................

1. In your experience, what are the elements of climate change affecting agriculture?

....

2. Do you see any signs of climate change in this area?

1. Yes ☐ 2 No ☐ Mention if yes..

3. What are the main effects of variability and climate change on agriculture in this region?

....

4. In your experience, what is the main factor of climate change in this municipality?

....

5. What adaptive strategies have local governments adopted to reduce the impact of climate change on agriculture?

....

6. Based on your experience now, how are local governments addressing issues related to climate change?

……………………………………………………………………………………..

7. What do you think organizations should do to reduce the impact of climate change in the future?

....

8. Has this municipality made any plans to protect agricultural land from urbanization?

....

9. How has the migration from rural areas to cities affected your municipality?

....

10. In your experience, how is rapid urbanization affecting natural resources?

....

11. Which organizations are working to reduce climate change, and what actions are they taking?

....

12. Are you thinking anything about the urbanization plan? |

....

13. Which wards are rapid urbanization and Why?

……………………………………………………………………………………

14. Do you use cash or food more, and why?

………………………………………………………………………………………

Appendix D: Rainfall of Panchkhal Municipality 1980-2020 (mm) (Station.1036)

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/1980	0	01/01/1981	12.2	01/01/1982	7.5	01/01/1983	17.8
02/01/1980	17.9	02/01/1981	1	02/01/1982	27.9	02/01/1983	4.8
03/01/1980	16.7	03/01/1981	19.7	03/01/1982	20.7	03/01/1983	18
04/01/1980	7.2	04/01/1981	50.8	04/01/1982	49.4	04/01/1983	68.6
05/01/1980	122.5	05/01/1981	176.2	05/01/1982	41.2	05/01/1983	102.5
06/01/1980	268.7	06/01/1981	142.5	06/01/1982	189.2	06/01/1983	36.2
07/01/1980	307	07/01/1981	237.9	07/01/1982	250.5	07/01/1983	366.9
08/01/1980	255.4	08/01/1981	242.1	08/01/1982	389	08/01/1983	213
09/01/1980	126.3	09/01/1981	215	09/01/1982	199	09/01/1983	101.5
10/01/1980	8.1	10/01/1981	1	10/01/1982	12.5	10/01/1983	113.2
11/01/1980	0	11/01/1981	8.8	11/01/1982	29	11/01/1983	0
12/01/1980	3.7	12/01/1981	0	12/01/1982	0.3	12/01/1983	0
	1133.5		1107.2		1216.2		1042.5
Average	94.45		92.26		101.35		86.87

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/1984	19.2	01/01/1985	10.5	01//1986	0	01/01/1987	0
02/01/1984	19.6	02/01/1985	4.5	02/1986	3.8	02/01/1987	6
03/01/1984	7.1	03/01/1985	0	03/1986	2.8	03/01/1987	6
04/01/1984	57.2	04/01/1985	21.9	04//1986	93.5	04/01/1987	23.5
05/01/1984	104.2	05/01/1985	170.7	05/1986	116.3	05/01/1987	48.5
06/01/1984	146.2	06/01/1985	138.6	06/1986	16	06/01/1987	30
07/01/1984	258	07/01/1985	393.4	07/1986	-	07/01/1987	-
08/01/1984	229.6	08/01/1985	274.9	08/1986	390.3	08/01/1987	-
09/01/1984	287.8	09/01/1985	373.2	09/1986	219	09/01/1987	-
10/01/1984	12.5	10/01/1985	217.8	10/1986	88.4	10/01/1987	-
11/01/1984	2.9	11/01/1985	0	11/1986	0	11/01/1987	-
12/01/1984	8.4	12/01/1985	57.3	12/1986	50	12/01/1987	-
	1152.7		1662.8		980.5		234
	96.05				81.7		39

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/1988	0	01/01/1989	51.5	01/01/1990	0	01/01/1991	23
02/01/1988	25.3	02/01/1989	7.4	02/01/1990	34.7	02/01/1991	8.9
03/01/1988	91.2	03/01/1989	16.9	03/01/1990	36.1	03/01/1991	62.3
04/01/1988	47.2	04/01/1989	2.5	04/01/1990	51.5	04/01/1991	10.7
05/01/1988	111.3	05/01/1989	121.8	05/01/1990	177.7	05/01/1991	140.5
06/01/1988	173.4	06/01/1989	116	06/01/1990	190.9	06/01/1991	172.6
07/01/1988	228.8	07/01/1989	311.7	07/01/1990	267.1	07/01/1991	183.3
08/01/1988	341.1	08/01/1989	266.4	08/01/1990	268.7	08/01/1991	290.1
09/01/1988	152.1	09/01/1989	254.5	09/01/1990	43.5	09/01/1991	163.9

10/01/1988	10.5	10/01/1989	2.4	10/01/1990	42.3	10/01/1991	0
11/01/1988	8.8	11/01/1989	0	11/01/1990	0	11/01/1991	0
12/01/1988	69.6	12/01/1989	0	12/01/1990	0	12/01/1991	13
					1212		1068.3
	81.70		95.92		101.04		89.05

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/1992	8	01/1993	10.5	01/01/1994	-	01/1995	0
02/01/1992	23.5	02/1993	18.5	02/01/1994	-	02/1995	31.4
03/01/1992	0	03/1993	27.1	03/01/1994	8	03/1995	10.2
04/01/1992	9.8	04/1993	54.1	04/01/1994	11	04/1995	3
05/01/1992	21.6	05/1993	97.5	05/01/1994	79	05/1995	85.1
06/01/1992	125	06/1993	187.2	06/01/1994	239.3	06/1995	316.8
07/01/1992	223.9	07/1993	265.1	07/01/1994	283.4	07/1995	408.6
08/01/1992	260.5	08/1993	291.5	08/01/1994	306.2	08/1995	217.7
09/01/1992	144.1	09/1993	80.8	09/01/1994	226.4	09/1995	77
10/01/1992	33.7	10/1993	16	10/01/1994	0	10/1995	34
11/01/1992	24	11/993	7.6	11/01/1994	15.2	11/1995	87.8
12/01/1992	8	12/1993	0	12/01/1994	1	12/1995	7
	882.1		1055.9		1169.5		278.6
	73.50		87.99		116.95		106.55

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/1996	63.8	01/01/1997	19.3	01/01/1998	0	01/01/1999	0
02/01/1996	13.3	02/01/1997	10.5	02/01/1998	23.3	02/01/1999	34.7
03/01/1996	11	03/01/1997	13.4	03/01/1998	96.6	03/01/1999	36.1
04/01/1996	7.2	04/01/1997	110.9	04/01/1998	74.5	04/01/1999	51.5
05/01/1996	58.4	05/01/1997	77.7	05/01/1998	154.1	05/01/1999	177.7
06/01/1996	249.2	06/01/1997	194.3	06/01/1998	176.7	06/01/1999	190.9
07/01/1996	331.5	07/01/1997	405.2	07/01/1998	332.5	07/01/1999	267.1
08/01/1996	355.5	08/01/1997	246	08/01/1998	328	08/01/1999	268.7
09/01/1996	38.1	09/01/1997	46	09/01/1998	160.3	09/01/1999	143.5
10/01/1996	40	10/01/1997	20.5	10/01/1998	40.4	10/01/1999	42.3
11/01/1996	9.4	11/01/1997	2.4	11/01/1998	10.5	11/01/1999	0
12/01/1996	0	12/01/1997	67.4	12/01/1998	0	12/01/1999	0
	1177.4		1213.6		1395		1212.5
	98.11		101.13		116.32		101.04

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/2000	0	01/01/2001	0	01/2002	15.9	01/01/2003	21.7
02/01/2000	0	02/01/2001	0	02/2002	23.3	02/01/2003	71.5
03/01/2000	0	03/01/2001	0	03/2002	3.5	03/01/2003	42.5
04/01/2000	15.2	04/01/2001	9.7	04/2002	29	04/01/2003	44.9
05/01/2000	175.9	05/01/2001	165.3	05/2002	117	05/01/2003	86.8
06/01/2000	236.7	06/01/2001	238.2	06/2002	161.7	06/01/2003	188.7
07/01/2000	335.3	07/01/2001	246.8	07/2002	263.5	07/01/2003	396
08/01/2000	297.5	08/01/2001	329.4	08/2002	456.7	08/01/2003	294.8
09/01/2000	131	09/01/2001	194.3	09/2002	169.4	09/01/2003	199.2
10/01/2000	33.3	10/01/2001	43.5	10/2002	43.9	10/01/2003	5.1
11/01/2000	0	11/01/2001	0	11/2002	19.4	11/01/2003	0
12/01/2000	0	12/01/2001	0	12/2002	0.7	12/01/2003	17
	1224.9		1217.5		1304		1368.2
	95.36		102.26		108.66		114.04

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/2004	13.5	01/2005	46	01/01/2006	0	01/01/2007	0
02/01/2004	0.6	02/2005	-	02/01/2006	0	01/01/2007	58.8
03/01/2004	-	03/2005	-	03/01/2006	6.6	01/01/2007	31.2
04/01/2004	56.1	04/2005	53.5	04/01/2006	85.4	01/01/2007	82.2
05/01/2004	120.5	05/2005	89.4	05/01/2006	86.1	01/01/2007	81.5
06/01/2004	162.5	06/2005	186.3	06/01/2006	153.3	01/01/2007	199
07/01/2004	395.5	07/2005	342.8	07/01/2006	253.8	01/01/2007	154.7
08/01/2004	186	08/2005	73.3	08/01/2006	208	01/01/2007	185.5
09/01/2004	212.5	09/2005	75.6	09/01/2006	131.6	01/01/2007	323.9
10/01/2004	61.5	10/2005	20.8	10/01/2006	46.1	01/01/2007	19
11/01/2004	0	11/2005	0	11/01/2006	2	01/01/2007	3
12/01/2004	0	12/2005	0	12/01/2006	20	01/01/2007	0
	1208.7		887.7				1138.8
	116.32		88.77				94.9

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/2008	1	01/01/2009	0	01/01/2010	0	01/01/2011	0.8
02/01/2008	0	02/01/2009	0	02/01/2010	0	02/01/2011	43.5
03/01/2008	13.7	03/01/2009	25.5	03/01/2010	30	03/01/2011	6.6
04/01/2008	35.2	04/01/2009	5	04/01/2010	40	04/01/2011	41.4
05/01/2008	53	05/01/2009	119.5	05/01/2010	201.3	05/01/2011	188.1
06/01/2008	208	06/01/2009	165.9	06/01/2010	205	06/01/2011	276.9
07/01/2008	115.9	07/01/2009	227	07/01/2010	330	07/01/2011	309.9
08/01/2008	177.8	08/01/2009	227.7	08/01/2010	227	08/01/2011	0

09/01/2008	5	09/01/2009	104.5	09/01/2010	110	09/01/2011	211.4
10/01/2008	100	10/01/2009	53	10/01/2010	60.4	10/01/2011	5.7
11/01/2008	0	11/01/2009	0.5	11/01/2010	0	11/01/2011	20.4
12/01/2008	0	12/01/2009	0	12/01/2010	0	12//01/2011	-
	709.6		928.6		1213.53		1104.7
	64.45		7.38		101.13		92.04

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/01/2011	0.8	01/2012	12.1	01/01/2013	8.2	01/01/2015	3.7
02/01/2011	43.5	02/2012	21.9	02/01/2013	2.2	02/01/2015	21.2
03/01/2011	6.6	03/2012	1.2	03/01/2013	11.8	03/01/2015	61.3
04/01/2011	41.4	04/2012	72.1	04/01/2013	145.2	04/01/2015	56.2
05/01/2011	188.1	05/2012	24.1	05/01/2013	267.6	05/01/2015	8
06/01/2011	276.9	06/2012	89.4	06/01/2013	215.9	06/01/2015	55.9
07/01/2011	309.9	07/2012	249.5	07/01/2013	114.9	07/01/2015	158.1
08/01/2011	0	08/2012	164.4	08/01/2013	107.9	08/01/2015	216.2
09/01/2011	211.4	09/2012	162.9	09/01/2013	-	09/01/2015	39.9
10/01/2011	5.7	10/2012	1	10/01/2013	-	10/01/2015	79.2
11/01/2011	20.4	11/2012	0	11/01/2013	0	11/01/2015	0
	1104.7	12/2012	0	12/01/2013	0	12/01/2015	0
	92.04		798.6		894.5		699.7
			66.55		89.45		58.3

Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall	Year	Rainfall
01/2016	0	01/2017	31	1/2018	8.5	1/2019	15	1/2020	32.3
02/2016	0	02/2017	0	2/2018	1.9	2/2019	47.5	2/2020	19.2
03/2016	0	03/2017	65.7	3/2018	61.4	3/2019	6.9	3/2020	14.5
04/2016	0	04/2017	63	4/2018	80.3	4/2019	118.3	4/2020	68.3
05/2016	84.2	05/2017	117	5/2018	120.3	5/2019	38.6	5/2020	127.3
06/2016	0	6/2017	107.5	6/2018	137.4	6/2019	123.9	6/2020	149.6
7/2016	375.2	7/2017	224.57	7/2018	211.5	7/2019	354.8	7/2020	377.8
08/2016	127.7	08/2017	230.6	8/2018	281.3	8/2019	337.6	8/2020	188.6
9/2016	201.5	9/2017	121.6	9/2018	77.2	9/2019	323.5	9/2020	217.8
10/2016	67.8	0/2017	74.7	10/2018	4.1	10/2019	39.7	10/2020	0
									0
11/2016	0	11/2017		-11/2018	0	11/2019	0	11/2020	0
			0						0
12/2016	0	12/2017	0	12/2018	0	12/2019	15.6	12/2020	0
									0
	856.4		1035.6		983.9		1330.4		1195.4
	71.36		86.33		81.99		110.86		99.61

Appendix E: Temperature of Panchkhal Municipality since 1980-2020

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/01/1980	21.28	01/01/1981	21.26	01/01/1982	18.62	01//1983	18.91
02/01/1980	24.46	02/01/1981	3.36	01/01/1982	24.71	02//1983	22.1
03/01/1980	27.87	03/01/1981	21.78	01/01/1982	27.66	03//1983	30.34
04/01/1980	33.46	04/01/1981	29.65	01/01/1982	30.81	04//1983	28.87
05/01/1980	31.28	05/01/1981	30.42	01/01/1982	33.49	05//1983	33.35
06/01/1980	34.03	06/01/1981	9.35	01/01/1982	32.19	06//1983	30.41
07/01/1980	30.46	07/01/1981	0.03	01/01/1982	32.36	07//1983	32.5
08/01/1980	31.61	08/01/1981	0.62	01/01/1982	29.79	08//1983	1.84
09/01/1980	28.39	09/01/1981	9.11	01/01/1982	30.67	09//1983	1.62
10/01/1980	28.4	10/01/1981	7.01	01/01/1982	6.81	10//1983	7.74
11/01/1980	24.09	11/01/1981	2.94	01/01/1982	21.59	11//1983	23.34
12/01/1980	22.52	12/01/1981	1.11	01/01/1982	19.66	12//1983	17.35
	337.85		316.64		328.4		328.37
Average	28.15		26.38		27.36		27.36

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/1984	20.44	01//1985	21.97	01/1986	23.4	01/1987	23.19
02/1984	6.15	02/1985	4.73	02/1986	25.04	02/1987	2.91
03/1984	31	03//1985	31.87	03/1986	33.58	03/1987	30.15
04/1984	29.48	04/1985	32.47	04/1986	29.57	04/1987	26.43
05/1984	32.1	05/1985	35.89	05/1986	31.54	05/1987	33.66
06/1984	31.95	06/1985	31.27	06/1986	31.44	06/1987	-
07/1984	29.67	07/1985	31.43	071986	-	07/1987	-
08/1984	31.07	08/1985	31.85	08/1986	27.81	08/1987	-
09/1984	30.46	09/1985	28.6	09/1986	23.18	09/1987	-
10/1984	27.59	10/1985	25.86	10/1986	17.94	10/1987	-
11/1984	23.46	11/1985	23.27	11/1986	75.21	11/1987	-
12/1984	17.5	12/1985	17.3	12/1986	1.71	12/1987	-
	330.87		336.51		275.21		138.34
	27.57		28.05		22.93		27.66

Yeat	Temp	Year	Temp	Year	Temp	Year	Temp
01/1988	21.12	01/1989	21.31	01/1990	25.48	01/1991	22.98
02/1988	24.18	02/1989	27.45	02/1990	20.27	02/1991	26.82
03/1988	28.72	03/1989	25.71	03/1990	26.85	02/1991	28.9
04/1988	31.31	04/1989	32.08	04/1990	30.36	04/1991	32.2
05/1988	30.75	05/1989	30.07	05/1990	32.29	05/1991	31.7
06/1988	33.57	06/1989	31.87	06/1990	32.75	06/1991	33.19
07/1988	31.62	07/1989	26.98	07/1990	30.13	07/1991	31.26

08/1988	30.41	08/1989	32.45	08/1990	32.65	08/1991	31.37
09/1988	31.78	09/1989	27.42	09/1990	31.03	09/1991	31.69
10/1988	28.32	0/1989	27.93	10/1990	27.05	10/1991	28.41
11/1988	25.77	11/1989	23.31	11/1990	24.9	11/1991	23.29
12/1988	21.25	12/1989	20.18	12/1990	19.93	12/1991	19.62
	338.8		326.76		333.69		340.43
	28.33		27.23		27.80		28.36

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/1992	22.9	01/1993	23.03	01/1994	-	01/1995	21.12
02/1992	24.41	02/1993	24.43	02/1994	-	02/1995	23.73
03/1992	31.24	03/1993	27.43	03/1994	28.41	03/1995	29.65
04/1992	33.18	04/1993	31.07	04/1994	30.72	04/1995	35.45
05/1992	34.73	05/1993	31.55	05/1994	33.19	05/1995	35.34
06/1992	33.07	06/1993	31.62	06/1994	32.83	06/1995	31.98
07/1992	31.02	07/1993	31.09	07/1994	30.94	07/1995	30.19
08/1992	32.6	08/1993	30.48	08/1994	32.45	08/1995	32.73
09/1992	27.44	09/1993	30.83	09/1994	30.8	09/1995	30.31
10/1992	28.67	10/1993	28.35	10/1994	28.32	10/1995	29.55
11/1992	23.69	11/1993	25.18	11/1994	21.67	11/1995	33.97
12/1992	20.81	12/1993	23.73	12/1994	20.06	12/1995	21.59
	343.76		338.79		289.39		345.61
	28.64		28.23		28.39		28.8

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01//1996	22.31	01/1997	20.28	01/1998	-	01//1999	22.28
02/1996	26.56	02/1997	22.77	02/1998	-	02//1999	26.99
03/1996	31.92	03/1997	24.15	03/1998	-	03//1999	28.82
04/1996	31.06	04/1997	28.2	04/1998	28.07	03//1999	35.9
05/1996	34.06	05/1997	31.27	05/1998	34.17	04//1999	34.22
06/1996	27.3	06/1997	28.47	06/1998	32.77	05//1999	30.4
07/1996	32.85	07/1997	33.58	07/1998	31.7	06//1999	30.54
08/1996	30.29	08/1997	31.85	08/1998	28.72	07//1999	29.8
09/1996	30.79	09/1997	30.36	09/1998	30.96	08/1999	29.84
10/1996	28.74	10/1997	26.68	10/1998	28.39	09//1999	28.95
11/1996	24.04	11/1997	22.78	11/1998	25.64	10//1999	25.7
12/1996	23.05	12/1997	20.24	12/1998	21.043	12//1999	20.58
	342.9 7		320.63		261.65		343.39
	28.54		28.64		29.94		28.61

Year	Temp	Year	Temp	Year	Temp	Temp	Temp
01/2000	21.36	01//2001	23.86	01/2002	19.87	01/2003	19.18
02/2000	21.65	02//2001	25.67	02/2002	23.59	02/2003	24.1
03/2000	31.48	03/2001	31.42	03/2002	26.65	03/2003	28.26
04/2000	33.36	04/2001	32.25	042002	28.79	04/2003	28.02
05/2000	31.49	05//2001	31.65	05/2002	29.9	05/2003	34.03
06/2000	30.5	06//2001	33.31	06/2002	30.61	06/2003	30.7
07/2000	30.22	07/2001	29.48	07/2002	31.68	07/2003	31.14
08/2000	29.9	08//2001	31.96	08/2002	32.48	08/2003	32.19
09/2000	30.46	09/2001	31.78	09/2002	30.81	09/2003	28.81
10/2000	29.44	10/2001	29.21	10/2002	27.51	10/2003	29.62
11/2000	23.8	11/001	23.67	11/2002	25.37	11/2003	22.93
12/2000	21.77	12/2001	21.08	12/2002	16.97	12/2003	17.77
	335.4		345.34		324.23		326.75
	27.94		28.77		27.01		27.22

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/2004	18.93	1/2005	17.42	01/2006	23.44	01/2007	23.31
02/2004	28.49	2/2005	-	02/2006	31.23	02/2007	23.73
03/2004	29.83	3/2005	-	03/2006	30.3	03/2007	33.03
04/2004	31.19	4/2005	24.05	04/2006	33.47	04/2007	30.97
05/2004	33.19	5/2005	27.9	05/2006	33.08	05/2007	35.74
06/2004	31.37	6/2005	37.64	06/2006	32.44	06/2007	32.91
07/2004	32.15	7/2005	33.25	07/2006	33.19	07/2007	30.91
08/2004	29.9	8/2005	34	08/2006	31.46	08/2007	28.44
09/2004	26.93	9/2005	32.24	09/2006	32.23	09/2007	27.51
10/2004	24.59	10/2005	31.94	10/2006	27.47	10/2007	27.78
11/2004	17.42	11/2005	37.31	11/2006	23.16	11/2007	25.29
12/2004	-	12/2005	21.1	12/2006	21.55	12/2007	21.05
	305.79		296.85		353.02		340.67
	27.8		29.7		29.41		28.4

Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/2008	17.03	01/2009	25.88	01/2010	-	01/2011	21.81
02/2008	24.98	02/2009	27.01	02/2010	-	02/2011	27.31
03/2008	30.31	03/2009	29.62	03/2010	-	03/2011	27.35
04/2008	34.12	04/2009	35.03	04/2010	-	04/2011	23.1
05/2008	34.19	05/2009	30.88	05/2010	-	05/2011	30.03
06/2008	30.49	06/2009	31.56	06/2010	33.51	06/2011	29.91
07/2008	32.85	07/2009	29.56	07/2010	-	07/2011	30.31
08/2008	28.74	08/2009	33.21	08/2010	--	08/2011	-

09/2008	28.24	09/2009	32.59	09/2010	-	09/2011	31.12
10/2008	30.06	10/2009	29.63	10/2010	-	10/2011	26.84
11/2008	27.54	11/2009	25.04	11/2010	-	11/2011	25.51
12/2008	22.1	12/2009	-	12/2010	-	12/2011	22.92
	339.65		330.01				296.21
	28.3		30.0				26.9

Year	Temp.	Year	Temp.	Year	Temp.	Year	Temp.
01/2012	21.97	01/2013	24.24	01/2014	25.14	01/2015	21.46
02/2012	27.24	01/2013	29.29	02/2014	24.86	02/2015	26.15
03/2012	31.48	01/2013	28.71	03/2014	-	03/2015	21.19
04/2012	33.12	01/2013	31.9	04/2014	-	04/2015	-
05/2012	34.71	01/2013	33.55	05/2014	-	05/2015	-
06/2012	33.51	01/2013	31.62	06/2014	-	06/2015	-
07/2012	33.21	01/2013	-	07/2014	-	07/2015	-
08/2012	32.94	01/2013	-	08/2014	30.35	08/2015	32.6
09/2012	33.28	01/2013	31.84	09/2014	26.48	09/2015	30.35
10/2012	29.31	01/2013	27.02	10/2014	32.72	10/2015	26.48
11/2012	29.97	01/2013	25.77	11/2014	23.59	11/2015	21.09
12/2012	22.13	01/2013	21.35	12/2014	22.94	12/2015	22.31
	362.87		285.29		185.05		201.63
	30.24		28.53		30.85		33.6

Year	Temp	Year	Temp	Year	Temp	Year	Temp	Year	Temp
01/2016	20.89	01/2017	25.57	01/20218	20.41	01/2019	21.95	01/2020	21.73
02/2016	27.48	02/2017	25.97	02/20218	28.26	01/2019	20.17	02/2020	24.66
03/2016	28.87	03/2017	28.96	03/20218	28.65	01/2019	30.99	03/2020	30.93
04/2016	36.13	04/2017	31.42	04/20218	27.61	01/2019	33.59	04/2020	28.8
05/2016	30.13	05/2017	32.18	05/20218	31.18	01/2019	32.2	05/2020	29.52
06/2016	32.73	06/2017	33.38	06/20218	31.95	01/2019	34.28	06/2020	31.89
07/2016	28.34	07/2017	32.82	07/20218	31.79	01/2019	33.03	07/2020	31.29
08/2016	33.64	08/2017	33.35	08/20218	32.56	01/2019	33.65	08/2020	33.75
09/2016	30.76	09/2017	32.15	09/20218	33.02	01/2019	28.59	09/2020	32.58
10/2016	28.96	10/2017	26.07	10/20218	30.67	01/2019	27.53	10/2020	31.34
11/2016	25.95	11/2017	23.8	11/20218	25.62	01/2019	24.09	11/2020	25.05
12/2016	23.49	12/2017	-	12/20218	21.25	01/2019	21.16	12/2020	21.08
	347.37		325.67		342.97		341.23		342.62
	28.9		29.6		28.58		28.43		28.56

Appendix F: Status of Community Forest

S.N.	Name of community forest	Ward no.	Covering area (in hector)
1	Alchhedudha Holka	1	16
2	Simle lamidanda	1	137.8
3	Tiratire	1	58.5
4	Madan devi	1	36.25
5	Juke tatha chimse	1	37.1
6	Mayal danda	1	31.65
7	Tundi danda	1	7.00
8	Kaki khop	2	41.75
9	Tanke	2	21.50
10	Jaamunbote	2	75.75
11	Mankalekanthesote	2	55.8
12	Aanparumti bigne	2	35.6
13	Kaalidaha	2	27.0
14	Laihking Ghyaanle (Female)	2	179.3
15	Tatale archale	2	19.20
16	Moule pokhari	2	9.04
17	Thuli (Female)	3	54.16
18	Bhainsekhola	3	138.61
19	Golmadevi	4	60.0
20	Nagdi khola	4 and 11	45.25
22	Dharapanibisauna	5	10.25
23	Dhairanipankha	5	9.745
24	Khanwako Ratomate pankha	5	108.1
25	Ratamate	5	21.25
26	Bhirawari kholathanpe	5	19.06
27	Kajiko Dhaireni	6	181.8
28	Kolako dando	6	4.75
29	Bhasme pankha	6	13.25
30	Kubhindepakha Narayasthan khatridanda	7	8.48

S.N .	Name of community forest	Ward no.	Covering area (in hector)
31	Shikharpur	7	59.41
32	Dableng hadabade kimsi	8	10.82
33	Bhuwaneshwori	8	24.62
34	Dharapani	8	11.5
35	Janata	8	25.0
36	Devisthan pandula	8	49.02
37	Niranjaladevisthan	8	17.87
38	Thuli	8	17.87
39	Ekle pankha	8	34.44
40	Chiuri ghari	8	28.0
41	Sataneshwari mahadev	9	166.93
42	Topal bhimasen	9	7.16
43	Bahalekhola	9	39.8
44	Bhanse pokhari	9	3.09
45	Belapankha	10	161.53
46	Belakholepakha	10	141.3
47	Belapakha	10	161.53
48	Mahadevsthan padherapaankha	11	27.73
49	Baskotepankha	11	11.76
50	Petare khola	11	5.50
51	Karketaar	12	60.70
52	Lamidanda	13	143.3
	Total		2737.54

Source: Municipality Profile, 2020

Appendix G: Perception of Climate Change

Variables	Response					Total
	SD	D	U	A	SA	
Climate is changing over last 3 decades	38	40	105	272	113	568
Climate change is caused by human activities	18	27	63	266	194	568
The world is issues in climate change	21	48	153	211	135	568
Global warming is rising due to climate change	23	32	76	240	197	568
Climate change is the change in average weather	14	39	204	197	114	568
Climate change is making a hole in the weight layer	20	35	181	200	132	568
Deforestation is the cause of climate change	28	60	62	226	192	568
More use of organic fertilizers is due to climate change	93	204	89	120	62	568
Pollution from industry causes climate change	27	32	106	257	146	568
Cause of poor waste management	24	58	66	210	210	568
Total	306	575	1105	2199	1495	5680
Percent	5.4	10.1	19.5	38.7	26.3	100.0

Appendix H: School Curriculum Related Climate Change

S.N.	Class/Subject- Science		
	6	7	8
1	To introduce the disaster and find ways to manage it	To introduce climate change, state its causes and identify its impact on people's lives	Introducing weather and climate and mentioning the factors that brings about changes in climate
2	Social studies		
	To introduce the disaster and find ways to manage it	To introduce climate change, state its causes and identify its impact on people's lives	Introducing weather and climate and mentioning the factors that brings about changes in climate

Science Education

2	9	10
	Explain the interrelationship of biotic and abiotic components in aquatic and terrestrial ecosystems 6.2 Introducing food chain and food web in ecological system to show the interrelationship of organisms. 6.3 To describe the types of interactions between organisms in an ecosystem	To explain the conceptual causes and effects of climate change 6.2 To find and adopt measures to reduce climate change
3	**Social Studies**	
	To identify the climate found in Nepal and analyse its impact on people's lives.	To explain the elements that influence climate, the types of climate in the world and its effects on flora, fauna and human life.
	Horticulture education	Agriculture education
	Identify the main elements of climate that affect horticulture: temperature, light, rain, relative humidity, snow, dew	- Introduction of weather and climate, introduction of the main elements that determine whether

and use them in practice.

(rain, sun, temperature, humidity, snow, clouds, hail, frost, frost), the effect of climate on plant production, division of regions of Nepal according to climate and the main plants found in those regions, seasonal Measures to protect crops from disasters.

Appendix I: Course Conducted by Lob Green Nepal

- Program objective operational process
- I.P.M. Methods, characteristics and basic needs of schools, importance
- Gender and Social Inclusion schedule creation, crop type land and land owner selection and selection of actual participants, formation of core committee nominations
- Creation of crop calendar, prioritization of construction problems, identification of main problems, determination of study tests
- Information on nursery management principles, pesticides and organic fertilizers.
- Nursery establishment, botanical construction
- Introduction to soil and composting techniques
- Seed introduction, quality and practice of organic fertilizer production
- Practices related to seeds (checking quality, hybrid and local breed racial purity, seed treatment and germination test) about Raithane seeds and seed banks
- Varietal and ethnic characteristics of cauliflower crops
- Discussing the results of seed germination test, information on grape rot disease, discussing chemical fertilizers
- Introduction of soil, type, structure, layer, quality, water holding capacity of soil, micro-organism activity, methods of soil removal, cow shed management, animal urine collection, manure management, organic gas management, soil sampling and testing.
- About test type, plot, fertilizer and micro-food plant growth.
- Land surveying and land preparation
- Animal urine collection and manure improvement and quality fertilizer making demonstration set up
- To move the berna and fix the test
- Treatment and testing of berna uprooting fixed decision, irrigation management
- To clarify the basis for agro-ecosystem analysis observations, monitoring, sample selection and trapping of agro-ecosystems.
- About the agro-ecosystem
- About life cycle and food chain
- Irrigation methods and irrigation management with drawing of dead insects
- Agro-ecosystem analysis – 1 Crop observation data collection, processing, presentation, discussion, review with question and answer and crop decision making
- Cauliflower, cabbage, broccoli, crop growth conditions sensitive to waterlogging and irrigation
- Agro-ecosystem analysis – 2 Crop observation record collection, record processing, presentation discussion, review with question and answer and crop decision making

- Information on worm houses and case studies and information on establishment tunnel farming
- Agro-ecosystem analysis – 3 Crop observation record collection, record processing presentation, review findings and crop decision making
- Pest introduction, root rot disease and leafhopper, leafhopper identification and management
- Agro Ecosystem Analysis – 4 Crop Observation Data Collection, Processing Presentation Review Decision Worm House and Case Study Study Presentation
- Detailed information about the disease, introduction of crop diseases
- Agro-ecosystem analysis – 5 crop observation record collection, processing, presentation discussion, review with question and answer and crop decision
- Agro-ecosystem analysis – 6 crop observation record collection, processing, presentation discussion, review with question and answer and crop decision presentation of worm house cup study and other tests
- Nutrition and management of internal disorders and information on major and micronutrients
- Agoute and Pachhote darduva datha Kuhine, Fedh Kuhine
- Agro-ecosystem analysis – 8 crop observation record collection, processing, presentation discussion, question and answer, review findings and decision cup study presentation of worm house and other study tests
- Information on bricklaying butterfly management lures and identification of insect damage.
- Agro-ecosystem analysis – 9 crop observation record collection, processing, presentation discussion, question and answer, review conclusions and decisions
- Agro-ecosystem analysis – 10 Crop observation record collection, processing, presentation cup study worm house and presentation of other study tests
- Information about traps and lures traps and lures
- Grouping of insects based on activity
- Effects of pesticides on friendly and hostile organisms Practice the process of reaching nutrients to other parts of the plant through the roots.
- Imaginative thinking of pesticides, self-monitoring of pesticide toxicity final ballot box test
- Sampling of crop production, measurement and weight measurement of main plots and sub-plots of study trials
- Construction of crop benefit cost study analysis table
- School report, learning achievement
- Report benefit cost presentation of Kira Ghar cup study trial

Appendix J: Other Diseases and Pesticides

Crops/ Vegetable	Diseases	Pesticides
Paddy	Wilt, False smut, Sheath blight, Brown spot, Blast of Paddy, Bacterial leaf blight, Root knot disease	Streptocycline, Streptocycline , streptomycin sulphate, tetracycline, and copper oxychloride,Bavistin, Indofil M-45 Indofil Z-78, Propiconazole
Maize	Late blight, Army insect, Turcicum Leaf Blight, (Exserohilum turcicum), Downy Mildew (Peronosclerospora spp.), Common Rust (Puccinia sorghi), Maize Streak Virus (MSV), Banded Leaf and Sheath Blight (Rhizoctonia solani)	Mancozeb, Chlorothalonil, Copper-based fungicides
Wheat	Yellow Rust (Puccinia striiformis), Leaf Blight (Bipolaris sorokiniana) Powdery Mildew (Blumeria graminis), Karnal Bunt (Tilletia indica),Loose Smut (Ustilago tritici).	Propiconazole, Tebuconazole, Chlorothalonil
Potatoes	Cutworm, Agrotis, segetum/ Agrotis ipilon, red ant White grubs,Potato tuber moth, Aphids and Myzus persicae Late blight (डडुवा) Light blight, Wart disease Brown rot/ Bacterial wilt,Common scab	Malathin, Chlorpyrifos, Bacillus thuringiensis, Dimethoate, Mankojev, Bliching powder
Cabbage	Cabbage butterfly, Diamond Back moth Flee beetle, Soil insects, Cabbage aphids	Malathin, Beauveria Bassiana EC (Myco-jaal) Cypermethrin, Fipronil,

		Nuvaluron, Deviban 10%, durswan,Fineban
Cauliflower	Altenaria Leaf Spot, Sclerotinia Stalk Black rot, Downy mildew, Club Root	Dythen M-45,Anu M-45, Hexaconazole, Flusulfamide 3%WP
Pumpkins, Cucumber, Gourd, Ghiraula, Bitter gourd	Red pumpkins beetle, Fruit flies, Powdery Mildew Downy Mildew, Mosaic Virus, Soybean hairy caterpillar, Pot bores, Helicoverpa armigera, Cowpea Aphids, Rust, Powdery mildew Mosaic virus	Malathin 50% EC,Dinocap 48% WP, Sulphur 80%WP, Thiram 75%WP, Oxychloride 50%MP, Dythen M 45, Indofil M 45, Surya M 45, Deltamethrin 2.8% EC, Cypermethrin 10% EC
Tomato	Tomato fruit worm, Tobacco Caterpiller, Whitefly, Aphids, Tomato leaf minor	Azadirecitan 0.03 % EC, Nuvaluron 10 EC,Spodo-NPV100LE,BTK,Verticillium lecani 1.15 WP, Ezadirektin 0.03% EC, Imidacloprid 17.8 SL, Chloranthraniprole 18.5%SC,Spinosad 45%SC.
Brinjal	Brinjal shoot and fruit borer (भन्टाको मुना र फलको गवारो), Brinjal leaf webber Late blight, Mosaic Virus, Leaf Curl Virus Wilt, Root Knot Nematode	Multineem, Nimbecidine, Emamectin benzoate 5% SG, Fenvalerate 20% EC, Oxychloride,Menkojeb 75% WP,
Ginger	Ginger root, pythium spp, Leaf spot, White grubs Wilting, Shoot borer	Carndazim 50% WP, Mancozeb 0.3% Copper Oxychloride, Malathin

Source: Field Survey, 2021