Climate Change and Sub-Saharan Africa

The Vulnerability and Adaptation of Food Supply Chain Actors

Edited by

John K. M. Kuwornu

School of Environment, Resources and Development, Asian Institute of Technology, Thailand

Series on Climate Change and Society

VERNON PRESS
## TABLE OF CONTENTS

INTRODUCTION ix

LIST OF FIGURES xi

LIST OF TABLES xiii

LIST OF ABBREVIATIONS xvii

LIST OF CONTRIBUTORS xix

FOREWORD BY SURESH BABU xxvii

FOREWORD BY VENKATAchalam ANBUMOZHI xxix

FOREWORD BY JOYASHREE ROY xxxi

PREFACE xxxiii

ACKNOWLEDGEMENTS xxxv

CHAPTER 1 The Policy environment of climate change adaptation 1
Derick T. Adu and John K.M. Kuwornu 1
1.1 Introduction 1
1.2 Policies 2
References 22
CHAPTER 2  Assessing the vulnerability of smallholder women rice farmers to climate variability in the Northern Region of Ghana: The livelihood vulnerability index approach 27
Suhiyini Issah Alhassan, Yaw Bonsu Osei-Asare, John K.M. Kuwornu

Abstract 27
2.1 Introduction 28
2.2 Materials and Methods 29
2.3 Results and Discussion 43
2.4 Conclusions 55
Acknowledgements 56
References 56

CHAPTER 3  Food crop vulnerability to climate variability and change at the household level in Bui Division, Northwest Cameroon 61
Suiven John Paul Tume, Mbu Dora Nyuykighan, Moye Eric Kongnso, Bankui Andrew Dzeaye, Mairong Frederick Nsaikii, Njodzeka Gilbert Njodzeka

Abstract 61
3.1. Introduction 62
3.2 Materials and Methods 64
3.3 Results and Discussion 72
3.4 Conclusions 79
References 80

CHAPTER 4  Perceptions of climate change, traditional beliefs and determinants of farm households' adaptation decisions in Northern Togo 83
Ali Essossinam

Abstract 83
4.1 Introduction 84
## CHAPTER 5  Social capital and climate change adaptation among smallholder farmers in the Central Region of Ghana

Sampson Osei and Abdulrazak Karriem

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Introduction</td>
<td>108</td>
</tr>
<tr>
<td>5.2 Materials and Methods</td>
<td>110</td>
</tr>
<tr>
<td>5.3 Results and Discussion</td>
<td>116</td>
</tr>
<tr>
<td>5.4 Conclusions</td>
<td>126</td>
</tr>
<tr>
<td>References</td>
<td>127</td>
</tr>
</tbody>
</table>

## CHAPTER 6  What factors influence farmers’ vulnerability to climate change and variability? Empirical evidence from smallholder women rice farmers in the Northern Region of Ghana

Suhiyini Issah Alhassan, Yaw Bonsu Osei-Asare, John K.M. Kuwornu

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Introduction</td>
<td>132</td>
</tr>
<tr>
<td>6.2 Materials and Methods</td>
<td>133</td>
</tr>
<tr>
<td>6.3 Data Analysis</td>
<td>139</td>
</tr>
<tr>
<td>6.4 Results and Discussion</td>
<td>143</td>
</tr>
<tr>
<td>6.5 Conclusions</td>
<td>151</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>152</td>
</tr>
<tr>
<td>References</td>
<td>152</td>
</tr>
</tbody>
</table>
## CHAPTER 7

**Impacts of participation in climate change projects on Ghanaian maize farmers’ yields, income and resilience to climate shocks**

Armah Ralph Nii Armah, Ramatu M. Al-Hassan, John K. M. Kuwornu

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>157</td>
</tr>
<tr>
<td>7.1 Introduction</td>
<td>158</td>
</tr>
<tr>
<td>7.2 Materials and Methods</td>
<td>159</td>
</tr>
<tr>
<td>7.3 Results and Discussion</td>
<td>162</td>
</tr>
<tr>
<td>7.4 Conclusions</td>
<td>169</td>
</tr>
<tr>
<td>References</td>
<td>170</td>
</tr>
</tbody>
</table>

## CHAPTER 8

**Vulnerability of smallholder maize farming households to climate variability in the Eastern Region of Ghana**

Mustapha Abubakar Sadiq, Ramatu M. Al-Hassan, John K. M. Kuwornu

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>173</td>
</tr>
<tr>
<td>8.1 Introduction</td>
<td>174</td>
</tr>
<tr>
<td>8.2 Materials and Methods</td>
<td>175</td>
</tr>
<tr>
<td>8.3 Results and Discussion</td>
<td>182</td>
</tr>
<tr>
<td>8.4 Conclusions</td>
<td>187</td>
</tr>
<tr>
<td>References</td>
<td>188</td>
</tr>
</tbody>
</table>

## CHAPTER 9

**A multinomial logit analysis of farmers’ adoption of climate variability adaptation strategies: The case of smallholder women rice farmers in the Northern Region of Ghana**

Suhiyini Issah Alhassan, John K.M. Kuwornu, Yaw Bonsu Osei-Asare

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>191</td>
</tr>
<tr>
<td>9.1 Introduction</td>
<td>192</td>
</tr>
<tr>
<td>9.2 Materials and Methods</td>
<td>194</td>
</tr>
<tr>
<td>9.4 Conclusions and Recommendations</td>
<td>217</td>
</tr>
</tbody>
</table>
CHAPTER 10  Perceptions and determinants of the adoption of indigenous strategies for adaptation to climate change: Evidence from smallholder livestock farmers in North-West Ghana

Mohammed Tiyumtaba Shaibu, Suhiyini Issah Alhassan, Franklin Kodzo Avornyo, Elaine Tweneboah Lawson, Adelina Mensah, Christopher Gordon

Abstract

10.1 Introduction
10.2 Materials and Methods
10.3 Results and Discussions
10.4 Conclusions
Acknowledgements
References

CHAPTER 11  Gender-based climate change impacts and adaptation strategies among smallholder farmers in Northern Ghana – What lessons for nationally-appropriate mitigation actions exist?

Joseph Amikuzuno, John K. M. Kuwornu, Damba, T. Osman

Abstract

11.1 Introduction
11.2 Materials and Methods
11.3 Results and Discussion
11.4 Conclusions
Reference

Appendix 11.1: Adaptation (DSSAT)
Appendix 11.2: Adaptation (APSIM)
CHAPTER 12 Smallholder maize farmers' constraints to climate change adaptation strategies in the Brong-Ahafo Region of Ghana

Derick T. Adu, John K. M. Kuwornu, Avishek Datta

Abstract 271
12.1 Introduction 272
12.3 Results and Discussion 278
12.4 Conclusions 284
References 284

CHAPTER 13 General discussion on the vulnerability and adaptation of food supply chain actors to climate change

John K. M. Kuwornu and Derick T. Adu

13.1 Introduction 289
13.2 Discussion 291
References 314

CHAPTER 14 Conclusions and recommendations

John K. M. Kuwornu

14.1 Conclusions 321
14.2 Recommendations 325
References 328

INDEX 329
INTRODUCTION

The adverse effects of climate change and variability have become some of the biggest environmental and socio-economic challenges for society as a whole and food supply chain actors in particular. Climate change serves as a serious inhibitor to the attainment of food security (i.e., the availability, accessibility, stability and utilization of nutritious food and quality drinking water). Climate change has attracted the attention of the academic community, and governmental and non-governmental organizations. Numerous studies have examined the effects of climate change on food production and the livelihoods of farming households dependent on semi-subsistence agriculture for their continued existence.

Nevertheless, entire food supply chains are believed to be adversely affected by climate change and variability. The key questions are: How vulnerable are food supply chain actors (i.e., input suppliers, farmers, wholesalers, processors, middlemen, exporters, retailers) to climate change and climatic variability? What adaptation strategies are they adopting? How is the resilience of food supply chains being supported? By what means are they adopting the adaptation strategies? Are they being financed and/or supported by international organizations to cope with climate change? And what governmental support are they receiving to help cope with climate change? These and many related questions are addressed in this book.

This book empirically examines these issues to shed light on the effects of climate change across entire food supply chains with special reference to smallholder farmers, and to provide an exposition on the policy environment of climate change adaptation. This is a “must read book” and an essential resource for students, lecturers, researchers, agribusinesses, marketing firms, agricultural institutions, climate change adaptation institutions, policymakers and many others with an interest in agricultural development and the global food industry.

Editor
John K. M. Kuwornu
LIST OF FIGURES

Figure 1. 1: Adaptation Policy Framework 7
Figure 2. 1: Map of Savelugu/Nanton Municipality and West Mamprusi District showing the study communities 33
Figure 2. 2: Vulnerability spider diagram of study communities 53
Figure 2. 3: Vulnerability Spider Diagram of Study Districts in Northern Region 53
Figure 3. 1: Location of Bui Division 65
Figure 3. 2: Slightly increasing rainfall trend, Tatum (1957-2015) 69
Figure 3. 3: Decreasing rainfall trend, Shisong (1975-2015) 69
Figure 3. 4: Slightly increasing rainfall trend, Jakiri (1961-2006) 69
Figure 3. 5: Decreasing food crop output trend, Mbiame Sub-Division (2006-2010) 72
Figure 3. 6: Relatively stable beans output, Oku 73
Figure 3. 7: Decreasing maize production trend, Oku 73
Figure 3. 8: Decreasing solanum potatoes production trend, Oku 73
Figure 4. 1: Study areas and different agro-ecological zones in Northern Togo 86
Figure 4. 2: Farmers’ suggestions to reduce climate change impacts in Northern Regions of Togo 96
Figure 5. 1: Different Forms of Individual Social Capital 113
Figure 6. 1: Average daily rainfall by year in Savelugu/Nanton and West Mamprusi 135
Figure 6. 2: Average daily maximum and minimum temperatures by year in Savelugu/Nanton and West Mamprusi 135
Figure 6. 3: Map of Savelugu/Nanton Municipality and West Mamprusi District showing the study communities 138
Figure 7. 1: Farmers’ Perceptions of Temperature Changes 165
Figure 7.2: Farmers’ Perceptions of Rainfall Changes 165
Figure 8.1: Vulnerability Spider Diagram 185
Figure 8.2: Vulnerability Triangle of LVI-IPCC for Ayensuano and Yilo Krobo 187
Figure 9.1: Average daily rainfall by year in Savelugu/Nanton and West Mamprusi (1987-2015) 195
Figure 9.2: Average daily maximum and minimum temperatures by year (1987-2015) 195
Figure 9.3: Average Annual Yield of Rice under Rain-fed Conditions (2009 – 2014) 196
Figure 9.4: Map of Savelugu/Nanton Municipality and West Mamprusi District showing the Study Communities 197
Figure 10.1: Fruits of Achiapo Tree 231
Figure 10.2: The degree of farmers’ adoption of the Indigenous climate change adaptation strategies 237
Figure 11.1: Climate change impact on Mean Net Returns Per farm (Without Adaptation) under GCMO 256
Figure 11.2: Climate change impact on mean net returns per farm (without adaptation) under GCMK 257
Figure 11.3: Percent Gains, Losses and Net Impact under GCME 259
Figure 11.4: Percent Gains, Losses and Net Impact under GCME 259
Figure 11.5: Percent Gains, Losses and Net Impacts of GCMR 259
Figure 12.1: Smallholder Maize Farmers’ Access to Formal Credit 281
Figure 12.2: Educational Level of Smallholder Maize Farmers 281
Figure 12.3: Smallholder Maize Farmers’ Membership of a Local Social Group 281
Figure 12.4: Smallholder Maize Farmers’ Access to Extension Services 282
Figure 13.1: Implications of climate change drivers for supply chain management 290
Figure 13.2: Elements in the food supply chain 292
Figure 13.3: A depiction of the food supply chain processes 293
Figure 13.4: Conceptual model of vulnerability 294
Figure 13.5: Simplified drought impact chain along the coffee value chain in Uganda 309
LIST OF TABLES

Table 1. 1: Typology of climate change adaptation action 4
Table 1. 2: Annual Adaptation Costs in Developing Countries (US$ billion) 9
Table 1. 3: Summary of the UNFCCC climate-related funding mechanisms 10
Table 1. 4: UNFCCC Adaptation Funds in Operation (US$ Million) 11
Table 1. 5: Proposed Sources of New Funding for Climate Change Adaptation 13
Table 1. 6: Global Studies of Climate Change Adaptation Costs 14
Table 1. 7: Adaptation Initiatives in Selected Developing Countries 15
Table 1. 8: Possible Scenarios for an Adaptation Outcome in Cancun 19
Table 1. 9: New Climate Change Adaptation Laws and Policies Passed in 2014 20
Table 2. 1: Sample Size Distribution by Communities and Districts 34
Table 2. 2: Major Components and Sub-components for Estimating the Livelihood Vulnerability Index (LVI) 38
Table 2. 3: Computed Major Component Indices and LVIs for Study Communities and Districts 43
Table 2. 4: Computed Sub-component Indices for the Study Communities and Districts 46
Table 2. 5: Two Sample t-test Results on Differences in Means of Major LVI Components between Savelugu/Nanton and West Mamprusi 49
Table 2. 6: Computed Vulnerability Contributory Factors and LVI
IPCC Indices 54
Table 2. 7: Two Sample t-test Results of Differences in Means of the IPCC Vulnerability Contributory Factors for Savelugu/Nanton and West Mamprusi 55
Table 3.1: Agricultural Basins of Bui Division 65
Table 3.2: Rainfall Characteristics for Bui Division 67
Table 3.3: Rainfall Seasonality Indices (SI) Regimes 68
Table 3.4: Distribution of respondents 71
Table 3.5: Climate change vulnerability factors in crop production in Bui Division 74
Table 3.6: Food crop adaptation to climate change in Bui Division 75
Table 3.7: Supplementary livelihood activities in Bui Division 76
Table 3.8: Limiting factors to climate change adaptation in the agricultural sector in Bui Division 77
Table 4.1: The socioeconomic characteristics of the surveyed farm households in Northern Togo 90
Table 4.2: Farm households’ perceptions of climate change 92
Table 4.3: Observed climate change impacts in Northern Togo 94
Table 4.4: Barriers to climate change adaptation in Northern Togo 95
Table 4.5: Farmers’ suggestions to reduce the effects of climate change in the Northern Regions of Togo by Regions 97
Table 4.6: Probit regression results of the factors influencing the farmers’ climate change adaptation decisions in Northern Togo 99
Table 5.1: Basic household characteristics of survey respondents 117
Table 5.2: Responses to the items in the position generator questions 118
Table 5.3: K-means cluster analysis of tie strength 120
Table 5.4: K-means cluster analysis of the social distance of personal network members of the household head 121
Table 5.5: Descriptive statistics of individual social capital variables 122
Table 5.6: Independent sample t test of individual social capital by gender 122
Table 5.7: Proportion of households by adaptation strategies 123
Table 6.1: Description of variables used for the Tobit regression model 142
Table 6.2: Socio-demographic profile of respondents 143
Table 6.3: Institutional factors for respondents 144
Table 6.4: Computed Major Components Indices and LVIs 147
Table 6.5: Classified levels of vulnerability of women rice farmers in study districts 147
Table 6.6: Tobit regression results of the determinants of women rice farmers’ vulnerability to climate variability 148
Table 7.1: Variables used for the Logit regression model 162
Table 7.2: Description of dichotomous variables 163
Table 7.3: Characteristics of participants and non-participants in climate change-related projects 163
Table 7.4: Descriptive statistics of outcome variables for participants and non-participants 164
Table 7.5: Farmers’ responses to changing climatic conditions 166
Table 7.6: Results of the Logit regression model of the factors influencing participation in climate change-related projects 167
Table 7.7: Average treatment effect on treated (i.e., effect of participation) 169
Table 8.1: Components of the LVI 178
Table 8.2: IPCC contributing factors to vulnerability 181
Table 8.3: Summary of the major LVI components 183
Table 8.4: Results of a Two-Tailed T-Test for Differences in Mean LVI Between the Two Districts 186
Table 8.5: LVI-IPCC Contributing Factors 186
Table 9.1: Description of Independent Variables for the Multinomial Logit Models 202
Table 9.2: Categories of Indigenous adaptation strategies used by smallholder women rice farmers in the Northern Region of Ghana 207
Table 9.3: Categories of research-based adaptation strategies used by women rice farmers in the Northern Region of Ghana 208
Table 9.4: Factors influencing the choice of Indigenous adaptation strategies by women rice farmers in the Northern Region of Ghana 210
Table 9.5: Factors influencing the adoption of research-based adaptation strategies by women rice farmers in the Northern Region of Ghana 214
Table 10.1: Identified Indigenous climate change adaptation strategies 230
Table 10.2: Marginal effects of factors influencing the adoption of Indigenous adaptation strategies 234

Table 11.1: Summary of the key variables used to estimate the TOA-MD model 251

Table 11.2: Temperature and Precipitation Projections of the Selected GCMs 253

Table 11.3: Yield projections for maize and cowpea by DSSAT and APSIM across 5 GCMs 254

Table 11.4: Representative Agricultural Pathways (RAPs) Analysis for northern Ghana 255

Table 11.5: Impacts of climate change on mean net returns per farm with and without adaptation (DSSAT Model) 260

Table 11.6: Impacts of climate change on per capita income with and without adaptation (DSSAT Model) 261

Table 11.7: Impacts of climate change on poverty rates with and without adaptation (DSSAT model) 263

Table 12.1: Socioeconomic characteristics of the smallholder maize farmers in the Brong-Ahafo Region of Ghana (n = 150). 279

Table 12.2: Constraints to the adoption of climate change adaptation strategies of the smallholder maize farmers in the Brong-Ahafo Region of Ghana (n = 150). 283

Table 13.1: Overview of disaster risk at the component level along food supply chains 296

Table 13.2: Commodity supply chain at glance 300

Table 13.3: The impact pathways of climate change and variability for Uganda’s fisheries sector 302

Table 13.4: Potential adaptation strategies within the fisheries value chain in Uganda 303

Table 13.5: Overall four-step approach of the Climate-Resilient Coffee Value Chains (CRCV) initiative 306

Table 13.6: Examples of responses to climate hazards along the coffee value chain 308

Table 13.7: Future research approaches regarding climate change and supply chain management 311
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptation Policy Framework</td>
<td>APF</td>
</tr>
<tr>
<td>African Development Bank</td>
<td>AfDB</td>
</tr>
<tr>
<td>Agricultural Training Programme</td>
<td>ATP</td>
</tr>
<tr>
<td>Clean Development Mechanism</td>
<td>CDM</td>
</tr>
<tr>
<td>Climate Investment Funds</td>
<td>CIF</td>
</tr>
<tr>
<td>Climate Vulnerability Index</td>
<td>CVI</td>
</tr>
<tr>
<td>Community-based Health Planning and Services</td>
<td>CHPS</td>
</tr>
<tr>
<td>Demographic Health Survey</td>
<td>DHS</td>
</tr>
<tr>
<td>Divisional Delegate of Agriculture and Rural Development</td>
<td>DDARD</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>EPA</td>
</tr>
<tr>
<td>Farmer Based Organization</td>
<td>FBO</td>
</tr>
<tr>
<td>Food and Agricultural Organization</td>
<td>FAO</td>
</tr>
<tr>
<td>Ghana Statistical Service</td>
<td>GSS</td>
</tr>
<tr>
<td>Global Climate Financing Mechanism</td>
<td>GCFM</td>
</tr>
<tr>
<td>Global Environmental Facility</td>
<td>GEF</td>
</tr>
<tr>
<td>Green Care Association</td>
<td>GCA</td>
</tr>
<tr>
<td>Household Vulnerability Index</td>
<td>HVI</td>
</tr>
<tr>
<td>Information Communication Technology</td>
<td>ICT</td>
</tr>
<tr>
<td>Institute of Statistical, Social and Economic Research</td>
<td>ISSER</td>
</tr>
<tr>
<td>Intergovernmental Panel on Climate Change</td>
<td>IPCC</td>
</tr>
<tr>
<td>International Air Passenger Adaptation Levy</td>
<td>IAPAL</td>
</tr>
<tr>
<td>International Development Research Centre</td>
<td>IDRC</td>
</tr>
<tr>
<td>International Institute for Environment and Development</td>
<td>IIED</td>
</tr>
<tr>
<td>International Institute for Sustainable Development</td>
<td>IISD</td>
</tr>
<tr>
<td>International Institute of Tropical Agriculture</td>
<td>IITA</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>International Maritime Emission Reduction Scheme</td>
<td>IMERS</td>
</tr>
<tr>
<td>Least Developed Countries</td>
<td>LDC</td>
</tr>
<tr>
<td>Livelihood Vulnerability Index</td>
<td>LVI</td>
</tr>
<tr>
<td>Ministry of Energy, Science, Technology and Innovation</td>
<td>MESTI</td>
</tr>
<tr>
<td>Ministry of Food and Agriculture</td>
<td>MoFA</td>
</tr>
<tr>
<td>National Association of Counties</td>
<td>NACO</td>
</tr>
<tr>
<td>National Adaptation Programme of Action</td>
<td>NAPA</td>
</tr>
<tr>
<td>National Oceanic and Atmospheric Administration</td>
<td>NOAA</td>
</tr>
<tr>
<td>Non-governmental Organization</td>
<td>NGO</td>
</tr>
<tr>
<td>Official Development Assistant</td>
<td>ODA</td>
</tr>
<tr>
<td>Organization of Economic Co-operation and Development</td>
<td>OECD</td>
</tr>
<tr>
<td>Pilot Program for Climate Resilience</td>
<td>PPCR</td>
</tr>
<tr>
<td>Propensity Score Matching</td>
<td>PSM</td>
</tr>
<tr>
<td>Roll Black Malaria</td>
<td>RBM</td>
</tr>
<tr>
<td>Shisong, Strategic Humanitarian Services</td>
<td>SHUMAS</td>
</tr>
<tr>
<td>Special Climate Change Fund</td>
<td>SCCF</td>
</tr>
<tr>
<td>Standard International Occupational Prestige Scale</td>
<td>SIOPS</td>
</tr>
<tr>
<td>Statistics, Research and Information Directorate</td>
<td>SRID</td>
</tr>
<tr>
<td>Strategic Priority for Adaptation</td>
<td>SPA</td>
</tr>
<tr>
<td>Third Assessment Report</td>
<td>TAR</td>
</tr>
<tr>
<td>United Nation Development Program</td>
<td>UNDP</td>
</tr>
<tr>
<td>United Nations Employment Programme</td>
<td>UNEP</td>
</tr>
<tr>
<td>United Nations Framework Convention on Climate Change</td>
<td>UNFCCC</td>
</tr>
<tr>
<td>Upper Nun Valley Development Authority</td>
<td>UNVDA</td>
</tr>
<tr>
<td>West and Central African Council for Agricultural Research and Development</td>
<td>WECARD</td>
</tr>
<tr>
<td>World Health Organization</td>
<td>WHO</td>
</tr>
</tbody>
</table>
LIST OF CONTRIBUTORS

John K. M. Kuwornu holds a PhD in Agricultural Economics and Marketing from Wageningen University, Netherlands. He is currently an Associate Professor in Agribusiness Management Field of Study at the School of Environment, Resources and Development, Asian Institute of Technology, Thailand. His areas of teaching and research include: Agribusiness Management, Agricultural Marketing and Trade, Agricultural Development, Agricultural Policy, Marketing Channels, Consumer Behaviour, Supply Chain Management, Commodity Futures Markets, Econometrics, Quantitative Methods, Climate Change, Food Security, Agrobiodiversity and Stock Markets.

Al-Hassan M. Ramatu has a BSc (Hons) Agriculture, MA Agricultural Economics and PhD Agricultural Economics. She is currently an Associate Professor at the University of Ghana, Legon. Her research area is in smallholder agricultural development in Ghana, including analysis of productivity, food security, poverty, and market access. Her areas of teaching are Research Methods, Production Economics, Farm Management, and Agriculture in Development Policy.

Derick T. Adu holds Master of Philosophy degree in Agricultural Economics from University of Ghana, Legon. He works as a Part-Time Lecturer in Faculty of Agriculture and Social Sciences at Anglican University College of Technology (Ghana), and a Project Officer at Freshmacs Ghana Limited. His teaching and research interests include Applied Econometrics, Managerial Economics, Macroeconomics, Environmental Economics, Climate Change Economics, Education Economics, Microeconomics, and Development Studies. He reviews for a number of reputable international journals. He has published in international peer-reviewed journals including Cogent Economics and Finance, Springerplus, Kasetsart Journal of Social Sciences, Cogent Food and Agriculture, and International Journal of Education Economics and Development.
**Suhiyini Issah Alhassan** is a Ghanaian by birth and Tamale is his home town. He holds Master of Philosophy degree in Agribusiness (University of Ghana), Bachelor of Arts degree in Development Studies (University for Development Studies, Ghana), Diploma in Education (University of Education, Winneba, Ghana) and a certificate in Information Technology (Technonet Ghana Ltd). Suhiyini is an educationist and works with The Ghana Education Service, Ministry of Education Ghana. He is also a researcher and engages in consultancy services for individuals, private enterprises and other Non-governmental Organisations. His research interest and expertise include but not limited to agribusiness, food security, climate change, supply and value chain management, land use management, poverty and small and medium scale enterprises development. He remains focused on developing himself as a distinguished researcher and welcomes new ideas in his field of research. He has an understanding of both quantitative and qualitative analytical tools. Hitherto, he had served as the Saboba district director of the ADPL Nationwide Farming Scheme and also the Team Leader of Enterprise Life Assurance Company Limited, Tamale. Suhiyini Issah Alhassan is currently a PhD student in the Department of Agricultural and Resource Economics, Faculty of Agribusiness and Communication Sciences, University of Development Studies, Tamale, Ghana.

**Yaw B. Osei-Asare** holds a PhD Development Economics from the University of Bonn, Germany. He is currently a Senior Lecturer in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon. He teaches Microeconomics and Macroeconomics, Quantitative Methods and Operations Research, and Environmental Economics. His areas of research interest include Environmental, Economic and Social Impact Assessments and Baseline Studies, Resource and environmental economics, ecosystem valuations, trade policy, poverty reduction and general economic policy issues.

**Suiven John Paul Tume** (Cameroon) has a Bachelor's Degree in Geography (2004), a Postgraduate Diploma in Education (2006) and Master's Degree in Geography (2008) all from the University of Buea. He is currently a PhD research fellow working on indigenous adaptations to climate change in the agriculture and water sectors. He volunteers at Green Care Association, Shisong—Cameroon as a researcher on indigenous climate change adaptation. He is also a consultant and volunteer researcher at Green Future Consulting where he works on climate change vulnerability and adaptation. He is a part-time instructor at the Department of Geography and Environmental Studies of the Catholic University of
Cameroon (CATUC), Bamenda and at the Department of Geography and Planning at the University of Bamenda. He has several publications in diverse subjects on climate change and the environment.

**Mbu Dora Nyukighan** (Cameroon) holds Bachelor’s Degree in English Language from the University of Buea (1996), Post Graduate Diploma in Education from the National Teachers’ Institute Kaduna, Nigeria (2009) and a master’s degree in African Literature from the Ahmadou Bello University in Zaria, Nigeria (2012). She is a PhD research fellow on ‘Gender Representations in Cameroon Drama of English Expression’ at the University of Yaounde I. She is a lecturer in the Department of English and Literary Studies, Federal University Lokoja, Nigeria. She has carried out academic research on gender-related environmental issues in Anglophone Cameroon and papers articles on female power and empowerment, traditional and modern education of the Cameroonian child. She is interested vulnerability and adaptation of rural women to climate change in the Northwest Region of Cameroon.

**Moye Eric Kongnso** (Cameroon) holds a Bachelor’s Degree in Geography and Environmental Management (2007) and a Masters Degree in Geography (Applied Agro-climatology, 2011), both from the Dschang. He is currently a PhD fellow. He is a member of a number of professional and research groups in environmental issues. He has co-published articles and book chapters on climate variability and change in the agriculture and water sectors.

**Bankui Andrew Dzeaye** (Cameroon) holds a Bachelors degree in International Business Management at the Furtwangen University of Applied Sciences, Germany and a Master’s degree in International Management at the Fulda University of Applied Sciences, Germany. He has been Senior Project Manager in SHUMAS - Cameroon (Strategic Humanitarian Services - Cameroon) in partnership with the German Technical Cooperation (GIZ) for expatriates. He is an assistant lecturer at the Department of Agricultural Economics of the Catholic University of Cameroon (CATUC), Bamenda. He is currently working on his PhD thesis on economic and social impacts of adopting soil fertility management technology: the case of western highlands of Cameroon at the Faculty of Agronomy and Agricultural Sciences, University of Dschang.

**Mairong Frederick Nsaikii** (Cameroon) holds a higher teachers’ diploma in biology, a bachelor’s degree in biology and a master’s degree in plant biology. He has several years of teaching experience in secondary and high schools. He is currently enrolled for a PhD at the Faculty of Agronomy and
Agricultural Sciences, University of Dschang. His research area is on climate change and food security in the Northwest region of Cameroon.

**Njodzeka Gilbert Njodzeka** (Cameroon) has a Diploma in Tree Nursery and Soil Conservation (1997) at Rural Training Centre (RTC), Mfonta. He is the Coordinating Manager and Head of Project Development at Green Care Association, Shisong—Cameroon. He is a crusader in combating environmental degradation through tree planting, apiculture, water catchment protection, developing renewable energy and animal husbandry through non-conventional livestock. He has won several international awards such as Bui Family Union, New Jersey Chapter—Appreciation of Service, 2010; United Kingdom-Commonwealth Mid-Career Fellowship (2010) and United Kingdom-World Environment Radio-First Prize, Best Feedback (2008).

**Ali Essossinam** is a lecturer. Essossinam teaches International Negotiation of Agricultural Products, Agricultural Finance, Microeconomics and Macroeconomics in Faculty of Economics and Management Sciences at University of Kara (TOGO) and Production Economics and Agricultural Policy in School of Agriculture at University of Lomé (TOGO). He has his Ph.D. in Applied Agricultural Economics and Policy from University of Ghana, Legon, Accra, (GHANA) and MSc in Applied Macroeconomics from University of Abomey Calavi-UAC, (BENIN) under the New Graduate Interuniversity Program (NPTCI). He got his MA and B.Sc degree in Economics from University of Kara (TOGO). The areas of research interests of Dr. ALI include Climate Change and Poverty, the Analysis of demand of Weather Index-based Insurance in Developing countries, the Economic Valuation of Non-market Commodities, Food Security Issues, Economic Impact Valuation Research, Agricultural Finance, and Environmental Issues.

**Sampson Osei** is a PhD candidate in Development Studies at the University of the Western Cape, South Africa. He holds Masters Degrees in Development Management and Development Studies from the Ruhr University, Germany and the University of the Western Cape, respectively.

**Abdulrazak Karriem** is a Senior Lecturer in the Institute for Social Development at the University of the Western Cape in Cape Town, South Africa. He received his PhD in City and Regional Planning from Cornell University. Prior to entering academia, he worked for the Department of Land Affairs in the Nelson Mandela government.
Abugri A. Stephen is an MPhil Graduate of the Agricultural Economics Programme in the University for Development Studies (UDS), Tamale, Ghana. He has a strong background in action and development research.

Dr. Joseph Amikuzuno holds a PhD Degrees in Agricultural Economics and is an expert in Price Transmission and Climate Change Impact analyses. He is currently a Senior Lecturer and the Head of the Climate Change and Food Security Department of the UDS.

Dr. Osman Tahidu Damba holds a PhD in Agricultural Economics from Ataturk University, Turkey, an MPhil in Agribusiness from the University of Ghana and BSc. Agricultural Technology from the University for Development Studies, Tamale, Ghana. Dr. Damba is currently a Lecturer at the Department of Climate Change and Food Security, Faculty of Agribusiness and Communication Sciences (FACS) at the University for Development Studies. He is focused on food security and climate change dynamics, Agricultural Markets, time series forecasting for volatility, value chains, FBO Development and agribusiness start-ups in developing countries. Dr. Damba has firm and extensive understanding in applied research and hands-on field practical techniques. He has extensive experience in the not-for-profit sector and has had stints with local and international organizations through roles at the Association of Church Development Projects (ACDEP) as a Market Access Coordinator, Farmers Organization Network in Ghana (FONG) as Agribusiness Cluster Officer, Pan African Organization for Sustainable Development (POSDEV) as a Project Officer as well as the International Fertilizer Development Center (IFDC) as a Business Development Advisor. Dr. Damba has further worked closely with several local farmer associations in capacity development and also facilitated linkages for Agricultural Commodity companies in Northern Ghana. Dr. Damba currently teaches Social and Environmental Impacts of Climate Change, Food Economics as well as Agricultural Finance and Farm Management at the graduate and postgraduate levels.

Armah Ralph Nii Armah holds an MPhil in Agricultural Economics from the University of Ghana. He is currently a Doctoral Candidate at Kansas State University, USA.

Mohammed Tiyumtaba Shaibu is a Senior Technologist working for Ghana's Council for Scientific and Industrial Research-Animal Research Institute. He had his education in Ghana and holds a BSc in Agricultural Economics and Extension and an MPhil in Agribusiness from the University for Development Studies and the University of Ghana respectively. He has one journal publication and 9 conference papers to
his credit. He has attended several workshops/trainings/short courses both locally and internationally. Shaibu’s interest is in socioeconomics of livestock production including Crop-Livestock Systems, Agricultural Marketing, Agricultural Commodity Value Chains and Climate Change Adaptation of Farmers. He is currently implementing a project on climate change and variability implications for fodder production and goat value chains in Northern Ghana.

**Dr. Franklin Kodzo Avornyo** is a Principal Research Scientist who works at the Council for Scientific and Industrial Research – Animal Research Institute, Nyankpala Station near Tamale in Ghana. He holds an MSc. in Sustainable Agriculture and a PhD. His specialty is in Animal Science and has published works in the areas of improving livestock productivity, livestock value chains, integration of crop-livestock systems and climate change and livestock production interface. He has 25 refereed journal publications, 25 edited conference papers, one book and other publications to his credit. His interests include addressing challenges in the livestock sector.

**Dr. Adelina Maria Mensah**, a Senior Research Fellow at the Institute for Environment and Sanitation Studies (IESS), University of Ghana (UG), has an interdisciplinary background in environmental sciences with a focus on aquatic sciences and the human dimensions that impact on its management and sustainability. Dr. Mensah has worked extensively with numerous national and international institutions and stakeholders on a wide range of environmental and sustainable development issues, including aquatic ecosystem functioning, natural resource management, and climate adaptation. Her current interests are research and innovation in science and technology for promoting sustainable futures.

**Dr. Elaine Tweneboah Lawson** has over 14 years’ experience in teaching, research and academic programme coordination at the University of Ghana. Her teaching and research have focused on coupled human-environment systems at a variety of scales. Her research interests include climate change adaptation, coastal ecosystems, dimensions of poverty, environmental policy processes, gender, and social dimensions of zoonotic diseases. Dr. Lawson has a doctorate degree in Environmental Resource management from the Brandenburg University of Technology, Cottbus, Germany.

**Prof. Christopher Gordon** holds Bachelor of Science and Master of Science degrees in Zoology from the University of Ghana, Legon and a UNESCO Post-Graduate Certificate in Limnology awarded by the Austrian
Academy of Sciences. He has a Doctorate degree in Human Environmental Sciences from King’s College, University of London, United Kingdom. He has a distinguished academic career spanning over thirty years at the University of Ghana in the fields of research, teaching as well as advisory and fundraising services at both local and international levels. He has successfully supervised over 100 graduate students, - two of whom have won the Silver Medal of the Ghana Academy of Arts and Sciences for Best Post-graduate thesis in Ghana.

**Dr. Avishek Datta** is an Associate Professor of Agricultural Systems and Engineering Programme at the Asian Institute of Technology, Thailand. He obtained his PhD in Agronomy from the University of New England, Armidale, New South Wales, Australia and conducted his Postdoctoral Research at the University of Nebraska-Lincoln, Nebraska, USA. He has more than ten years of experience working in multidisciplinary agricultural research and development activities. His main areas of expertise include crop production under conventional and organic farming systems in relation to food security and climate change.
Achieving UN Sustainable Development Goals will greatly depend on how developing countries tackle the deleterious consequences of the climate change on the welfare indicators. While the governments of the developing countries are trying to address the issue of climate change and develop measures to mitigate and adapt to the changing environments, they are often faced with limited information on the indicators and causal factors that affect the food system in general and the food supply chains in particular.

In this book, Dr. John Kuwornu compiles a set of studies that deal with several key policy and programmatic issues related to adaptation of the key actors and players of the food supply chains. The chapters of this book address the nature of the adaptive measures the actors of the food supply chains take to manage the effects of climate change. The chapters also address the challenges related to building resilience of the food supply system.

The case studies compiled in this book are also useful as cross-community learning as the context of the chapters take us through various scenarios under which the vulnerable nature of the food systems is managed through adaptive measures. The book will be an essential reference for those involved in analyzing the effects of climate change on the socioeconomic conditions of actors in food supply chains in Africa and rest of the World.

Dr. Suresh Babu
Head, Capacity Strengthening,
International Food Policy Research Institute,
Washington D.C.
One aspect of the climate change that has been studied with fewer details so far is related to its economic impacts along the food value chain. This is due, perhaps, to the intrinsic complexity among the different actors that characterizes long-term social predictions and short-term adaptation measures. The truth is that some communities in the food value chain will suffer severe vulnerabilities from the new climate conditions.

We should worry more about the food value chains and the communities associated with that, which have never enjoyed technological advances but adjusted with ecosystem-based adaptation measures, but now see their economic welfare is threatened by accelerated climate risks. For instance, farming communities from sub-Saharan Africa, whose lands are increasingly becoming less productive and dry, providing testimony of what might happen in other parts of the world such as South East Asia, if the average temperature rises more than 2°C. The vulnerability of food value chains to climate change in terms of geography and timescale have diverse difficulties to understand the consequences for the major crops and small-scale farming communities.

This book explores the impacts of climate change on a wide variety of value chains and places in Sub-Saharan Africa, their vulnerabilities, and mitigative and adaptive capacities. In this book, we find a very useful exploration of agronomic and economic approximations connected to these consequences as well as innovative ideas of micro and macro adaptation along the value chain. For sure, the new assessment tools and adaptation measures developed in the chapters of this book will be extremely helpful for building an accurate diagnosis and to achieve a greater resilience of small-scale farming communities, all of which face the long-term consequences of climate change.

Dr. Venkatachalam Anbumozhi
Senior Economist
Economic Research Institute for ASEAN and East Asia (ERIA), Jakarta, Indonesia
FOREWORD
BY JOYASHREE ROY

Several recent expert opinion-seeking surveys show that hunger is one of the 17 SDGs with the greatest potential and chance of being solved in the next decade. However, this will need multi-dimensional strategies. IPCC’s ‘Special report on Global Warming of 1.5°C above pre-industrial levels and the likely impacts and pathways in the context of strengthening the global response to the threat of climate change, sustainable development and efforts to eradicate poverty’ reports high confidence in a relatively reduced impact but it still reports an increase in climate-related risks to food security at 1.5°C compared to 2°C and the disproportionate effect on vulnerable populations that are dependent on agriculture and coastal livelihoods in dryland regions and less developed countries. Overlapping risks across livestock, water, energy, and food exacerbate current hazards, exposure and vulnerabilities. Regional examples are limited by the availability of local scale studies. Also, the assessment is confident in the role of redistributive policies to ameliorate adverse impacts on already disadvantaged populations of multiple mitigation options when accelerated and scaled up in the short window of opportunity within the next decade.

This present book, based on mostly field level first-hand primary evidence from within Africa, can be considered as a major contribution to the bridging of this knowledge gap through methodological rigor. The selected articles for this volume bring up one point very clearly that in Africa there is diversity in vulnerability and exposure. Hence, the resultant risks to households, farmer groups, region-specific crop varieties, and subnational administrative units highlight the need for a wide variety of attention and interventions towards adaptive capacity enhancement and risk reduction. The vulnerability of particular crop varieties, communities, indigenous populations, farmer categories by gender and responsible climate parameters are well covered. Offering regional diversity through studies of Ghana, Cameroon, and Togo, high-quality sets of data are presented that could inform global assessments. The book not only focuses on the food production system and producers’ vulnerability but
also on the vulnerability of the supply chain is also assessed in relation to Uganda. Policy recommendation provides a starting point for a more extensive research agenda to understand what works better under what circumstances.

In this book, the conclusions based on empirical evidence from various studies support the portfolio approach by taking into consideration synergies and tradeoff among multiple SDGs, which are also mentioned in the assessment of the IPCC special report on the global warming of 1.5°C.

The new granular insights brought up by the various articles in the book are very useful for informing the larger global debate. From an intellectual point of view, the editor's compilation of articles that study various regions of Africa and the arrangement of each article in a similar format helps in the understanding of the vulnerability and adaptation of farmers and other food supply chain actors to climate change.

The articles in this book will be of considerable interest and use to the authors of the IPCC Sixth Assessment Report and the development community including academia and decision makers like national governments, bilateral and multilateral funding agencies, and civil societies engaged in developmental actions in the region. This book will generate interest for further studies in Africa and in other countries in order to advance deeper regional and global debate, struggle and understanding.

Joyashree Roy
Bangabandhu Chair Professor
Asian Institute of Technology, Thailand
Professor of Economics (On lien) and Founder Advisor to Global Change Programme & SYLFF-JU Programme of Jadavpur University, India.
This book provides an exposition on the effects of climate change on food supply chains. It seeks to explore the effects of climate change at the farm level, the effects on intermediaries in the food supply chains, and the role of policymakers and international institutions regarding adaptation to climate change.

Chapter 1 by Derick T. Adu and John K. M. Kuwornu provides an overview of the policy environment of climate change adaptation.

Chapter 2 by Suhiyini Issah Alhassan, Yaw Bonsu, Osei-Asare, and John K.M. Kuwornu examines the vulnerability of women rice farmers to climate variability in the Northern Region of Ghana using the Livelihood Vulnerability Index Approach.

Chapter 3 by Suiven John Paul Tume, Mbu Dora Nyuykighan, Moye Eric Kongnso, Bankui Andrew Dzeaye, Mairong Frederick Nsaikii, and Njodzeka Gilbert Njodzeka assesses food crop vulnerability to due climate variability and change at the household level in Bui Division in the northwest of Cameroon.

Chapter 4 by Ali Essossinam examines the farm households’ perception of climate change, traditional beliefs and determinants of the adaptation decisions in northern Togo.

Chapter 5 by Sampson Osei and Abdulrazak Karriem examines social capital and climate change adaptation among smallholder farmers in the Central Region of Ghana.

Chapter 6 by Suhiyini Issah Alhassan, Yaw Bonsu Osei-Asare, and John K.M., Kuwornu examines the factors influencing women rice farmers’ vulnerability to climate change in the Northern Region of Ghana.

Chapter 7 by Armah Ralph Nii Armah, Al-Hassan M. Ramatu, John K. M. Kuwornu examines the impact of participation in climate change projects on maize farmers’ resilience to climatic shocks, yields and income.

Chapter 8 by Mustapha Abubakar Sadiq, Al-Hassan M. Ramatu, John K. M. Kuwornu examines the vulnerability of smallholder maize farming households to climate variability in the Eastern Region of Ghana.
Chapter 9 by Suhiyini Issah Alhassan, John K.M. Kuwornu, and Yaw Bonsu Osei-Asare examines the climate change adaptation strategies by women rice farmers in the Northern Region of Ghana.

Chapter 10 by Mohammed Tiyumtaba Shaibu, Suhiyini Issah Alhassan, Franklin Kodzo Avornyo, Elaine Tweneboah Lawson, Adelina Mensah and Christopher Gordon explores the perceptions and determinants of adoption of indigenous strategies for adaptation to climate change by smallholder livestock farmers in the North-Western Region of Ghana.


Chapter 12 by Derick T. Adu, John K. M. Kuwornu and Avishek Datta explores smallholder maize farmers’ constraints to climate change adaptation strategies in the Brong-Ahafo Region of Ghana.

Chapter 13 by John K. M. Kuwornu and Derick T. Adu provides a general discussion on the vulnerability and adaptation of food supply chain actors to climate change.

Finally, chapter 14 by John K. M. Kuwornu provides conclusions and recommendations regarding the vulnerability and adaptation of food supply chain actors to climate change.
ACKNOWLEDGEMENTS

I would like to thank all the authors for their invaluable contributions this book. My special appreciations also go to the reviewers of the individual chapters and the entire book. I am really grateful to Mr. Derick T. Adu for formatting the text in the book. My special gratitude also goes to Vernon Press for publishing this book. Thanks also to Dr. John Meadows for proofreading the final draft of the manuscript.
PAGES MISSING
FROM THIS FREE SAMPLE
INDEX

A

a priori expectation, 142, 150, 216
Abakah, J., 170
Abdrabo, M.A, 81
Abdul Kadri, A. O., 218
Abdulai, A., 170, 171
Abdul-Rahman, S., 171
Abdul-Razak, M., 264
Abeyesinghe, A, 80, 82
Aborisade, A. S.,, 153
access to agricultural information, 109
access to credit, 204, 209, 216, 224, 234, 236, 238, 249, 277, 280, 282, 283, 284, 322, 324, 326
Access to extension services, 163
access to information, 216, 246, 275
accessibility, ix, 111, 119, 204, 211, 325
Acosta-Michlik, L.,, 317
actors along the supply chain, 297, 306
Adams, M.,, 264
adapt to the impacts of climate change, 9
Adaptation, 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 57, 58, 62, 63, 75, 80, 81, 82, 107, 109, 123, 127, 128, 129, 130, 153, 154, 155, 170, 171, 185, 189, 191, 202, 206, 207, 208, 218, 219, 220, 221, 223, 225, 233, 238, 239, 240, 247, 254, 256, 258, 260, 261, 263, 264, 265, 266, 267, 269, 303, 304, 317, 318
adaptation action, 2
Adaptation Committee, 19
adaptation programmes, 3, 244
Adaptation to Climate Change Initiative of Australia, 12
adaptive capacity, 8, 27, 29, 30, 31, 32, 36, 53, 54, 55, 58, 62, 64, 75, 110, 129, 134, 139, 152, 154, 174, 176, 180, 181, 243, 244, 245, 294, 299, 311, 321, 322, 326
adaptive measures, 273
Adebayo, F. A.,, 218
Adepoju, O. A.,, 221
Adewuni, M. O.,, 218
Adger, W. N, 24, 56, 58, 127, 189, 218, 264, 284, 285, 286, 314, 315
Adiku, S.G.K.,, 264
Adjei, K. A.,, 154, 220
administered, 66, 70, 115, 139, 181, 198, 224, 226, 277
adopt conservation practices, 224
adoption, xxxiv, 15, 19, 57, 105, 109, 110, 126, 127, 149, 152, 153, 166, 171, 189, 191, 193, 201, 203, 204, 205, 206, 207, 208, 209, 212, 213, 214, 215, 216, 217, 218, 219, 224, 225, 228, 236, 237, 238, 239, 241, 243, 244, 245, 247, 250, 251,
252, 254, 265, 266, 274, 275, 308, 323, 324, 326, 327
adoption of technology, 109
Adu, D. T, 152, 264
adverse, ix, 3, 7, 8, 9, 12, 17, 28, 62, 108, 125, 131, 174, 204, 206, 224, 225, 242, 256, 294, 296, 308, 310
adverse effects, 274
ADVISEN LTD, 314
Agali, A., 264
agent, 63, 111, 162, 274
Aggarwal, P., 265
aggregation of potential resources, 111
Agrawal, A, 285
agricultural, xix, xxv
agricultural activities, 28, 134, 151, 193, 205, 246, 249, 275, 304
agricultural and natural-resource dependent communities, 31
Agricultural Extension Agent, 235
agricultural sector, 21, 32, 75, 79, 108, 137, 158, 196, 218
Agricultural Training Programme, 79
Agriculture’s productivity, 132
agro-chemical shops, 127
agro-ecological knowledge, 275
agro-pastoral, 78
Agyapong, A. A., 154, 220
Ajibefun, I. A., 218
Alam, M., 81
Alemu, T, 57, 128, 153, 219
Alexander, L, 285
Al-Hassan, R. M., 57, 153, 218, 219, 264, 265, 285
Allison, E., 317
Allison, E.H., 314
Allison, P. D., 239
Amadou, Z., 240
Amaechina, E. C., 129
amend prevailing planning processes, 6
Amikuzuno, J, 56, 152, 219, 264
amount of rainfall, 272
Amuakwa-Mensah, F, 56, 219
Amusa, T. A, 285
Anbumozhi, V., 318
Andrew, N.L., 314
Anim, F. D., 154, 220
Anim, F.D.K., 129
Anim-Somuah, H, 152
Annex I Parties, 16
Annex 11 economies, 16
Annor- Frempong, F., 239
annually, 158, 272
anthropogenic, 15, 133, 273
anticipatory, 2, 63
Antle, J.M., 264, 265
Antwi-Agyei, P., 152, 285
Anuja., 266
apiculture, xxii, 76, 79
Appiah-Adjei, E. K., 154, 220
approaches in measuring vulnerability, 30, 136
Ariyawardana, A., 316
Armah, F. A., 155
Armah, F.A., 265
Armah, R. N. A., 170, 265
Arnell, N, 24, 189
Asante, F. A, 56, 219
Asare, A., 56, 152
assessing current vulnerability, 6
assessing spatio-temporal scale
difference in vulnerability, 31
Assessment, 1, 9, 13, 16, 23, 57,
80, 81, 82, 153, 154, 170, 189,
220, 264, 301, 316, 318
assigning paradoxical weight to
indicators, 31
Assistance, M.K., 130
Asuming-Brempong, S.,, 221
Asymptotic, 283
Athula, S.,, 170
attributing causation without
stringent assumptions, 30,
136
authority, 113, 274
authority gradients, 113
autonomous contingent, 2
availability, ix, 114, 175, 183,
184, 185, 204, 208, 242, 260,
291, 300
average minimum and
maximum temperatures, 32,
137, 196
average Rainfall Seasonality
Index, 62
average treatment effect, 161
Avornyo, F. K., 240
awareness, 158, 170, 193, 206,
243, 275, 283, 306, 307, 308,
310
Awotide, B. A.,, 219
Awunyo-Vitor, D.,, 170
Ayantunde, A. A.,, 240
Ayoade, J.O, 80
Ayuya, O. I.,, 152

B
Babcock, B. A.,, 240
Badjeck, M.C.,, 314, 315
Baffoe-Asare, R.,, 239
Bagamba, F.,, 265, 315
Bailis, R.,, 267
Baker, J.L.,, 170
balanced weighted average, 35
Banyopadyay, S. K.,, 266
Baptiste, A, 58
Barahona, C.,, 266
Barakat, S.,, 82
Barnard, S, 23
Barnes, L, 57, 153
Barnett, J.,, 239, 284
barrier to climate change
adaptation, 275, 276
barrier to diffusion, 121
Baschieri, A, 285
Bashaasha, B. C.,, 265
basic education, 162, 163, 280
Bauer, S.,, 239
Bawakyillenuo, S.,, 153, 219, 240
Bawakyillenuo, S.,, 153, 219
Bayard, B.,, 153
Becerril, J.,, 170
Beermann, M.,, 314
Beg, N, 22
Behera, B.,, 266
Behrman, J.,, 154, 221
belief systems, 276
Berkhout, F.G.H.,, 81
Bernabucci, U.,, 240
Berrang-Ford, L, 285
Berry, M, 57, 153
Beveridge, M.C.M.,, 314
Bhatta, G.,, 265
Biagini, B, 22
Bierbaum, R.,, 22
Bierbaum, R.,, 22
Bokelmann, W.,, 223
Bokhari, T. Z.,, 239
Boko, M.,, 153, 170
bonding social capital, 112
bonding, bridging and linking
social capital, 116
Bonini, C.,, 314
Bostrom, A.,, 315
Bourdieu, P.,, 127
Boyd, E, 24
Bridging social capital, 113, 122
Brklacich, M, 316
Brong-Ahafo Region, xxxiv, 271, 273, 277, 279, 280, 283, 284, 324
Brooks, N, 56
Brown, K., 189, 218, 284, 286, 314, 315
Bryan, E., 129, 285
Buah, S.S.J.,, 171
Buchenrieder, G., 128
Buenos Aires Programme, 2
Bunzeck, I. G.,, 171
Burton, C, 57, 153
Burton, I, 23, 24, 315
bushfires, 30, 31, 35, 41, 48, 52, 54, 132, 134, 139, 149, 200, 249
Canada’s Climate Change Impacts, 3
Cancun Adaptation Framework, 19
Canziani, J. P, 285
Canziani, O.F, 23
capacity building, 10, 11, 15, 109, 127, 305, 307, 310
capital assets, 274
Caravani, A, 23
carbon dioxide, 13, 16
Carbon Disclosure Project, 298, 314
Caribbean Community Climate Change Centre, 3
Carter, T.R, 22
Carvajal-Escobar, 242, 265
Casey, F., 127
censoring of the data, 136
century, 21st, 108, 272
challenges, ix, xxiv, 61, 62, 63, 150, 158, 168, 170, 173, 205, 223, 246, 294, 299, 305
Challinor, A.J.,, 82, 317
Chamberlin, J., 153
Chang, C, 285
Changes in climatic variables, 272
changing rainfall patterns, 66, 307
channels, 191, 206, 207, 217, 274, 303, 323
Chi-square calculated, 283
Chi-square critical, 283
choice of technology, 275
Christensen, L, 58, 155
Christopher, M.,, 314, 328
Chudhury, M.,, 265
City of New Orleans OHSEP, 300, 314
City of New York., 315
Claudia, R.,, 129
Clean Development Mechanism, 11
Clemencon, R, 22
climate change adaptation, ix, xx, 6, 8, 12, 66, 77, 107, 109, 115, 127, 158, 242, 243, 245, 247, 248, 261, 274, 304, 322, 327
Climate change and variability,, 132, 272
climate change related research, 276
Climate change vulnerability, 57, 62, 74, 153
climate change vulnerability spectrum, 132
climate change-prone operations, 289
climate dependent, 275
climate forecasting, 80
climate information, 5, 185, 249, 322
Climate Investment Funds, 11
climate projections, 275
climate system, 1, 5, 15, 133
Climate Technology Fund, 11
climate variability, 6, 27, 28, 30, 31, 52, 54, 55, 62, 64, 132, 133, 147, 149, 151, 173, 174, 175, 187, 191, 192, 193, 196, 203, 205, 206, 224, 234, 235, 246, 321, 323
Climate Vulnerability Index, 31
climate-dependent activities, 272
cclimate-related funding mechanism, 9
climate-related impacts and risks, 109
cclimate-smart, 79
climatic events are enhanced, 2
coastal zone management, 7
Cochrane, K, 82, 317
coefficient of variation, 66, 67, 68
coffee supply, 296, 305, 307, 308, 310, 311
Cohen, S, 22
Coleman, J.S., 128
collective asset, 111
Collins, M, 22
communicable diseases, 44
community, 273
Community-based Health Planning and Services, 56
comparative analysis, 271
Complexity and dimension of stages and networks, 295
comprehensive mandate of adaptation covering, 11
comprehensive responses and policy strategies, 1, 321
Concentration of suppliers, 295
conceptualization of vulnerability, 30
conglomerate adaptation projects, 11
conditional probability of participation, 160
Conference of Paris, 2
certainty intervals and standard errors, 30, 136
considerable deprivation, 3
constrained diversification ability, 307
constraints, xxxiv, 64, 76, 81, 109, 166, 171, 242, 243, 245, 246, 264, 271, 273, 277, 278, 282, 283, 284, 285, 286, 324
continental, 273
continuing the adaptation process, 6
contract farming, 160, 171, 310
contributing factor, 36, 181
Conway, D., 218, 314
Cool Earth Partnership of Japan, 12
cooperativeness index, 110
CoP11 in Montreal, 2005, 3
CoP7, 2
cope, 273
coral reefs, 272
Corell, R. W., 58, 155
counterfactual framework, 161
counterfactual situation, 160
country-driven approach, 17
Cramer, L., 266
credibility, 275
credits, 244, 276, 310, 326
Crimp, S., 58, 154, 316
crop production sector, 66
Crop Related Strategies (CLRS), 200
crop yields, 79, 242, 272, 324
cross-sectional data, 157
Cruz, R. O., 155
cultural and traditional practices, 79
cultural backgrounds, 276
cultural constraints, 62, 322
Cultural dimensions, 284
cultural practices, 79, 193, 207, 209, 211, 276
Cultural Practices Related Strategies, 200
Culture, 276
Cutter, S. L, 57, 153

D
Dai X.,, 239
Damptey, P. T. M., 265
Daquah, J.A.,, 239
Dasaklis, T.K.,, 315
Dasgupta, A, 285
data verification and cleaning, 115
Dave, R, 80, 220
Davidson, O, 22
Daw, T.,, 315
Dazé, A., 188, 285
death of livestock, 163, 164, 168, 169
Decadal rainfall averages, 66
decision-making, 109, 248
degree of agreement, 277
Degrees of freedom, 283
Dehejia, R.H., 171
Dei, H. K, 240
Dekens, J., 315
Delhi Declaration, 2
Della-Marta, P, 285
dependent variable, 42, 136, 137, 141, 199, 201, 202, 228, 229, 233
Deressa, T. T., 57, 128, 153, 219, 239, 285
designed, 6, 7, 8, 159, 252, 264, 277
Dessai, S., 239, 285
destruction of processing, 297
deterioration of export earnings, 297
determination of choice probabilities, 228
developed economies, 8, 9, 11, 12, 15, 17, 19, 246, 266
developing an adaptation strategy, 6
developing countries., 272
development of improved crop varieties, 275
development programming, 176
developmental agenda, 272
developmental and income generation projects, 56
developmental context, 6
Devkar, T. B.,, 58, 154
DHS, 38, 39, 40, 41, 57
Diagne, A.,, 219
Diagnostic statistics, 283
Diamond, J., 315
Diancoumba, M.,, 264
Diarra, D.Z.,, 264
Dias, M.C., 170
different livelihood systems, 61
Dilys, S.D.,, 264
Ding Y.,, 239
Dinh, Q.H.,, 128
Diouf, A, 82
disappearing short dry spell, 272
disease, 50, 62, 164, 302
disseminate, 274
Divase, G. T.,, 58, 154
divergent approaches, 110
Divisional Delegation for Agriculture and Rural Development, 66
Dobardzic, S, 22
Dokken, D.J, 23
domestic demand for maize, 272
Donahue, K.,, 317
Donkoh, S. A, 56, 152, 219
Doss, C. R., 57, 219
Dougill, A. J., 152, 285
Dovers, S, 23
Dow, K.,, 81
Downing T.E, 22, 23
Drehtaghe, J, 23
drought-resistant crops, 62, 322
Drucker, A., 267
DSSAT model, 262, 263, 264
Dufhues, T., 128
Duflo, E., 171
Dugje, I.Y., 171
Dulal, H. B., 58
Dulvy, N. K., 314
dummy variable, 160, 161
Dumroese, R. K., 155

early warning systems, 5, 18, 275
Ebi, K., 22
ecologically specific, 273
econometric and indicator
techniques, 30, 136
econometric approach, 30, 136,
175
econometric assumptions on
hypothesis, 30, 136
economic sustainability of
farmers, 125
ecosystem management, 7
Edenhofer, O., 265
education on climate change,
277, 283
effects, ix, xxxiii, 1, 2, 3, 7, 8, 12,
17, 29, 62, 74, 108, 131, 137,
139, 149, 158, 167, 171, 174,
192, 193, 195, 200, 204, 206,
208, 209, 211, 215, 224, 225,
228, 233, 234, 240, 242, 248,
251, 256, 266, 291, 295, 296,
298, 302, 307, 308, 310, 313,
321
efficient agricultural
investments, 28, 193
Egyir, I.R., 170
Eiser, J.R., 315
Elliott, J., 317
Ellis-Jones J., 171
Elver, H., 315
emerging themes, 116
emission, 273
empirical model, 141, 201, 229
Enete, A. A, 129, 285
Entsminger, J. S., 155, 221
environmental, ix, xx, xxi, xxii,
xxiv, 3, 6, 8, 10, 12, 14, 16, 20,
61, 63, 66, 76, 109, 110, 127,
139, 145, 153, 158, 159, 170,
189, 200, 215, 227, 237, 238,
245, 250, 252, 253, 265, 266,
289, 291, 299, 305, 314, 315,
325
environmental changes, 61, 64
Environmental Protection
Agency of Ghana, 174
environmentally persistent
threat, 108
environmentally-sensitive
customers, 291, 325
Epouhe, O. F., 266
Eric, G. O., 152
Ericksen, P. J., 315
erratic climatic conditions, 273
erratic rainfalls, 51, 149, 192
error term, 142, 147, 198, 201,
226
Essel, A, 81
Essel, A. K., 265
Ethakadu, O., 81
Etwire, P. M., 57, 128, 153, 170,
188, 189, 218, 219, 239, 264,
265, 266, 285
Evans, E, 57, 153
evapotranspiration rate, 174,
272
ex-ante, 63, 252
exercising power, 274
exogenous variable, 137, 200,
228
expanding the variety of coping
strategies, 7
Expected Poverty, 30
ex-post, 63
exposure, 27, 29, 36, 37, 39, 53,
62, 133, 139, 176, 178, 180,
181, 294, 302, 303, 305, 307,
311, 321, 326
exposure to climatic stresses, 27
extension officer, 114, 118, 202,
274
extension officers, 108, 119, 124,
125, 144, 150
extension personnel, 274
INDEX

F

Fafchamps, M, 128, 219
Faltermeier, L., 171
Fankhauser, S, 22
farm income, 117, 131, 142, 143, 147, 149, 151, 152, 161, 163, 164, 169, 171, 202, 205, 249, 322, 323, 324
farmer-based organisations, 111, 124
farmers, 273
Farming Households, 62, 129
farm-to-market roads, 77, 79
Faruqee, R.R., 171
Fatondji, D.,, 264
Fatuase, A. I.,, 153
FBO membership, 50
Fediw, T.S, 58
feminist intersectional approach, 243, 267
Ferreira, S., 315
Ficke, A.D.,, 315
Field data collection, 66
financial constraint, 274
financial institutions, 145, 215, 276
Fisher, S., 318
fishery ecosystems, 272
Flap, H. D., 128, 130
flood, 18, 41, 42, 48, 161, 163, 168, 169, 191, 203, 207, 216, 217, 284, 323, 326
flood mitigation projects, 18
floods, 15, 18, 30, 31, 35, 41, 48, 52, 54, 68, 132, 133, 134, 137, 139, 149, 158, 174, 180, 184, 192, 200, 203, 297, 307
focus group discussion, 229
Foltz, J. D., 58
Food Agruculrure and Natural Resources Policy Analysis, 153, 219
Food and Agriculture Organisation, 57, 128, 219
Food Production Systems, 62, 82, 317
food shortages, 299
food supply chain, ix, 292, 294, 295, 298, 321, 327
food wholesaling and distribution hub, 299
Forch, C., 266
Ford, J. D, 285
forecast of the rainfall, 275
forest ecosystems, 272
forestry, 7, 10, 14, 79, 80, 128
formal credit, 124, 144, 174, 192, 202, 212, 214, 215, 217, 280, 323
formal education, 70, 71, 144, 174, 182, 209, 280
formal financial market participation, 160
formal institutional index, 110
formulating adaptation projects, 7
Foster, S. O, 57, 154, 189
Fosu-Mensah, B., 153, 219
framework law, 20
Fraser, E. D, 152, 285
Freauhah, B.S.,, 264
Freed, J., 318
frequency of climate variation, 30
Frich, P, 285
Friedkin, N.E., 128
Fussel, H. M., 23, 57, 153
future climate risks, 6, 8

G
Ganzeboom, H, 128
Garcia-Vargas, 265
Gatiso, T. G., 239
Gbetibouo, G. A., 57, 220, 285
GEF, 2, 6, 11
gender, xxi, xxiv, xxxiv, 28, 57,
62, 116, 122, 133, 154, 182,
192, 219, 221, 233, 241, 242,
243, 244, 245, 246, 247, 248,
249, 251, 252, 255, 261, 262,
264, 265, 266, 267, 278, 322,
324, 326
gender-disaggregated, 241, 244,
250, 252, 255, 326
general public health, 7
general trust, 113
Gennaioli, C, 22
geographical locations, 272
Ghana, xvii, xix, xx, xxii, xxiii,
xxiv, xxxiii, xxxiv, 27, 28, 29,
31, 34, 44, 45, 50, 56, 57, 59,
107, 108, 109, 115, 116, 117,
126, 128, 129, 131, 132, 133,
134, 136, 137, 138, 139, 142,
145, 146, 149, 152, 153, 154,
155, 157, 158, 159, 160, 164,
170, 171, 173, 174, 176, 181,
188, 189, 193, 194, 196, 197,
198, 202, 207, 213, 216, 217,
218, 219, 220, 221, 223, 224,
237, 238, 239, 240, 241, 242,
243, 244, 245, 246, 248, 249,
250, 255, 257, 260, 261, 262,
263, 264, 265, 266, 271, 272,
275, 277, 279, 280, 283, 284,
285, 286, 322, 323, 324
Ghana Meteorological Service,
27, 34, 131, 134, 139, 145, 146,
194, 198, 218
Ghana Statistical Service, 57,
132, 154, 171, 220, 239
Githeko, A.,, 170
Githeko, M, 153, 285
Gleason, B, 285
Glennerster, R.,, 171
global, 273
Global Carbon Adaptation Tax,
13
global economies, 272
Global Environment Facility
Trust Fund, 10
Global Environmental Facility, 6
global environmental issues, 6
global warming, 273
globalized food chains, 63
Goh, A. H. X., 265
Goulden, M., 285, 316
government, xxii, 4, 12, 15, 18,
40, 47, 50, 56, 66, 77, 118, 119,
124, 127, 152, 179, 183, 192,
213, 218, 246, 249, 271, 274,
284, 305, 322, 326
government officials, 119, 124
government policies, 249, 271
Granovetter, M, 128
Green Care Association, xx, xxii,
79
Greene, W. H., 220, 239
Greenhouse Gas Emissions, 1
greenhouse gases, 273
Gregory, P.J.,, 316
Griggs D. J.,, 239
GSS, 28, 32, 33, 44, 50, 57, 132,
134, 137, 154, 158, 175, 196,
198, 220, 236, 239, 279, 280
Gujarati, D. N.,, 154
Gunerapal, B.,, 267
Gupta, S. K., 240
Gyamfi, I.,, 171

H
Hahn, M. B.,, 57, 154, 189
Haji, J.,, 130
Halls, A.S.,, 314
Hammill, A, 23
Handmer, J, 23
Hanjra, M. A., 189
Hanson, C. E, 285
Hara, S, 218
Hare, C.A, 80
Harasawa, H, 22
Harvey, C.A, 80
Hassan M, xix, xxxiii
Hassan, R, 57, 152, 153, 170, 188, 189, 218, 219, 220, 221, 239, 240, 264, 265
Hassan, R.M, 57, 170, 189
Hassan, T., 128
Hathie, I.,, 264
Hausman, J. A.,, 239
Haylock, M, 285
Heinrich, C.,, 171
Hepworth, N.,, 316
heteroskedastic errors, 142
high dependence, 272
high poverty levels, 28
high temperatures, 134, 174, 194, 216, 272
High, C., 129
higher education, 119
Hired labour, 142, 150, 202, 214
Hoeschle-Zeledon, I.,, 171
Holden, S., 58, 220
Holvoet, N.,, 265
homogenous, 112
homoscedasticity, 147
horizontal, 113, 313
Houghton H. J.,, 239
household level data, 273
household vulnerability, 273
Household Vulnerability Index, 136
households’ vulnerability to shocks and hazards, 30
Howden, S. M., 58, 82, 154, 317
Hulme, M, 22, 218, 285
Human Development Report, 9, 24
human life, 272
Humphrey, N., 316
Hunter, J.W, 82
Huq, S, 23, 218
Hurricanes Katrina, 299
Huyer, S., 265
hypothesis, 187, 201, 247, 278

I
Idowu, T, 221
impact of technology adoption, 160
impacts of climate change, 273
impersonal, 113
implementation, 2, 8, 10, 19, 168, 248
implementation of climate change strategy, 275
improve farmers’ literacy, 132, 325
improvement in technology, 275
Inaccessibility of health services, 50
Inberg, L., 265
Independence of Irrelevant Alternatives, 233
indicator approach, 30, 31, 57, 136, 175, 176
indigenous adaptation strategies, 63, 126, 192, 200, 201, 209, 210, 212, 217, 224, 237, 249, 265, 322, 323, 324
indigenous and new technologies, 191
individual interactions, 274
informal institutional index, 110
information communication technology, 160, 170
Ingram, J.S.I.,, 316
insect/pest attacks, 74
insecticides, 124, 208, 215
Institute of Statistical, Social and Economic Research (ISSER), 108, 128
institution, 273
institutional constraint, 274
institutional economics, 110
institutional factors, 144, 243
institutional structure, 276
institutionalized power, 113
intellectual capacity, 275
intense, 273
intensification technologies, 160
interaction among individual farmers, 109
interconnects stakeholders, 274
interdependence of agents, 108
INDEX

interest rate, 322
Intergovernmental Panel on
Climate Change, 1, 29, 35, 57, 80, 81, 82, 128, 153, 154, 170, 220, 264, 272, 316, 318
International Air Passenger, 13
International Climate Initiative (ICI) of Germany, 12
International Institute for Environment and Development, 81, 318
International Institute for Sustainable Development, 305, 310, 316
International Maritime, 13
International Trade Center, 311, 316
intrinsic sensitivity, 294
introduced adaptation strategies, 123, 126, 127, 213, 322
IPCC Fourth Assessment Report, 13
Iqbal, M.M, 82, 317
irrigation and hydroelectric development, 3
irrigation techniques, 275
Isik, M.,, 266

J
Jalloh, A.,, 82
Johnson, C. A., 239
Johnson, C.,, 58
Johnston, D.,, 315
Jolly, C.M.,, 153
Jones, E. M.,, 266
Jones, R. N.,, 239
Jordan, J., 129
Jost, C.,, 265
journalists, 118, 119
Juana, J. S.,, 58

K
Kabat, P, 285
Kabeer, N, 128
Kahaka, Z.,, 58
Kakota, T.,, 266
Kalinda, T.,, 240
Kamara, A.Y.,, 171
Kambewa, E.V.,, 316
Kanaroglou, P.,, 317
Kankam-Yeboah, K, 154, 220
Kanton, R.A.L.,, 171
Kaplinsky, R, 316
Karki, L. B.,, 239
Kasper, J.X., 189
Kasper, R. E.,, 58, 155, 189
Kates, R.W, 23, 25
Kelly, P. M.,, 58
Kendall’s coefficient of concordance, 277, 278
Kenneth, W. S.,, 152
key informant interview, 229
Khan, A.,, 239
Khan, R. U.,, 239
Khan, S. U.,, 239
Khandker, R.S, 171
Khanna, M.,, 266
Kianjun, J.,, 266
Kihila, J. M, 239
Kinyangi, J.,, 265
Kii, T., 23, 24, 81
Klein, T. R, 57, 153
Klastermann, J. E, 285
K-means cluster analysis, 107, 116, 126
Knorr, W.,, 189
Kogi-Makau, W.,, 266
Kokic, P., 58, 154
Kolawole, D.O.,, 81
Kombiok, J.M.,, 171
Konlan, S. P.,, 240
Koomson, E.,, 264
Koru, B.,, 58, 220
Kremer, M.,, 171
Kristjanson, P., 266
Kruse, S., 264
Kumar, A.,, 240
Kumar, S. N.,, 266
Kuntashula, E.,, 240
Kunzekweguta, M.,, 220
Kurukulasuriya, P., 240
Kuwornu, J. K. M., 57, 128, 152, 188, 189, 221, 239, 264, 265, 266, 285
Kyazze, F., 265
Kyoto Protocol, 2, 11, 13, 16, 17, 24

L

La Rovere, E.L, 22
labour intensive, 212, 279
Lacetera, N., 240
lack of a ready market for produce, 271, 282, 283, 284, 324
lack of access to credit, 271, 282, 284, 310, 324, 326
lack of appropriate climate data, 275
lack of appropriate storage facilities, 276
lack of market for farm produce, 276
lack technical and financial abilities, 8
Lamboll, R., 318, 328
land use, 274
Larbi, A., 171
large-scale agriculture, 3
Lasco, R. D., 155
Leary, N.A, 23
Least Developed Countries Fund, 10
least pressing, 277
Lebailly, P, 129
Lee, K.M., 318
Leemans, R., 317
legality, 275
Lennard, C., 81
level of experience, 273
Lewis, G., 316
likelihood ratio, 147, 201
Lim, B, 23
Lim-Camacho, L., 316
Lin, N., 129, 130
linear random utility model, 198, 227
Livelihood and Food Security Trust, 30
livelihood diversification, 4, 56, 302
livelihood strategies, 272
livelihoods resilient to climate change, 63
livestock rearing, 76, 79, 80, 111, 235
Lizaso, J.I, 264
loan lending, 109
Lobell, D.B., 82, 317
local communities, 171, 274
local knowledge, 273
logistic cumulative distribution, 161
Logit, 152, 162, 167, 191, 199, 200, 202, 248
London Assembly Economy Committee, 316
longer dry season, 68, 272
long-term climate change, 273
Lorenzoni, I, 285
loss of biodiversity, 232
loss of vegetation cover, 273
Lotze-Campen, H., 265
low soil productivity, 272
low technical know-how, 276
Luxon, N., 81
Lynne, G.D., 127

M

MacCarthy, D., 153, 219
MacCarthy, S., 264
MacFadyen, G., 317
Mackinnon, J, 80
MacRae, R., 317
Maddison, W. P., 220
Madhuri, S. R., 58, 154
Madsen, P., 155
Madukwe, M. C., 129
Maffioli, A., 171
Maize, 65, 163, 164, 169, 170, 175, 221, 239, 251, 254, 272, 281, 286, 300
major component, 35, 36, 37, 44, 45, 50, 51, 52, 140, 141, 177, 181, 183, 184, 186
maladaptation, 75, 311
Malone, E, 23
Mandleni, B., 129, 154, 220
INDEX

Mangheni, M., N., 266
Manyatsi, A., 154
Maoh, H., 317
marketing channel, 276
Marrakesh Funds, 2
Marshall, N., 284
Martin, P, 58, 154
Martin-Lopez, B., 267
Mashingaidze, N., 220
Maskell K., 239
Masuku, M. B., 154
Masvaya, E. N., 220
Matson, P. A, 58, 155
maximum disagreement, 277
maximum likelihood estimates, 142, 167
maximum variance, 278
Mavzimavi, K., 220
Mbakayha, G. M., 220
McCarthy, J. J., 23, 58, 155
McClure, J., 315
McNeeley, S.M, 22
Mean Annual Rainfall, 66
measurement, 141, 275
mechanisms, 6, 107, 108, 109, 115, 159, 243, 257, 274, 275, 310, 312, 322
Medany, M., 170
Mednay, M, 285
Mehmood, S., 239
Meigh, J.R., 58
Meinke, H., 58, 154
Mendelsohn, R., 240
Mendola, M., 171
Mensah-Bonsu, A., 221
meteorological agencies, 275
meteorological information, 277, 283, 284
meteorologists, 119
Metzger, M.J., 317
Micro-financing, 64
Microsoft Excel, 66
Midgley, G.F., 81
Minani, B., 129
Minia, Z., 221
Ministry of Energy, Science, Technology and Innovation, 28
Ministry of Food and Agriculture, 118, 124, 129, 151, 154, 189, 198, 221, 238
Ministry of Trade Industry and Cooperatives, 305
mismatch coding and omissions variables, 115
mitigation and adaptation, 1, 18, 321
mitigation measures, 2
mixed methodology, 107
Mkwbambisi, D., 266
Mmopelwa, G., 81
models, 273
moral obligation, 112
morbidity, 3, 296
Morlot, J. C, 22
Morris, M., 57, 219, 221, 316
mortality, 3, 296
Morton, J. F., 58, 154
Moser’s Assets Vulnerability Framework, 30
most pressing, 277, 282, 283, 284, 324
Motsholapheko, M.R, 81
Moussis, N, 317
Müller, C., 317
Mülleris, B., 82
multinomial logit, 136, 191, 192, 201, 208, 224, 227, 228, 229, 233, 238, 249
multinomial logit model, 136, 191, 201, 224, 227, 228, 233, 249
multinomial probit, 110, 228
multi-stage, 33, 115, 131, 138, 159, 191, 198, 225, 277
multi-stage sampling technique, 33, 115, 131, 138, 159, 182, 191, 198, 225
multi-stakeholder dialogues, 306
Munasib, A, 129
Municipality, 27, 32, 33, 34, 42, 43, 44, 45, 50, 51, 52, 53, 54, 55, 56, 131, 134, 136, 137, 138, 139, 146, 147, 149, 151, 173, 191, 194, 195, 196, 197, 198, 206, 212, 217, 277, 278, 279, 280, 282, 283, 284, 323, 325
Mureithi, D, 129
Mvumi, B.M., 318, 328
Myrick, C.A, 315

N
N’diaye, O.,, 264
Naab, J.,, 265
Naess, L. O.,, 266
Nakhoda, S, 23
Nakuja, T.,, 266
Nam, P.,, 129
name generator instrument, 114
Narayan, D, 130
Nardone, A.,, 240
Nath, P. K.,, 266
national, 273
National Adaptation Programs of Action, 10
national aggregates, 273
National Agricultural Extension and Research Programme, 78
National Agricultural Statistics, 110
National Climate Change Policy, 18, 29
national development strategy, 7
national economy, 7
nationally appropriate
mitigation actions, 241, 244, 255
Natural and man-made systems, 321
natural disasters, 27, 29, 31, 35, 48, 52, 55, 57, 134, 140, 146, 153, 173, 176, 180, 184, 188, 247, 284, 321, 326
natural resources, 272
Ndiema, A. C., 220
Neelormi, S.,, 265
negative effect, 151, 272, 322
Nelson, D. R, 189, 285, 286
Nelson, R., 58, 154
Nelson, S.,, 265
New York City Economic Development Corporation, 299, 317
Newton, K., 129
Ngigi, M. W.,, 129
Ngombe, J.,, 240
Ngwenya, B. N, 81
Nhemachena, C.,, 220, 239, 240
Niang, A, 153, 285
Niang, I.,, 81, 170
Nicholson-Cole, S, 24
Nishioka, S, 22
Nkondze, M. S.,, 154
Nkonya, E.,, 154, 221
Noguer M.,, 239
non-climate drivers and stressors, 62
non-conventional, xxii, 20, 79
non-farm income, 132, 163, 168, 325
non-governmental organizations, ix, 284, 326
normally distributed, 141, 326
norms, 112, 113, 243, 245, 247
Northern region of Ghana, 27, 28, 32, 133, 191, 321, 323
Nti, F. K., 154
numeric scale, 277
Nyamangara, J.,, 220
Nyariki, D.,, 266
Nyborg, I.P.,, 189
Nyengerai, K.,, 220
Nyong, A, 170, 285
Nyong, C.,, 153
Nzuma, J., 171

O
O’Brien, K, 284, 285
Obayelu, O. A.,, 221
Odej, J. O.,, 155
OECD, 9, 14, 17, 23, 62, 63, 74, 75, 78, 81
Official Development Assistant, 9
Okali, C.,, 266
Okello, J., 171
Okesse, Y.A, 22
Okurut, F. N., 58
Olaniran, OJ, 81
Oliver, C.,, 267
Omisope, E. T.,, 153
Omonona, B. T., 219
Onokala, P.,, 129
Onumah, E. E.,, 155
operationalizing individual network social capital, 116
ordered multinomial logit regression, 136
Organization for Economic Co-operation and Development, 81
Osei-Owusu, Y, 57, 153, 188, 189, 219, 264, 265, 266, 285
Osman-Elasha, B., 170
Other Related Indigenous Strategies, 200
outcome variables, 157, 160, 161, 163, 323, 324
out-migration, 45, 56, 325
Owusu, V., 171
Oxfam, 9, 14, 23, 189, 294, 317
Ozor, N., 129

P

Padaria, R, 266
Padgham, J., 81
Palik, B. J., 155
Palutikof, J. P, 285
Pappis, C.P., 315
paramount traditional ruler, 79
Parikh, K, 22
Paris Agreement, 17, 18, 24, 80, 82
Parry, J.E, 23
Parry, M. L, 22, 285, 287
Pascula U., 267
past farm experiences, 275
Paterson, J, 285
Paton, D., 315
Patt, A.G., 82
Paudel, G.S., 189
Pauw, P., 317, 328
peasant farmers, 134
Pegels, A., 317, 328
Pelling, M, 129
Perez, C., 155
Perez, C., 266
periodic, 275
Perrin, N, 285
Perry, A., 314
Personal resources, 112
Pest, 62
pest outbreak, 284, 326

Peterman, A., 154, 221
Peterson, T, 285
Pettengell, C., 189
petty trading, 76
Pielke, R A, 23
Pilifosova, O, 23, 82
Pilling, G.M., 314
Pilot Program for Climate Resilience, 11
Pius, C, 81
planned, 2, 63, 327
planting distances, 124
policy environment, ix, xxxiii, 307
poor extension services., 271
Poor people, 273
poor physical infrastructure, 276
poorer economies, 8
poorest continent, 9
poorest countries, 273
Population and Housing Census, 57, 154, 220, 278, 286
population displacement, 3
Porter, D. C, 154
Porter, J.R, 82, 317
position generator instrument, 114
Poulton, C., 152
poultry farming, 76
poverty, 272
poverty eradication, 2
precipitation, 31, 42, 48, 52, 62, 66, 68, 70, 164, 175, 253, 254, 298, 299, 300, 302, 303
Prentice, I. C, 189
pre-participation characteristics, 160
Preston, B.I., 81
pre-tested, 277
primary data, 27, 31, 34, 115, 131, 139, 181, 191, 198, 225, 271, 277, 284
principal components analysis, 31, 110
principal constraints, 283
principal hindrances, 275
private, xx, 2, 63, 129, 289, 301, 305, 310
probability of information flow, 120
Probit, 199, 228, 239
procedural, 275
Programme for the
Improvement of
Competitiveness of Family
Agro-pastoral Farms, 78
projects to support farmer
adaptation, 157
Prolois, C, 80
propensity score matching, 157, 160
pseudonyms, 116
public, 2, 4, 7, 58, 63, 124, 129,
155, 221, 289, 301, 303, 305,
310
Pulhin, F. B.,, 155
Pulhin, J. M.,, 155
Putnam, R.D., 129
Putnam’s concept of social
capital, 112

Q
questionnaire, 34, 57, 66, 70,
115, 116, 131, 159, 181, 182,
191, 224, 250, 277
Quintero-Angel, 265
Quisumbing, A. R., 154, 155, 221
Qureshi, M.E., 189

R
Rabarijohn, R.H.,, 80
Rahman, A.A, 22
Rajaofara, H, 80
Rakotobe, Z.L., 80
Ranieri, M. S.,, 240
rankers, 282, 283
ranking, 277, 278, 284
Rao, N.S.,, 80
Rashid, M.,, 266
Ravallion, M., 171
Ravera, F.,, 267
Razafimahatratra, H.,, 80, 220
reactive, 2, 63, 313
Reddy, V.R.,, 318
reducing vulnerability to long-
term climate change, 6
Regional analytical report, 278
regression analysis methods, 30,
136
regression model, 131, 132, 136,
142, 147, 167, 249
Regulatory, physical and market
drivers, 291, 325
relative humidity, 272
relevant indicator of social
status, 115
Ren, L., 154, 220
Requena, F., 129
research institutions, 152, 218,
274
research-based agronomic
practices, 144
resilient to climatic shocks, 284,
326
respondents, 50, 52, 70, 71, 107,
114, 115, 116, 117, 119, 121,
122, 123, 125, 126, 139, 143,
144, 145, 165, 166, 173, 182,
184, 185, 207, 225, 277, 280,
282, 283, 284, 326
Reyes, R. R., 267
Reynolds, J.D.,, 314
Rhodes, E.R.,, 82
Riederer, A. M.,, 57, 154, 189
Ringius, L, 22
Ringler, C, 57, 128, 153, 219, 239,
285
rise in sea level, 174
risk management, 7, 125, 295,
301, 304, 327, 328
risk of extinction, 108
risks, 5, 8, 14, 57, 64, 78, 80, 154,
158, 185, 189, 204, 220, 242,
244, 276, 297, 298, 299, 300,
301, 304, 305, 306, 307, 308,
310, 312, 314, 328
Robinson, J, 22
robust standard error, 147
Rodenberg, B., 267
Rogers, E.M.,, 129
Ronchi, B.,, 240
Rosenbaum, P. R.,, 171
Rothman, D, 22
Rotter , R.,, 240
Rounsevell, M.D.A.,, 317
Rubin, D.R.,, 171
Ruppel, O.C, 81
rural livelihoods, 61, 63
Rurema, D., 129
Ruxton, G. D., 58

S

Safo, E., 153, 219
sampling, 33, 34, 107, 115, 131, 138, 159, 181, 182, 191, 198, 225, 247, 277
Sandy, 299
Sarpong, D. B., 170, 221
Sasaki, N., 152, 264
Saxena, A., 267
Scarborough, H., 170
Schalatek, L., 3
Scholze, M., 189
Schröter, D., 82
Schwarteis, C., 82
Scientific, 273
scientific and policy debate, 1
scientific technologies, 274
Seasonality Index, 66, 67
Semenza, J., 22
semi-arid environment, 231
semi-structure, 224
sensitivity, 27, 29, 30, 31, 36, 37, 53, 62, 134, 139, 174, 176, 180, 181, 186, 192, 248, 265, 272, 294, 321, 326
Shah, I. A., 239
Shah, U. K., 58
Shannon, D.A., 153
Sharmais, A., 82
Shaw, M.R, 81
Shisong, Strategic Humanitarian Services, 79
significance, 163, 164, 167, 187, 201, 234, 278, 283
significant statistical difference, 29
Simane, B., 58
Simelton, E, 285
simple random sampling, 115, 139, 226
Singh, S. V., 240
Sitaula, B.K., 189
Skinner, M.W, 24
smallholder farmers, xxxiii, xxxiv, 28, 29, 80, 107, 108, 109, 126, 127, 131, 132, 139, 157, 159, 174, 175, 192, 206, 215, 220, 241, 243, 244, 245, 246, 247, 248, 249, 256, 260, 262, 264, 266, 318, 322, 323, 324, 328
smallholder maize farmers, xxxiv, 136, 146, 248, 271, 273, 277, 278, 279, 280, 283, 284, 324, 326
Smit, B, 23, 24, 82
Smith, T.M., 318
Smithers, J, 24
smooth flow, 274
Snijders, T.A., 130
Sobel, J., 129
social bonding, 274
social capital, 107, 109, 111, 129
social capital indicators, 110
social distance, 113, 116, 126
social disturbance, 3
social group, 40, 174, 280
social network, 27, 50, 52, 55, 112, 114, 146, 321
social obligations, 111
social relationships, 110, 119, 125, 126, 322
social resources, 112, 115
social values, 112
society, ix, 2, 3, 6, 7, 8, 24, 112, 113, 115, 119, 123, 125, 157, 158, 232, 242, 246, 291
socio-demographic profile, 27, 31, 35, 44, 52, 55, 140, 143, 146, 176, 182, 321
socioeconomic, ix, 8, 76, 107, 115, 121, 126, 162, 192, 200, 227, 237, 243, 272, 285, 305, 322
Sociologists, 115
Soil Related Strategies, 200, 207, 210
Sokona, Y, 22
Song, J.S.,, 318
Spanger-Siefried, E, 23
Special Climate Change Fund, 2, 10
stability, ix, 74, 108, 297
Standard Deviation, 66, 67, 143
standard international occupational prestige Scale, 115
standardize, 35, 140, 176
Stanturf, J. A.,, 155
state of the art equipment, 275
Stathers, T.,, 318, 328
Stern Review., 318
Stern, N, 24
Strategic Climate Fund, 11
Strategic Priority for Adaptation, 10
Stringer, L. C., 152, 285
strong ties, 113, 119, 120
Students’ t-test, 42
Stults, M, 22
sub-components, 31, 35, 36, 37, 43, 44, 45, 50, 51, 52, 140, 141, 176, 177, 182, 183, 184, 186
Sub-Saharan, 56, 61, 63, 219, 241, 247, 249, 265, 274, 275, 276, 282
Sub-Saharan Africa, 275
Sub-Saharan African, 247, 274, 276
substantial crop yield reductions, 272
suitable policies, 273
Sullivan, C, 58, 155
sum of ranks, 277
sunshine duration, 272
supplementary activities, 76
supply chain, ix, xxxiv, 289, 290, 291, 292, 294, 295, 296, 298, 299, 300, 303, 304, 305, 307, 308, 310, 311, 312, 313, 314, 316, 318, 319, 325, 327, 328
supporting production resources, 28, 193
survey data, 110
susceptible to climate variability, 29
Sussman, F.,, 318
sustainability of a natural system, 76
sustainable crop production, 273
sustainable development, xxiv, 6, 10, 21, 22, 301, 327
Sustainable Livelihoods Approach, 176
sustainable practices, 79, 251
sustained levels, 273
system’s susceptible, 29
Szreter, S., 129

T
Tabbo, A. M., 240
Tabo, R.,, 170
Tacoli, C.,, 318
Tank, A. K, 285
Tapia, M. A. (2006), 155
Tapio-Biostrom, M.,, 265
Tate, E.,, 57, 153
Tazeze, A.,, 130
Techiman, 136, 271, 277, 278, 279, 280, 282, 283, 284, 326
technological constraint, 276
Technology, 1, xviii, xix, xx, xxiii, xxv, 6, 11, 28, 219, 221, 239, 265, 275, 312
Tekade, A. R, 58, 154
Teli, I.A.,, 171
Tembo, G.,, 240
temperature patterns, 145, 194, 275
Tenth Malaysia Plan, 18
Termeer, C. J, 285
terrestrial, 74, 108
tertiary education, 117, 280
Teye, J., 153, 219
Teye, J.K., 240
*The magnitude of the impact*, 295
theory of social capital, 111, 119
Third Assessment Report, 1, 154
Thomas, J.P, 22
Thorlakson, T., 82
Thornton, P. K., 266
threshold, 67
Tigana, L., 264
Tilburg, X.V., 171
times of planting, 124
Tiwari, K.R., 189
TOA-MD model, 250, 252, 265
Tobin, J., 155
Tobit, 131, 132, 136, 141, 142, 147, 148
Tobit model, 136, 147
Tompkins, E.L, 24
Töpfer, K., 82
traditional coping strategies, 273
traditional knowledge, 18
transport infrastructures, 297
transportation, 7, 218, 300, 311, 317, 327
Traore, P.C.S., 264
Traore, S., 264
Travasso, M.I., 82, 317
Treiman, D., 128
trust index, 110
Tume, S.J.P., 82
Turner, B. L., 58, 155
Tweneboah, C. K, 189
Tyani, L, 22

**U**

Uddin, M. N., 155, 221
UK’s Climate Impacts Programme, 3
UKCIP, 2, 24
Umbrella model, 30
unable to adapt to the negative impacts of climatic stresses, 30, 134
UNDP, 2, 6, 9, 14, 23, 24, 35
UNFCCC, 1, 7, 9, 10, 11, 14, 16, 17, 19, 24, 63, 82, 321
United Nations Department of Economic and Social Affairs Division for Sustainable Development, 3
United Nations Framework Convention on Climate Change, 1, 24, 82, 321
United Nations General Assembly, 176
United States, 17, 220
unreliable nature of natural water sources, 51
Upadhyay, R. C., 240
Upper Nun Valley Development Authority, 78
Urquhart, P., 81
utilization, ix, 112, 248

**V**

Valdivia, R.O., 264
valuable input to National Communications, 7
value systems, 276
valued good, 112
van Brakel, M., 314
van de Geijnm S.C., 240
Van Der Gaag, M, 128, 130
Van Der Geest K., 59
van der Linden, P. J, 239, 285
van der Pligt, J., 315
variability, ix, xxi, xxiv, xxxiii, 2, 6, 8, 23, 24, 27, 28, 29, 30, 31, 34, 35, 37, 43, 44, 48, 49, 52, 54, 55, 56, 57, 58, 61, 62, 63, 66, 67, 75, 76, 79, 131, 132, 133, 136, 137, 139, 140, 141, 143, 146, 147, 148, 149, 150, 151, 152, 153, 154, 157, 158, 164, 170, 173, 174, 175, 176, 181, 182, 183, 184, 186, 187, 188, 189, 191, 192, 193, 196, 199, 200, 202, 203, 204, 205, 206, 207, 208, 211, 212, 213,
INDEX


Variance Inflation Factor, 233
variation in climate, 272
variation in the rainfall pattern, 272
Vázquez, G., 171
Vlek, P, 153, 219
Vogel, C, 170, 285
Vogel, M.,, 153
volunteering action, 113
vulnerabilities to climate, 2
vulnerability contributory factors, 42, 54
vulnerability indicators, 29
vulnerability of mixed crop farming households, 32
Vulnerability Spider Diagram, 53

W

Wabba, S., 171
Wainaina, W.,, 171
Walsh, R.P.D., 82
Wandel, J, 24
water conservation, 62, 123, 124, 160, 171, 247, 321
water resources, 7, 56, 241, 248
water scarcity, 192
water shortage, 51
Waughray, D, 22
weak ties, 113, 114, 116, 119, 120, 125
Weatherhead, K, 24
weed, 62
well-timed prediction, 275
Wenchi, 136, 271, 277, 278, 279, 280, 283, 284, 326
wetlands, 272, 303
Wheeler, T.,, 318
White, A, 318
White, K.S, 23
White, M.,, 315
WHO/RBM, 39, 40, 59
WHO/Roll Back Malaria, 59
Wilbanks, T.J, 25
Williams, M. I.,, 155
wind speed, 272
Winkler, J, 82
Winter-Nelson, A.,, 266
Wise, D. A.,, 239
withstand, 30, 131, 274, 295, 327
Wodon, Q, 56, 219
Wolski, P.,, 81
women farmers, 28, 56, 133, 149, 152, 192, 193, 216, 217, 241, 242, 249, 260, 324, 326
Woolcock, M.,, 129, 130
World Bank, 8, 9, 11, 13, 14, 25, 39, 40, 41, 56, 59, 130, 134, 155, 164, 171, 174, 189, 192, 219, 221, 298, 319
World Climate Change, 13
WorldFish Center., 319
Woudsma, C.,, 317
Wreford, A, 285
Wu, J. J., 240
Würtenberger, L.,, 171

X

Xiaomin, W.,, 266
Xie, L.,, 82, 317

Y

Yanda, P.,, 170, 285
Yang, H.,, 319
Yaro, J. A.,, 153, 219, 240
Yengoh, G. T.,, 155
Yesuf, M, 57, 128, 153, 219
Yiwei, G., 266

Z

Zaitchik, B. F, 58
<table>
<thead>
<tr>
<th>Name</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zake, J.</td>
<td>319</td>
</tr>
<tr>
<td>Zhang, J.</td>
<td>319</td>
</tr>
<tr>
<td>Zhao, Y.</td>
<td>130</td>
</tr>
<tr>
<td>Zoughmore, R.</td>
<td>265</td>
</tr>
</tbody>
</table>