University of Reading

Assessing vulnerability and adaptation of rice value chains to multiple, combined pressures in Benue State, Nigeria

A thesis submitted for the degree of Doctor of Philosophy (Human Geography)

School of Archaeology, Geography and Environmental Science

Fanen Terdoo

September, 2018

Declaration of Original Authorship

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Fanen Terdoo

Abstract

The rice value chains (RVCs) in Nigeria are vulnerable to combined multiple climatic, and economic pressures. Yet existing research has rarely studied how climate change and variability (CCV) and other pressures simultaneously impact RVCs, and has overlooked parts of the value chain other than production. To fill this gap, a synchronic baseline assessment of the complexities of the RVCs in Benue State, Nigeria, was conducted.

Two complementary approaches, namely Vulnerability Scoping Diagrams (VSD) and Participatory System Mapping (PSM), were used. Data sets were drawn from face-to-face (n=72) and six workshops (n=36) interviews with RVCs actors (growers, millers, and traders) in three study sites. The VCD framework helped examine in detail the RVC systems' components of exposure and sensitivity, and also the adaptive practice of the various actors to multiple, combined pressures. The PSM, using stock and flow diagrams, helped elicit the RVCs systems' component maps based on the perspectives held by the various actors in the chain.

This study uncovered that millers and traders in Benue State are more exposed and sensitive to economic pressures than to prolonged wet conditions, high moisture contents or excess dryness of the rice, and water scarcity, the effects of which may have been exacerbated not only by CCV but also by their continuous use of artisanal milling technologies, selling decisions and social distinctions (e.g., educational level and practical experience in rice milling and trading). This study showed that these pressures do not only result in poor rice yield and milling quality, but also limit the ability of the domestic rice industry to effectively compete in a market whose demand is driven by quality.

Regarding their response to pressures, this study found that RVC actors employed a number of adaptive practices that, instead of reducing their exposure and sensitivity to pressures, result in maladaptation outcomes which increased them, as most of the practices are reactive and short-termed, often unplanned and individually employed. Moreover, these practices were characterised by trade-offs and uncertainties which were often inadequate to offset the magnitude of recent pressures and which tend to occur rapidly and on a large scale (e.g., flooding and price crashes).

Accordingly, the study has identified seven entry points for a reduction in the vulnerability and resilience building of rice RVCs' actors to multiple, combined pressures. These include the need for: (i) information, both short- and long-term, to help with publicity and the diffusion of promising adaptive practices more widely; (ii) adoption of anticipatory, or preventive and long-term adaptive practices; (iii) more planned adaptive practices; (iv) scaling up the adoption of collective adaptive practices and coordination; (v) upgrading rice milling technologies and infrastructure; (vi) assessing

trade-offs between different adaptation practices and the cost implications; and (vii) addressing uncertainties regarding the pressures themselves, policy options, and certain adaptation practices in the study region.

In addition, this study has revealed specific ways in which PSM can build resilience in the RVCs, which are: (i) the promotion of social learning about the RVC system through the visualisation of system structures, challenges and opportunities; (ii) information for better decision-making at either individual or group level, through the uncovering of connections and interdependencies between value chain subsystems and, also as a result of the above points (iii) the promotion of community problem solving, through the establishment of a collective space and collaboration platform, and a common language and understanding of the value chain and its vulnerability and potential for change.

This study suggests that research needs include: (i) an assessment as to whether trade-offs between adaptation and costs really do form the bedrock of adaptation practices employed by rice growers, traders, and millers in response to CCV, economic/markets in the study region, and whether actors have adequate information to make adaptive decisions that entail trade-offs; (ii) the development of a fully-fledged quantitative system dynamics model, where different adaptation options can be evaluated, possibly in a participatory manner; and (iii) an investigation of the constraints to the adoption of collective adaption practices by growers in the study region; collective actions may be important to help growers build synergy and pool resources together in response to pressures, in the absence of government support.

Acknowledgements

Before and during the period I have undertaken this research project, I have received guidance, support and encouragement from many people in the UK and in Nigeria, without which this thesis would not have been completed. I think first of my primary supervisor, Dr. Giuseppe Feola, a man I first contacted online on the 7th of August back in 2012, when I started thinking of studying abroad. He motivated and inspired me to undertake the PhD in the first place, and throughout the period of my research he has offered and provided unequalled support and encouragement. I feel privileged to have studied under you, and I remain most grateful for the opportunity. My appreciation also goes to Dr. Geoffrey Griffiths, my second supervisor, and Dr. Nicholas Branch, the chair of my research advisory panel, for their unwavering support throughout the period of my research project. I am also grateful to the staff and the Head of the Department of Geography and Environmental Science, Dr. Steve Musson, for the opportunity I have been given to learn and to participate in the field and in demonstration classes.

This study would not have been possible without funding from the Tertiary Education Trust Fund (TETFund), Federal University Dutsinma (FUDMA), Katsina State, Nigeria. I am grateful for the support I received from the then Vice Chancellor, Prof. James O.I. Ayatse, and the Registrar, Muhammad Yusufu Abubakar who approved my study fellowship at Reading. I am equally grateful to the Ag. Vice chancellor, Prof. Armiya'u Hamisu Bichi, and Registrar, Aliyu Dalha Kankia , the past and present Head of the Department of Geography and Regional Planning, Prof. Ojonigu Friday Ati, and Dr. Andrew Ubogu and my colleagues at FUDMA for their continuous support.

I sincerely appreciate all who have participated in this research by giving their valuable time during the fieldwork. Without your contribution, this research would not have been completed. I am thankful to Dr. Angol and Barrister Stella Naswem and their children for their friendship and care while in Makurdi. I must also thank Akumba Jeremiah Terhumba and Terseer Disha, my worthy field assistants, for their service. I must not forget to thank Dr. Godwin Akpehe of the Department of Sociology, Benue State University, Makurdi, and Engr. Kenneth Achan and the staff of MIKAP Nigeria Limited, Makurdi, for offering me valuable information and connecting me with other participants.

Here at Reading, I wish to express my gratitude to the Wycliffe Baptist Church family for their love and care. My research and family experience in Reading would have been much more challenging if not for the love, care, and support of Engr. Simon and Dr. Jillian Bird, and their children, Joanna, Andrew, and Matthew. This family supported us in so many ways that I cannot mention them all here. My family and I are highly indebted to you all. I also think it necessary to thank Mr. Walter and Manya Chung and their son, Paul, for their friendship and care, while not forgetting Kenneth and Helen Craig and their children, Hannah and Benjamin, for their friendship and care also.

My family here with me and in Nigeria have been very supportive. My profound appreciation goes to my wife, Shagbakwase, and our children, Daniel Terkuma and Lunen Elizabeth, for their unwavering support, love, patience, and understanding. I am also grateful to my parents, Mr. and Mrs. Terdoo and Dooshima Ityokase, my mother-in-law, Mrs. Winifred Korna and brothers and sisters for their support in many kind ways. I must also mention here Dr. Felicia Ayatse and her family for their encouragement and support.

I cannot forget to acknowledge Prof. A.A. Adepetu, who constantly encouraged me to further my academic pursuit. Similarly, I am also thankful to my uncle, Dr. Terzungwe Nyor and his family for supporting me through all my academic pursuits. My undergraduate friend, Dr. Olalekan Adekola is also appreciated for his support. There are a host of others who have made invaluable contributions to my completion of this thesis, although you are not mentioned by name, you are all highly appreciated.

Finally, to God, the blessed and only Ruler, the King of kings and Lord of lords, who alone is immortal and who lives in unapproachable light, whom no one has seen or can see. By whose mercies, graces, and numerous help alone am I able to come through this journey of several years amidst many challenges. To HIM alone be the glory, honour, and might forever.

Table of Contents

Declaration of Original Authorship……………………………………………………………………i

Abstract……………………………………………………………………………………………………ii

Acknowledgements…………………………………………………………………………………… iv

Table of Contents…………………………………………………………………………………………… vi

List of Tables……………………………………………………………………………………………xiii

List of Figures……………………………………………………………………………………………xvi

List of Appendices…………………………………………………………………………………… xix

Chapter 1: Introduction…………………………………………………………………………… 1

1.1 Background to the study problem……………………………………………………………………1

1.2 Aim and objectives………………………………………………………………………………………… 3

1.3 Structure of this thesis………………………………………………………………………………………4

Chapter 2: Literature Review……………………………………………………………………… 5

2.1 Introduction………………………………………………………………………………………………… 5

2.2 Theoretical Background and Methods………………………………………………………… 6

2.2.1 Theoretical Background and Definitions of Key Concepts……………………………… 6

2.2.2 Literature Selection……………………………………………………………………………… 8

2.2.3 Analysis... 9

2.3 Results 9

2.3.1 Literature Characterization……………………………………………………………………… 9

2.3.2 Vulnerability of Rice Value Chains in Sub-Saharan Africa……………………………… 10

2.3.2.1 Rice Value Chains and Climate Change and Variability…………………………… 10

2.3.2.2 Rice Value Chains and Economic Globalization…………………………………………14

2.3.3 Development Policies and Vulnerability of Rice Value Chains………………………… 16

2.4 Conclusion ……………………………………………………………………………………………… 21

Chapter 3: Methods…………………………………………………………………………………………………. 24

3.1 Introduction……………………………………………………………………………………………………24

3.2 Description of key concepts…………………………………………………………………………………24

3.2.1 Rice value chains ……………………………………………………………………………………24

3.2.2 Vulnerability…………………………………………………………………………………………. 25

3.2.3 Resilience……………………………………………………………………………………………..26

3.2.4 Adaptation ……………………………………………………………………………………………27

3.3 Approaches to assessing vulnerability of rice value chain (RVC) system……………………………28

3.3.1 Vulnerability scoping diagram (VCD)……………………………………………………………… 28

3.3.2 Participatory system mapping (PSM)……………………………………………………………30

3.4 Research design…………………………………………………………………………………………….30

3.5 Selection of study the sites…………………………………………………………………………………31

3.6 Methods of data collection………………………………………………………………………………… 32

3.6.1 Exploratory fieldwork………………………………………………………………………………32

3.6.2 Data needs to populate the VSD and generate the PSM……………………………………… 33

3.6.3 Sampling procedures: snowballing sampling………………………………………………………34

3.6.4 Sample size ………………………………………………………………………………………… 34

3.6.5 Interviews…………………………………………………………………………………………… 35

3.7 Participatory rice value chain system mapping workshops………………………………………………37

3.7.1 Stakeholders' identification …………………………………………………………………………. 38

3.7.2 Workshops…………………………………………………………………………………………… 39

3.8 Data analysis and presentation………………………………………………………………………………42

3.8.1 Transcription………………………………………………………………………………………… 42

3.8.2 Coding………………………………………………………………………………………………… 42

3.8.3 Validation of results ………………………………………………………………………………… 42

3.9 Limitations…………………………………………………………………………………………………… 42

3.10 Ethical issues………………………………………………………………………………………………… 43

3.11 Positionality……44

3.12 Conclusion……45

Chapter 4: Case study: rice value chains in Benue State, Nigeria……46

4.1 Overview of Benue State……46

4.1.1 Geographical settings……47

4.1.2 Geology, relief and soil……47

4.1.3 Climate and vegetation……48

4.1.4 The political, cultural, and economic settings……50

4.2 Characterisation of rice value chains in Nigeria and Benue State……50

4.2.1 Rice growing ecologies, systems and seasons……50

4.2.2 Rice growing activities and processes……52

4.2.3 Trend in average yield, area harvested and production/output……54

4.2.4 Rice aggregation……55

4.2.5 Milled rice production……56

4.2.6 Rice importation……58

4.2.7 Distribution, trading or selling of milled rice……59

4.3 Political economy of rice in Nigeria and Benue State……60

4.3.1 Mode of production, access to land and capital……61

4.3.1.1 Mode of production in the Nigerian RVCs……61

4.3.1.2 Access to land……62

4.3.1.3 Access to capital……64

4.3.2 Labour……65

4.3.2.1 Labour regimes in Nigeria and Benue State……65

4.3.2.1 Division of labour……66

4.3.3 Distribution of proceeds of labour from rice production, milling and trading…… 66

4.3.4 Use of proceeds of rice labour by RVCs' actors……67

4.4 Rice value chains systems' boundary in Benue State……68

4.5 Characterising climate change and variability in Nigeria and Benue State……69

4.5.1 Observed changes in temperature trends……69

4.5.2 Observed changes and variability in rainfalls trends…… 70
4.5.3 Projected changes in temperature…… 71
4.5.4 Projected rainfall change and variability……72
4.6 Implications of the observed and projected changes in climate for RVC…… 73
4.7 Conclusion…… 73
Chapter 5: Vulnerability and adaption of rice growers to climate change and variability, and agricultural market dynamics in Benue State, Nigeria…… 75
5.1 Introduction…… 75
5.2 Vulnerability of rice farming in Benue State, Nigeria…… 76
5.3 Exposure to climate change and variability (CCV)……77
5. 3.1 Exposure to CCV …… 77
5.3.2 Exposure to other pressures…… 83
5.4 Sensitivity to Climate Change and Variability …… 86
5.5 Adaptation to Climate Change and Variability, and other pressures……92
5.5.1 Rice fields management and water control practices…… 96
5.5.2 Best planting and diversified cropping practices…… 98
5.5.3 Weeds, pests and nutrients management practices…… 101
5.5.4 Communication of weather information…… 102
5.5.5 Access to knowledge through experts and entering into a farming programme…. 102
5.5.6 Claiming crop insurance…… 103
5.6 Exposure to agricultural market pressures (AMP)…… 104
5.7 Sensitivity to agricultural market pressures…… 110
5.8 Adaptation to unmilled market pressures…… 114
5.8.1 Best rice selling practices…… 117
5.9 Validation of results…… 121
5.10 Discussion …… 123
5.10.1 Information ……123

5.10.2 Anticipatory and long-term adaptation practices......124
5.10.3 Planned adaptation 125
5.10.4 Collective and coordinated adaptation responses...... 126
5.10.5 Trade-offs and costs of adaptation practices...... 127
5.10.6 Uncertainties......128
5.11 Summary and Conclusions......129
Chapter 6: Vulnerability and adaptation of rice millers and traders to combined climate change and variability, and market pressures in Benue State, Nigeria......132
6.1 Introduction 132
6.2 Vulnerability of rice millers in Benue State, Nigeria 133
6.3 Exposure of rice millers in Benue State...... 134
6.3.1 Exposure to climate change and variability...... 134
6.3.2 Exposure to non-CCV pressures...... 138
6.4. Sensitivity to pressures......144
6.5 Adaptation to CCV, and other pressures......148
6.5.1 Current adaptation practices of rice millers to CCV...... 152
6.5.2 Current adaptation practices of rice millers to non-CCV...... 154
6.6. Vulnerability of rice milled trading in Benue State, Nigeria 157
6.7 Exposure to combined CCV and to market pressures......159
6.7.1 Moisture and heat 161
6.7.2 Exposure to market price pressures...... 161
6.7.3 Other pressures affecting rice market price......164
6.8 Sensitivity to market pressures......166
6.8.1 Selling experience...... 169
6.8.2 Type of rice sold 169
6.8.3 Type of trader or seller...... 170
6.8.4 Selling season......170

6.9 Adaptation to market pressures…… 170
6.9.1 Current adaptation practice…… 171
6.10 Interactions of the effects of vulnerability of downstream parts off the RVCs……179
6.11 Validation of results……180
6.11.1 Validation of results on vulnerability of rice millers to pressures…… 180
6.11.2 Validation of results on vulnerability of rice traders to pressures……182
6.12 Discussion……183
6.12.1 Rice milling technology and infrastructure …… 184
6.12.2 Uncertainties and trade-offs……185
6.12.3 Collective action…… 186
6.12.4 Anticipatory and long-term adaptive practices…… 187
6.13 Summary and conclusion……188
Chapter 7: System models of rice value chains in Benue State: growers, millers and traders' perspectives…… 191
7.1 Introduction……192
7.2 Elicitation of different actors' understanding of rice value chain Systems in Benue State…192
7.2.1 Elicitation of RVC systems' components by growers…… 192
7.2.2 Elicitation of RVC systems' components by rice millers…… 194
7.2.3 Elicitation of RVC systems' components by rice traders……195
7.3 Diagramming the mental maps by RVC actors…… 197
7.4 Rice value chains actors' evaluation of the participatory mapping (PM)…… 201
7.4.1 Promote learning about the system…… 202
7.4.2 Inform better decision making…… 203
7.4.3 Promote community problem learning and solving……204
7.5 Discussion…… 204
7.6 Summary and conclusion…… 207

Chapter 8: Conclusions………………………………………………………………………………………… 208

8.1. Introduction……………………………………………………………………………………………… 208

8.2 Summary of the main research findings………………………………………………………………. 208

8. 2.1 Objective (1) to document the current pressures, sensitivity and adaptive practices of rice growers, millers and traders in Benue State, Nigeria………………… 208

8.2.2 Objective (II): To explore the variability of exposure, sensitivity and adaptive practices across Benue State………………………………………………………… 209

8.2.3 Objective (III): To examine current adaptation practices employed by rice growers, millers and traders and assess the (mal) adaptive outcomes of those practices… 210

8.2.4 Objective (IV): To elicit the understanding of the RVCs system (e.g. chains' components) held by different actors along the chain……………………………………… 210

8.2.5 Objective (VI): To highlights the implications of the different perspectives of RVC system for vulnerability and resilience…………………………………………………… 211

8.2.6 Objective (VI): To highlight the possible entry points for reducing vulnerability in Benue State………………………………………………………………………………………… 211

8.3 Contributions of this study……………………………………………………………………………… 212

8.4 Identification of avenues for future research………………………………………………………… 214

References……………………………………………………………………………………………………… 215

Appendices……………………………………………………………………………………………………… 230

List of Tables

Table 2.1. Number of papers that consider different types of disturbances, value chain components, and sub-regions and that employ different research methods………9

Table 3.1. Number of interviewees sampled ………………………………………………………………………..35

Table 3.2. Number of participants at workshops…………………………………………………………………..39

Table 4.1. Geography distribution of rice growing ecologies in Nigeria and their characteristics…. 51

Table 4.2. Key features of Nigerian rice growing systems ………………………………………………………… 52

Table 4.3. Rice growing calendar in Benue State……………………………………………………………………..53

Table 4.4. Modes of rice production in Nigeria and Benue State……………………………………………… 61

Table 5.1. Differences in exposure, sensitivity and adaption highlighted by the VSD across sites….77

Table 5.2. Types of CCV-related pressures by sociodemographic characteristics of rice growers…..79

Table 5.3. Highlights of growers' exposure to flooding and rainwater shortages………………………… 81

Table 5.4. Highlights of evidence on rice growers' exposure to other pressures………………………….. 84

Table 5.5. Factors of sensitivity to CCV-related pressures by sociodemographic Characteristics of rice growers ………………………………………………………………………………………… 87

Table 5.6. Highlights of evidence on grower's sensitivities to pressures across study sites ………… 89

Table 5.7. Rice seeds/varieties widely planted by growers across Benue State…………………………… 91

Table 5.8. Percentage of growers who adopted different adaptation practices……………………………93

Table 5.9. Adaptation practices in relation to CCV-related pressures by sociodemographic characteristics of growers……………………………………………………………………………………….. 94

Table 5.10. Highlights of grower's rice fields' management and water control adaptive practices..96

Table 5.11. Highlights of grower's rice planting and diversified cropping practices……………………… 98

Table 5.12. Differences in exposure, sensitivity and adaption highlighted by the VSD across sites..106

Table 5.13. Types of market-related pressures by sociodemographic characteristics of rice growers ……………………………………………………………………………………………………… 107

Table 5.14. Highlights on evidence of growers' exposure to market pressures across study sites… 108

Table 5.15. Factors of sensitivity to market-related pressures by sociodemographic characteristics of growers ……………………………………………………………………………………….. 112

Table 5.16. Percentage of growers who adopted different adaptation practices.............................. 114
Table 5.17. Adaptation practices by sociodemographic characteristics of growers.......................... 115
Table 5.18. Highlights of rice trading techniques employed by growers 116
Table 5.19. Weak spots and possible action identified by growers in Benue State.......................... 121
Table 6.1. Differences in exposure, stativity and adaptation of milled rice traders across sites....... 134
Table 6.2. Types of CCV-related pressures by sociodemographic characteristics of rice millers...... 135
Table 6.3. Highlights of millers’ exposure to CCV and seasonal changes.. 136
Table 6.4. Types of non-CCV pressures by sociodemographic characteristics of rice millers 140
Table 6.5. Highlights of millers’ exposure to non-CCV pressures...141
Table 6.6. Factors of sensitivity to CCV-related pressures by sociodemographic characteristics of rice millers 145
Table 6.7. Highlights on millers’ sensitivity to various pressures, climatic and non-climatic............ 146
Table 6.8. Percentage of millers who adopted different adaptation practices................................. 149
Table 6.9. Adaptation practices by sociodemographic characteristics of rice millers 150
Table 6.10. Highlights of adaptation practices employed by rice millers in response to CCV............ 152
Table 6.11. Highlights of adaptation practices employed by rice millers in response to non-CCV... 154
Table 6.12. Highlights of adaptation practices employed by rice millers in response to non-CCV... 156
Table 6.13. Differences in exposure, stativity and adaptation of milled rice traders across sites..... 159
Table 6.14. Types of pressures by sociodemographic characteristics of rice traders 160
Table 6.15. Highlights of milled rice traders exposure to market price pressures............................ 162
Table 6.16. Highlights of milled rice traders’ exposure to other pressures affecting market price... 164
Table 6.17. Highlights on factors of sensitivity reported by rice millers... 167
Table 5.18. Factors of sensitivity by sociodemographic characteristics of rice traders 168
Table 6.19. Percentage of milled rice traders who adopted different adaptation practices 171
Table 6.20. Adaptation practices by sociodemographic characteristics of rice traders 172
Table 6.21. Highlights of adaptive practices employed by rice traders... 173
Table 6.22. Highlights of adaptive practices employed by rice traders.. 175
Table 6.23. Highlights of adaptive practices employed by rice traders.. 177

Table 6.24. Downstream interactions of the effects of growers, millers and traders' vulnerability. 179

Table 6.25. Weak spots of the RVC system identified by rice millers…………………………………………… 181

Table 6.26. Weak spots of the RVC identified by rice traders ……………………………………………………… 182

Table 7.1. List of the RVC components identified by growers ……………………………………………………… 192

Table 7.2. List of the RVC components identified by individual millers……………………………………… 194

Table 7.3. List of the RVC components identified by individual rice traders ……………………………… 196

Table 7.4. Positive aspects of the PM as identified by participants …………………………………………… 201

List of Figures

Figure 3.1. A Generic definition of Rice Value Chain (RVC)………………………………………………………24

Figure 3.2 RVCs system resilience…………………………………………………………………………………………26

Figure 3.3. General form of the VSD……………………………………………………………………………………. 29

Figure 3.4. Exploratory field visits………………………………………………………………………………………… 33

Figure 3.5. Interview with upland rice growers……………………………………………………………………. 36

Figure 3.6. Interview with Rice Millers…………………………………………………………………………………. 36

Figure 3.7. Interview with lowland rice growers…………………………………………………………......... 36

Figure 3.8. Interview with rice traders……………………………………………………………………………………36

Figure 3.9. Diagram of phases in the participatory mental mapping of RVC system process…………38

Figure 3.10. Mental maps diagramming with different rice value chain actors…………………………. 41

Figure 4.1. Map of Nigeria showing Benue and study sites…………………………………………………… 46

Figure 4.2. Average Monthly Temperature and Rainfall for Benue State from 1901-2015……………. 49

Figure 4.3. Trend in average yield (a), area harvested (b) and annual production of

unmilled (paddy) rice (c) in Benue state from 1986-2017……………………………………………….. 54

Figure 4.4. Trend in price of unmilled rice in Makurdi, 2017…………………………………………………….. 55

Figure 4.5. Trend in annual milled rice production (a) and consumption,

(b) in Nigeria from 1960-2017……………………………………………………………………………………… 56

Figure 4.6. (a) The difference and (b) ratio between milled rice production and

consumption in Nigeria from 1960-2017…………………………………………………………………………. 57

Figure 4.7. Trend in milled rice importation in Nigeria from 1960-2017………………………………………58

Figure 4.8. Trend in the price of imported and domestic milled rice in Makurdi, Benue State……… 60

Figure 4.9. Rice value chains systems' boundary in Benue State……………………………………………… 68

Figure 4.10. 2012 temperature anomaly (a), cold season minimum temperature

(b) hot season maximum temperature………………………………………………………………………… 69

Figure 4.11. Onset dates anomaly in Nigeria: (a) from 1941-1970 and (b) from 1971-2000………… 70

Figure 4.12: Cessation dates anomaly in Nigeria: (a) from 1941-1970; (b) from 1971-2000………… 71

Figure 4.13: Monthly temperature and rainfall of Benue State Nigeria: projected (a) changes for 2020-2095 and historic (b) observed for 1985-2010………………………………. ….. 72

Figure 5.1. Vulnerability scoping diagram for Makurdi, Gboko and Adikpo, Benue State, Nigeria… 76

Figure 5.2. Percentage of growers who identified different CCV pressures in the three study site..77

Figure 5.3. Flooded rice field (A), Rice dying off because of flooding (B &C) Rice fields experiencing rainwater shortages ……………………………………………….. 82

Figure 5.4. Percentage of growers who identified different types of pressures ………………………. 83

Figure 5.5. Rice infested with weeds, (A), grasses (B) broadleaf and sedges……………………………… 85

Figure 5.6. Percentage of growers who mentioned different factors related to their sensitivity to CCV and other pressures in the three study sites …………………………………………………… 86

Figure 5.7. Local rice farming implements: (A) rice harvesting using hand knives, (B) Metal drum used as rice threshing equipment, (C) Threshing of rice using metal drum, (D) Rice threshing mat…………………………………………………….. ………. 90

Figure 5.8. Vulnerability scoping diagram for Makurdi, Gboko and Adikpo, Benue State, Nigeria …105

Figure 5.9. Percentage of growers who identified different types of pressures…………………………. 106

Figure 5.10. (A) Rice sold using accurate weights and measures (Kg/ton) and (B) Rice sold using inaccurate weights and measures (sacks of different inches)………………………. 109

Figure 5.11. Percentage of growers who mentioned different factors related to their sensitivity to various pressures in the three study sites……………………………………………… 111

Figure 6.1. Vulnerability scoping diagram for Makurdi, Gboko and Adikpo, Benue State, Nigeria… 133

Figure 6.2 Percentage of rice millers who identified different types of pressures relating to CCV in the study sites……………………………………………………………………………… 134

Figure 6.3. Percentage of rice millers who identified different types of non-CCV pressures in the study sites………………………………………………………………………………………… 138

Figure 6.4. Cemented slabs/pavements used for drying parboiled rice in small-size rice mills......... 139

Figure 6.5. Storage condition: rice stored in the open in a large-size mill (A) and rice stored inside a room in small-size mills... 142

Figure 6.6. Firewood use as energy (A) and metal drums (B) used for steaming and parboiling rice across small-size mills...143

Figure 6.7. Some of the old and obsolete technologies in use across small-size rice mills................ 144

Figure 6.8. Percentage of rice millers who mentioned different structural factors related to their sensitivity to various climatic and non-climatic pressures in the study sites..........................144

Figure 6.9. Level of milling technology used: engines without (A. small-size mills) and with (B. large-size mills) capability to remove all impurities in rice, sort and polish grains.......... 147

Figure 6.10. Vulnerability scoping diagram for Makurdi, Gboko, Adikpo, Benue State, Nigeria....... 158

Figure 6. 11. Percentage of milled rice traders who identified different types of pressures in the study sites.. 159

Figure 6.12. Domestic milled rice packaged and branded by one of the large-size mills (A) and unpackaged and branded rice from most small-size mill (B)..................................... 163

Figure 6.13. Percentage of milled rice traders of milled rice who mentioned different factors related to their sensitivity to pressures in the study sites.. 166

Figure 6.14. Various types of rice on the market: (A) Low quality rice milled from small-size mills and (B) high quality imported and packaged domestic rice from large-size mills.................169

Figure 7.1a: Stock and flow map of rice growers in Adikpo... 199

Figure 7.1b: Stock and flow maps of rice miller in Adikpo.. 199

Figure 7.1c: Stock and flow map of milled rice trader in Adikpo.. 199

Figure 7.2a: The stock and flow map of rice growers in Makurdi... 200

Figure 7.2b: The stock and flow map of rice millers in Makurdi... 200

Figure 7.3c: The stock and flow map of milled rice trader in Makurdi...200

List of Appendices

Appendix 2.1. Models on vulnerability and adaptation of RVCs to impacts of CCV and markets pressures……………………………………………………………………………………………..230
Appendix 3.1. Interview guide for rice growers, millers and traders…………………………………………. 232
Appendix 3.2. Rice value chains' actors workshop protocol………………………………………………………..234
Appendix 5.1. Social demographic characteristics of rice growers in Benue State……………………….. 239
Appendix 6.1. Social demographic characteristics of rice millers in Benue State…………………………. 241
Appendix 6.2. Social demographic characteristics of milled rice traders in Benue State……………… 242

Chapter 1

Introduction

1.1 Background to the study problem

Rice is an important staple food and a source of income for over 180 million households across Nigeria (Bamidele, Abayomi, & Esther, 2010; Daramola, 2005). While its production in the country dates back to the 1850s (Longtau, 2003), its growth as a major staple food dates back to the 1960s. Between the mid-1970s and early 1980s it became a strategic commodity for food security and the economy (T. Akande, 2001; Akpokodje, Lançon, & Erenstein, 2001; Longtau, 2003).

However, over the past four decades, the Nigerian rice sector has increasingly failed to provide income and employment, and this can be largely attributed to the inability to respond to growing climatic and economic/market pressures (Bosello, Campagnolo, Cervigni, & Eboli, 2017; Ezedinma, 2005; Niang et al., 2014). For example, in many states extreme weather events, such as temperature anomalies, flooding, rainwater shortages, and changes in onset and cessation of rainfall, amongst others, have been observed, and impacts spread across all parts of the RVC, including other sectors of the economy (Niang et al., 2014; Nigerian meteorological agency (NIMET), 2012). In addition to the pressures imposed by climate change and variability (CCV), rice value chains (RVCs) have been exposed to economic pressures, such as volatile markets; frequent, stark, and unexpected changes in agricultural policy; poor milling technology and infrastructure; and international competition (Daramola, 2005; Demont & Ndour, 2015; Demont, 2013).

The difficulties faced by the Nigerian RVCs can be traced back to the 'Dutch disease' effect of the early 1970s, when Nigeria first experienced an oil boom and underwent a major economic overhaul that entailed the shift from an agricultural to an oil-based economy (Daramola, 2005). As a result, investments in rice technology, infrastructure, and extension services were dramatically cut, with obvious effects on the capacity of the rice sector to respond effectively to the above-mentioned pressures. In addition, the adoption of a Structural Adjustments Policy (SAP) by the Nigerian Government in 1986 opened up the national agricultural market to global competition, and exposed the RVC to a whole new set of economic/market pressures (Akande, 2001; Bamidele et al., 2010). The situation resulted in massive out-migration to other sectors, paving the way for sustained rice imports, mostly from East Asia (e.g., Thailand, India, and Vietnam) (Daramola, 2005).

Over the decades, the Nigerian Government has implemented a number of policies aimed at boosting rice production, milling capacity, and quality, and to ultimately enhance its market demand and shield RVCs. Among a host of others, policies include: the national rice development strategy

(NRDS) and the national food security strategy (2009); the presidential initiative on increased rice production, processing, and export (2003); the agricultural policy (2001); the national agricultural seeds decree (1992); and the introduction of fertiliser subsidies (1976, removed in 1997, reintroduced in 1999, removed again in 2000, and reintroduced in 2006) (for details on rice policies refer to Daramola, 2005; Emodi & Madukwe, 2008; USAID, 2009) (Daramola, 2005; USAID, 2009). Other policies affecting the rice trade included: the opening to liberalised trade from 1975-1985; a protectionist turn from 1986-1995; and tariffs ranging from 10% to 100% from 1974 to the present (Akande, 2001; Daramola, 2005; Laroche Dupraz & Postolle, 2013; Mendez del Villar & Lançon, 2014; Obi-egbedi, Okoruwa, Yusuf, & Kemisola, 2013).

However, these policies have mostly failed to increase the ability of RVCs to respond effectively to the above-mentioned pressures. Various explanations for this failure have been suggested. First, most of these policies were characterised by inconsistencies in their implementation and were often short-lived due to frequent changes in the political administration (Daramola, 2005). Second, some of the policies (e.g., tariffs, fertiliser subsidies, and the rice seeds policy) were undermined by corruption (Akande, 2001). Third, an issue arose which concerned ownership and participation in some of the initiatives and strategies, most were of a top-down nature and did not involve stakeholder consultations (Emodi & Madukwe, 2008). Fourth, most of the policies, initiatives, and strategies were not holistic in their design as they focussed on the downstream parts of the RVC (e.g., production or milling), while the upstream parts (e.g. distribution and marketing) were omitted (Demont, 2013). Fifth, the policies were often targeted at large landholders, while the majority small landholders, who drive the system, were often overlooked (USAID, 2009).

Given Nigeria's declining national income owing to dwindling oil prices and the declining value of its currency, it is unlikely the country will be able to sustain its present volume of rice imports to meet internal demand in the coming years. Experience of the 2008 food crisis has shown that reliance on the international rice market is a risky strategy, should any shock or disruption to global market supply occur either in the short- or long-term (Dawe, 2002; Seck, Tollens, Wopereis, Diagne, & Bamba, 2010). Furthermore, climate projections have singled out Nigeria as one of the most vulnerable areas in Africa to climate change, with impacts expected to be felt earlier than the mid-21st century (Niang et al., 2014). The implication is, that to adapt and build resilience in the RVCs, which will ensure the continued, secured provision of the national staple and the income it generates, a holistic process is needed which goes beyond current, single, haphazard policies. Such a process must consider the entire RVCs and the interaction of factors that combine to put it under pressure.

However, little is known about the impacts of multiple, simultaneous pressures on RVCs, the effects of CCV on parts of the value chain other than production (e.g. rice milling and trading), or the forms and extent to which different adaptive practices employed by different actors (e.g. growers, millers and traders) hinder or enhance the resilience of RVCs in the face of climatic and other pressures in Nigeria (Terdoo & Feola, 2016). Such an understanding is the basis upon which evidence-based vulnerability intervention in the rice sectors of Benue State in particular and Nigeria broadly can stem from.

Thus, to fill this gap, a synchronic baseline vulnerability assessment of RVCs to the effects of combined CCV and to the dynamics of the agricultural markets was conducted in Benue State, North-Central Nigeria to help increase understanding of complexities of the RVCs, its adaptation and resilience in the face of these pressures. In so doing, the thesis aims to contribute to the debate about the impact of global environmental change on food security and agricultural development, providing a context-based analysis of vulnerability to multiple pressures, and by conducting an analysis of the entire RVC. Through the application of participatory diagrammatic methods (Vulnerability Scoping Diagrams (VSD) and Participatory System Mapping (PSM)) for the systemic analysis of RVC in low-income regions (Terdoo & Feola, 2016), this study advances participatory RVCs analysis as it develop and test a participatory system-based procedure to elicit system representations from distinct value-chain actors. Rarely applied to RVC in Africa, the approach is broadly recognised as critical for the construction of resilience in agri-food systems (Darnhofer et al., 2010; Ericksen et al., 2012).

1.2 Aim and objectives

The aim of the study is to assess the vulnerability (i.e., exposure, sensitivity, and adaptation) of RVCs to combined CCV, markets, and other pressures in Benue State, Nigeria.

The study addresses the research aim through the following objectives:

I. To document the current pressures, sensitivity, and adaptive practices of rice growers, millers, and traders in Benue State, Nigeria;

II. To explore the variability of exposure, sensitivity, and adaptive practices across Benue State;

III. To examine current adaptation practices employed by rice growers, millers, and traders and assess the (mal)adaptive outcomes of those practices;

IV. To elicit the understanding of the RVC system (e.g., different chain components) held by different actors along the chain;

V. To highlight the implications of the different perspectives of the RVC system for vulnerability and resilience; and,

VI. To highlight possible entry points for the reduction of vulnerability in Benue State.

1.3 Structure of the thesis

This thesis is comprised of seven chapters in addition to this first introductory chapter.

Chapter 2 reviews the literature on the vulnerability of RVCs in sub-Saharan Africa to climate change and variability and economic globalisation, it identifies the research gaps addressed.

Chapter 3 presents the research methods used, these include: interviews and participatory workshops; vulnerability scoping diagrams; and participatory system mapping. The chapter also highlights the ethical challenges faced, and how they were addressed.

Chapter 4 presents a case study of Benue State. It describes the geographical, political, and economic settings within which RVCs operate. Using secondary data, it characterises the RVCs (e.g., rice growing/production, aggregation/assemblage, processing or milling, and trading and consumption) and CCV.

Chapter 5 presents the results of the analysis of rice growers' exposure, sensitivity, and adaptive capacity to CCV and to agricultural market dynamics. The chapter also discusses the (mal)adaptive outcomes of growers' responses to external pressures, and highlights entry points for reducing vulnerability and building resilience.

Chapter 6 extends the analysis to cover rice milling and trading. This chapter also discusses possible options for building the resilience of these parts of the RVC. The findings from both Chapters 5 and 6 help shed light on the vulnerability of the entire RVC system in Benue State.

Chapter 7 presents the results of the participatory mapping exercises, these were conducted to elicit and compare the perspectives of different actors along the chain. The chapter highlights the usefulness of the participatory mapping process for social learning and enhanced decision-making, and reflects on the implications of diverse perspectives for building resilience and the vulnerability of the RVCs in Benue State.

Chapter 8 synthesizes the main findings of the study in relation to the research questions, it highlights the main contributions of the study and avenues for future research on vulnerability reduction and resilience building in the rice sector in Nigeria.

Chapter 2

Literature Review[1]

Abstract: Rice is one of the most important food crops in sub-Saharan Africa. Climate change, variability, and economic globalization threaten to disrupt rice value chains across the subcontinent, undermining their important role in economic development, food security, and poverty reduction. This paper maps existing research on the vulnerability of rice value chains, synthesizes the evidence and the risks posed by climate change and economic globalization, and discusses agriculture and rural development policies and their relevance for the vulnerability of rice value chains in sub-Saharan Africa. Important avenues for future research are identified. These include the impacts of multiple, simultaneous pressures on rice value chains, the effects of climate change and variability on parts of the value chain other than production, and the forms and extent to which different development policies hinder or enhance the resilience of rice value chains in the face of climatic and other pressures.

2.1. Introduction

Rice is one of the most important food crops in Africa, where rice and the economic activities related to its production, processing, distribution, and consumption are widely considered a key for economic development, food security, and poverty reduction (Demont & Ndour, 2014; Tollens, 2006; Velde & Maertens, 2014). In most of sub-Saharan Africa (SSA), rice is the most-demanded staple food and the food product traded in the highest quantities (Laroche Dupraz & Postolle, 2013; Tollens, 2006). The West African sub-region is regarded as the biggest rice market in SSA, accounting for two-thirds of the region's rice demand with 50% imports, which represents about 20% of the total volume of rice traded globally (Mendez del Villar & Lançon, 2014).

Following the advice of international organizations such as the World Bank and the International Monetary Fund, many governments in the region have implemented a liberalization of the agri-food sector, and have facilitated its opening to global markets as a strategy to increase competition, reduce food prices (especially in urban areas), and mitigate poverty (Garmann, 2014; Moseley, Carney, & Becker, 2010). However, the results of these policies have been contested, and while some studies have shown the benefits of agri-food liberalization policies, others have highlighted their disruptive effects and tendency to cause price fluctuation and volatility (C. B. Barrett, 2008; Laroche Dupraz & Postolle, 2013).

---

[1] This chapter was published as a peer-reviewed journal article: "Terdoo, F., Feola, G. 2016. The Vulnerability of Rice Value Chains in Sub-Saharan Africa: A Review. Climate, 4(3):47".

Increasing climate variability and change have compounded the effects of this opening to global agri-food markets. In large parts of SSA, droughts, declining rainfall and water scarcity, flooding, and rising average temperatures have put pressure on domestic rice value chains (Niang et al., 2014; Roudier, Sultan, Quirion, & Berg, 2011). The effects of climate change are projected to further aggravate value chains in the future (Niang et al., 2014; Roudier et al., 2011). However, while it is apparent that climate change represents a threat to rice value chains in SSA, less attention has been given to examining sub-regional variation and the patterns of effects of climate change along the value chains.

Against this background, this paper examines existing evidence on the vulnerability of rice value chains to climate change and to the opening of global agri-food markets in SSA. It also identifies research needs for building resilience in the rice value chains. Specifically, with reference to SSA, this paper aims to: (i) characterize existing research on the vulnerability of rice value chains; (ii) synthesize the evidence on the vulnerability of rice value chains to climate change and economic globalization; and (iii) discuss agriculture and rural development policies and their relevance for the vulnerability of rice value chains. Thus, the project maps the literature on rice value chains in SSA at a time of ongoing debate about policies for strengthening the rice sector in this region and of growing stress posed by climate change.

2.2 Theoretical Background and Methods

2.2.1 Theoretical Background and Definitions of Key Concepts

Ericksen (2008), Ingram (2011), and Tendall et al. (2015) reveal that food systems can be considered as social-ecological systems that consist of mutually interacting biophysical and social components. Food systems encompass the activities of food production, processing, distribution, retail, and consumption and involve multidimensional (e.g., social, economic, institutional, environmental, political, cultural) processes (Tendall et al., 2015). Food system components are embedded in place, and their processes are influenced by biophysical, social, economic, and political factors. At the same time, food systems can be examined in terms of their performance or ability to deliver selected outcomes, of which food security is a typical and highly relevant example (Ingram, 2011). As complex social-ecological systems (Scoones et al., 2007; Thompson & Scoones, 2009) food systems are characterized by interactions among system components and among factors, processes, and outcomes. Such interactions are often non-linear and are characterized by time and space lags and thresholds, which make it difficult to implement effective policies for promoting food security or food system sustainability. This highlights the need for whole-system analysis rather than the assessment of individual parts of the food system (Tendall et al., 2015).

The concept of the food value chain (FVC) is used in this review in close relation to the concept of food systems. FVC can be defined, following Morris Kaplinsky & Morris (2000: p. 4), as "the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use." Thus, the notion of FVC emphasizes the process of economic value creation along the chain, and consequently bears a more direct connection with issues of economic development that have been central to SSA for decades, while retaining a system perspective that encompasses the complex socio-ecological dynamics that characterize food systems.

Various scholars and international organizations have identified the adoption of a system approach as key to improving the resilience of the rice sector and reducing its vulnerability (e.g., Ericksen, 2008; Stave & Kopainsky, 2015). Tendall et al. (2015: p. 19) proposed the following definition of food system resilience: the "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances." This definition ties resilience to a functional goal, thus excluding the possibility of defining resilient food systems that deliver undesirable outcomes. Moreover, this definition points out the multi-level nature of food systems. For example, resilience can occur from the individual to national food systems to international value chains. Finally, according to this definition, resilience is a gradable property of food systems; systems can be more or less resilient. Furthermore, resilience is a dynamic property. Rather than enabling the system to face one-off disturbances, resilience constitutes the system's capacity to minimize food insecurity in a changing environment with recurring disturbances (Tendall et al., 2015). Resilience is therefore not a static target, but a property in flux that results from reactive but also preventive actions and their feedback on system components over time (Tendall et al., 2015).

As a large body of literature has shown, resilience and vulnerability are related (e.g., Gallopín, 2006), Miller et al. (2010). Vulnerability to a stressor is a function of sensitivity, exposure, and adaptive capacity (W. N. Adger, 2006). Consistent with food security approaches, food system vulnerability can be measured not only in terms of food availability, but also of access and utilization (Ericksen, Ingram, & Liverman, 2009). This calls for a system perspective and for the examination of sources of vulnerability at different levels and in relation to different components of the food systems and their interactions, including production, storage, and distribution (Leichenko & O'Brien, 2008; Stave & Kopainsky, 2014). Resilient food systems are less vulnerable to stresses because they harbor the capacity to respond to disturbances and plan for change.

Both the resilience and vulnerability literature acknowledge that socio-ecological systems can be simultaneously exposed to multiple stressors, such as climate change and globalization, and that the stressors or their effects may interact to threaten the resilience and sustainability of those systems (Leichenko & O'Brien, 2008). Several cases of agricultural and food systems under exposure to multiple exposures have been analyzed in the literature (e.g., Feola et al. 2015; Feola, Agudelo Vanegas, & Contesse Bamón, 2014; Luers et al., 2003; Mertz et al., 2009). The literature shows that when different stressors are addressed in isolation, maladaptation is often observed. This is because measures to adapt to one stressor may be maladaptive to a different stressor. On the other hand, resilience is built and vulnerability is reduced through effective adaptation when multiple exposures are considered (Brown, 2011).

2.2.2 Literature Selection

A literature search was conducted in the following major databases: Web of Science, Science Direct, Scopus, Geobase, Google Scholar, Journal Storage (JSTOR), Social Science Research Network, and African Journal Online. In addition, literature was collected from online databases and websites of relevant institutions, conference proceedings, and non-governmental organizations, such as the West Africa Rice Development Association (WARDA), the African Rice Centre, the Food and Agricultural Organization (FAO), the International Rice Research Institute (IRRI), the International Food Policy Research Institute (IFPRI) and the United States Agency for International Development (USAID). Throughout the process of running the literature search, particular attention was paid to identifying the various models of the RVCs developed by the African Rice Centre, the International Rice Research Institute (IRRI), and the International Food Policy Research Institute (IFPRI). The following keywords were used in various combinations: "vulnerability," "impact," "adaptation" "rice value chain," "production," "processing," "distribution," "marketing," "consumption," "climate change," "economic globalization," "trade liberalization," "policy," and "sub-Saharan Africa." The search was limited to publications published from the year 2000 onwards.

A total of 351 publications were initially identified. The publications with a strong emphasis on agronomic practices, including systems of intensification and their efficiency, were then excluded from the analysis. The studies reviewed focused on the social, political, cultural, and economic dimensions of vulnerability, rather than the technical and agronomic dimensions.

In addition, studies based on crop and economic modelling of the RVCs were curated (see also appendix 2.1). By applying these selection criteria, 67 articles were included in this review (see Table 2.1 below).

2.2.3 Analysis

The analysis of the literature addressed three aspects, corresponding to the research questions driving this study. First, the selected literature was characterized by: (i) the type of disturbances considered (i.e. climate change, economic globalization or trade liberalization, and others); (ii) the component of the value chain investigated (i.e. production, processing, distribution, consumption); (iii) the sub-regional focus within SSA (i.e. East, West, Central, and Southern Africa); and (iv) the research methods employed (qualitative, quantitative, mixed methods (e.g. qualitative and quantitative, or modelling). Subsequently, the literature was analysed to identify the impacts of the disturbances on rice value chains in SSA, and the policies recommended for rice sector development that are relevant for minimizing vulnerability and building the resilience of value chains. For these latter aspects, no predetermined analytical framework was adopted, as the analysis followed an emergent process of synthesis of the existing literature rather than the imposition of pre-determined conceptual schemes.

2.3 Results

2.3.1 Literature Characterization

The reviewed literature allowed for the characterization of existing research on the vulnerability of rice value chains (RVCs) in SSA, as illustrated in Table 2.1.

Table 2.1. Number of papers that consider different types of disturbances, value chain components, and sub-regions and that employ different research methods.

Criteria		Number of papers
Disturbance	Climate change	24
	Opening to global markets	31
	No climate change or market focus	12
Value chain component	Production	34
	Processing	6
	Distribution and marketing	16
	Consumption	4
	All components	7
Sub-region	East Africa	14
	Central Africa	8
	Southern Africa	14
	West Africa	43
	All sub-Saharan regions	8
Research methods	Quantitative	32
	Qualitative	12
	Mixed methods	6
	Structural models (with simulations)	17

In most studies reviewed, climate and economic disturbances were investigated separately, while a number of studies addressed aspects of the vulnerability of RVCs with no direct focus on either climate change or opening to global markets (Table 2.1).

The majority of studies on the vulnerability of RVCs to climate change in SSA are devoted to assessing the impacts on rice production. Similarly, the majority (31) of the studies on the impact of opening to global markets on RVCs focus on rice processing, distribution, and marketing, while little attention is given to assessing the impacts on other components of the RVCs, or on the RVCs as a whole. This marks a difference from studies on climate disturbances, which focus exclusively on production.

In terms of regional focus, the literature has mostly concentrated on West Africa (Table 2.1). Countries in this sub-region share a common history of traditional rice consumption (Saito, Dieng, Toure, Somado, & Wopereis, 2014) and common trends of increasing demand for rice caused by rapid population, urban, and income growth, which is not matched by domestic production and distribution capacity (Demont, 2013; P. a. J. van Oort et al., 2015). Nigeria has the highest concentration of studies (24), while Burkina Faso (8), Ghana (8), Senegal (6), Benin (6), Tanzania (6), Madagascar (7), Niger (6), Cote d'Ivoire (5), Uganda (4), Mali (5), and Togo (4) were also often researched. Most of these countries are importers of rice and have experienced severe impacts of the agri-food market opening on their domestic rice value chains (Demont, 2013).

Finally, in terms of the research methods employed, the majority of the reviewed studies adopted a quantitative methodological approach. Quantitative methods included statistical and econometrics or regression models that used secondary datasets or survey data, while qualitative methods included interviews (6) and policy analysis (12). Structural models (17) (e.g. process-based, agro-ecosystem and statistical models) were also used. Examples of such models are the physiological and crop models that employ mainly a biophysical approach to vulnerability assessment. The second type is represented by economic models, which focus on socioeconomic analysis of vulnerability, often in combination with the biophysical parameters (see Appendix 2.1).

2.3.2 Vulnerability of Rice Value Chains in Sub-Saharan Africa

This section presents and discusses the results of the literature review on the vulnerability of rice value chains to climate change, variability, and economic globalization.

2.3.2.1 Rice Value Chains and Climate Change and Variability

A number of studies have investigated the vulnerability of RVCs to climate change and variability (CCV) in SSA. While Knox et al. (2012) and Liu et al. (2008) argued that evidence of impacts of CCV on rice crop yields in Africa is contradictory, other scholars have advanced our understanding of the impacts of CCV in specific agri-food systems in SSA. This section synthetizes the findings of this review with a particular focus on observed and projected impacts of CCV on RVCs in SSA. The summary also examines the unevenness of these impacts, which helps shed light on the sources of RVCs' vulnerability.

CCV may influence agriculture in SSA mainly through rising temperatures, decreasing rainfall, and changes in CO_2 concentrations (as they relate to carbon fertilization), atmospheric humidity, and solar radiation. The RVC literature has focused almost exclusively on estimating the effects of these CCV manifestations on rice production, at the expense of other RVC components such as processing, distribution, and consumption, which may equally be impacted by climate change and variability.

There appears to be agreement on the negative effects (observed or projected) of CCV. These include the reduction of usable area for cultivating floating rice in the face of increased demand for rice in the Inner Niger Delta (Liersch et al., 2013); the reduction in rice yield in Burkina Faso (Kima, Traore, Wang, & Chung, 2014), Tanzania (Rowhani, Lobell, Linderman, & Ramankutty, 2011), Malawi (Daccache, Sataya, & Knox, 2015), West Africa (Roudier et al., 2011), and across SSA (Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2013; P. A. J. van Oort & Zwart, 2018; Ward, Florax, & Flores-Lagunes, 2014; Zwart, 2016); the reduction of both rice yield and grain quality in Nigeria (Bosello et al., 2017; Matthew, Abiodun, & Salami, 2015; Nwalieji & Uzuegbunam, 2012); the decline of crop productivity with higher negative impacts on irrigated than rainfed production in South Africa (Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2014); and significant crop and income losses among smallholder farmers in Madagascar (Harvey et al., 2014).

Most of these effects are associated with losses of arable lands, which can be observed in countries around the Sahel due to desertification and, in coastal and delta countries, due to the inundation of farmlands from frequent incidences of floods (Kima et al., 2014) and droughts (Liersch et al., 2013). Furthermore, the increasing variability of rainfall, rising temperatures, and the increased frequency of droughts and water shortages have affected productivity, while the frequency of diseases and pest infestation as a consequence of different climatic conditions has compounded these problems, often resulting in reductions in both rice yield and grain quality in the region.

The factors that account for the negative impacts differ according to regions and countries. For example, in Madagascar (Southern Africa), Harvey et al. (2014) found that extreme weather events such as cyclones, diseases, and pest infestations resulting from CCV were major causes of yield reduction. In Kenya (East Africa), on the other hand, Ochieng et al. (2016) determined that changes in temperature have a greater impact on crop production than changes in rainfall. This is because rice production in Kenya is mostly irrigated. In Burkina Faso (West Africa), rice production is largely rainfed, and Kima et al. (2014) found rainfall to be the most important factor for rice yield reduction.

The effects of changes in CO_2 concentrations, atmospheric humidity, and solar radiation may be more mixed than those of rising temperatures and decreasing rainfall. A number of studies have shown that rice will benefit more in terms of crop yield from the increase of CO_2 concentration than crops such as maize and wheat in Nigeria (Adejuwon 2006) and through out SSA (Liu et al. 2008; van Oort and Zwart 2018). On the one hand, van Oort and Zwart (2018) projected an increase in irrigated rice yields as a result of CO_2 fertilization in East Africa and a decrease in yield was reported in West Africa. Furthermore, a decreasing photosynthesis rate owing to CO_2 concentrations in East and West Africa was reported in the above stated studies. Regarding specific SSA countries, Liu et al. (2008) reported that seven countries, namely: Mauritania, Congo, Gabon, Botswana, Swaziland, Zimbabwe, and Angola will experience decreasing yield as a result of climate change. Conversely, 23 countries, namely: Lesotho, Madagascar, Eritrea, Togo, Ivory Coast, Equatorial Guinea, Nigeria, Burundi, Burkina Faso, Benin, Uganda, Ghana, South Africa, Liberia, Ethiopia, Guinea-Bissau, Rwanda, Guinea, Sierra Leone, Kenya, Malawi, Senegal, and Gambia will experience higher crop yield.

Furthermore, empirical evidence on rice production in Niger State, Nigeria suggests that increased relative humidity and minimum temperature have contrasting effects (negative and positive, respectively) on rice production (Ayinde, Ojehomon, Daramola, & Falaki, 2013). Some studies identified impacts on revenue among smallholder farmers in Kenya (Ochieng et al., 2016) and dry land and irrigated rice farmers in Nigeria (Ajetomobi, Abiodun, & Hassan, 2010). Other studies projected a slightly positive change in crop yield for six crops as a whole in SSA in 2030, with maize and rice in particular having slightly higher yields (Liu et al., 2008). This is broadly consistent with the positive impact projected by Adejuwon (2006) and Lobell et al. (2008).

Thus, the impacts of climate change and variability are unevenly distributed, and their occurrence and intensity vary by geographical location, production system, and farmer characteristics. This unevenness sheds some light on the sources of vulnerability of RVC in SSA.

Lobell et al. (2008) projected the impacts of precipitation and temperatures changes on crop production in SSA for 2030. In all four regions, namely Western, Central, Eastern, and Southern Africa, the study finds a positive impact for rice. On the other hand, Liu et al. (2008) projected that in 2030, rice in SSA will have a higher yield in Eastern and Southern Africa, but a lower yield in Central Africa. This finding agrees with Gerardeaux et al. (2012) who projected positive effects of climate change on rice in Madagascar and van Oort and Zwart (2018) who projected increase yield in irrigated rice in Eastern Africa and a decrease yield in rain-fed rice in West Africa.

Regarding production systems, Ajetomobi et al. (2010) found that in Nigeria, temperature increases will reduce net revenue for dry land rice farms, but revenue for irrigated farms is expected to increase. In the same vein, increases in precipitation will cause reductions in revenue for dry land rice farms but an increase for irrigated farms. In South Africa, on the other hand, Calzadilla et al. (2014) found that higher temperatures and less rainfall will lead to a decline in crop productivity, with higher negative impacts on irrigated than rainfed production. Moreover, other studies have shown that the reduction in rice production will result in an increase in price of rice and higher dependency on foreign imports due to increasing demand on rice caused by population growth in Nigeria (Bosello et al., 2017; M. Johnson, Takeshima, & Gyimah-Brempong, 2013) and across SSA (Liu et al., 2008; G. Nelson et al., 2009). These will result in GDP losses in Nigeria (Bosello et al. 2017); South Africa (Calzadilla et al., 2014), and through SSA (Calzadilla et al., 2013; Liu et al., 2008). This in turn may lead to inability to finance food imports and ultimately contribute to increase under-nutrition and poverty rates in most SSA countries (Liu et al., 2008; G. Nelson et al., 2009; Okodua, 2017).

Finally, there seems to be agreement in the literature on the greater vulnerability of smallholders in SSA (Ajetomobi et al., 2010; Harvey et al., 2014; Nwalieji & Uzuegbunam, 2012; Ochieng et al., 2016). For example, Harvey et al. (Harvey et al., 2014) found that smallholder rice, maize, and cassava farmers in Madagascar have been adversely impacted by the manifestations of CCV. These adverse effects are due to their high dependence on agriculture for their livelihoods, limited resources and capacity, isolation, and lack of access to state safety nets. Smallholders may have fewer options for diversifying their livelihoods and are sometimes found to be more affected by poor health, lack of access to land due to the traditional land tenure systems, lack of adequate water, low levels of technology and education, and institutional mismanagement (See Nyantakyi-Frimpong & Bezner-Kerr 2015 in Ghana and Ochieng et al., 2016 in Kenya).

Interestingly, Nyantakyi-Frimpong & Bezner-Kerr (2015) found that many farmers do not worry about CCV. Instead, intra-household property rights, liberalized markets, and insecure land access are more critical challenges for farmers. This shows that focusing research attention on estimating the impacts of CCV manifestations on RVCs alone, without considering socio-economic dynamics and pressures, may not be an appropriate approach for reducing the vulnerability and increasing the resilience of RVCs in the region.

2.3.2.2 Rice Value Chains and Economic Globalization

This review identifies three themes that appear to have been addressed most intensively in the literature on RVCs and economic globalization in SSA: limited government support for rice farmers, lack of investment in post-harvesting, and market inefficiency. Here it is suggested that these three themes correspond to three structural limitations that have contributed to RVCs' vulnerability to economic globalization in SSA, as manifested in the difficulty of the rice sector in SSA to respond to growing internal demand for quality rice and to compete in the global market (e.g. Adjao & Staatz, 2014; Demont, 2013; Demont & Ndour, 2014; Seck et al., 2010; Johnson 2016).

Various studies have suggested that rice farmers in SSA have been inadequately supported by their respective governments, and that this has effectively left most rice producers in SSA to compete unfairly with producers from other countries where farmers may enjoy greater financial and technological support from their own governments (e.g. Ammani, 2013; Aniekwe, 2010; Johnson, Takeshima, and Gyimah-Brempong 2013; Johnson 2016). The literature points to limited or uncertain access to credit as a problematic area, with poor governments providing limited support to rice producers in Benin and Ghana (Mumuni & Oladele, 2012; Totin et al., 2012). Other authors have stressed the need for support in the form of programs for technological development (Ammani 2013; Johnson 2016; Tiamiyu, Usman, and Ugalahi 2014). Nevertheless, these authors point out that it is not only the level of support, but also governmental intermittence and inconsistency over time that has been problematic for farmers in West Africa (Aniekwe, 2010). Others have argued that another key aspect is providing adequate support to the usually more marginal and underrepresented small-to-medium-scale rice processors (Johnson, et al. 2013).

The second factor in the vulnerability of RVCs to economic globalization in SSA is the lack of investment in key parts of the RVC, particularly post-harvesting processing. Demand for rice has increased steadily over the past decades, but consumers have increasingly sought high-quality rice. RVCs in SSA have often been found incapable of improving the quality of the final product and therefore have failed to compete with high quality imported rice in national markets. Typical value-adding post-harvesting activities include quality upgrading, capacity building, governance, branding, labelling, promotion, and advertising (Demont, 2013). However, lack of investment in post-harvest rice quality has been a problem in countries such as Senegal, Benin, and Togo (Fiamohe, Nakelse, Diagne, & Seck, 2015). In other countries, such as Nigeria, there are very low levels of on-farm and post-harvest quality-enhancing practices (Johnson, 2016; Tiamiyu et al., 2014). These findings contribute to explaining why domestically processed rice has remained of low quality and has been unattractive, especially to urban rice consumers across SSA countries.

An increased capacity to add value to rice production through post-harvesting processing may help overcome the limitations of market segmentation, which has come to characterize rice markets in SSA. The lack of value-adding to enhance the quality of domestically produced rice in the region has resulted in widespread consumer preference for imported rice, which is perhaps the most important hindrance to the growth of RVCs across SSA. For example, in Ghana, 86% of rice consumers preferred imported rice, while only 14% preferred domestically produced rice (Tomlins, Manful, Larwer, & Hammond, 2005). Thus, across SSA we see that the inability of the RVC system to tailor the intrinsic and extrinsic quality attributes of domestic rice to urban consumer preferences has put the domestically produced rice at a disadvantage in an import-biased market (Demont & Ndour, 2014). This has led to the segmentation of the rice market between imported and domestically produced rice in a number of SSA countries, especially in West Africa (Mendez del Villar & Lançon, 2014).

However, evidence indicates that investment in post-harvesting processing has the potential to increase the capacity of RVCs to respond to internal demand and global competition. For example, in Senegal, Demont and colleagues reported that the majority of urban consumers are willing to pay quality premiums for local rice (Demont & Rizzotto, 2012; Demont, Rutsaert, Ndour, & Verbeke, 2013). A similar situation was found in Benin (Demont et al., 2012) and Togo (Fiamohe et al., 2015). In most of these countries, rice is parboiled using improved processing technology and is often priced above the rice that is processed using traditional parboilers and milling machines. This observation underscores the importance of enhanced post-harvest processing and its ability to increase the competitiveness of domestic rice across SSA. However, without investment in post-harvest processing and with the removal of state subsidies for fertilizer and modern seeds, privatized extensions, and liberalized prices and imports, the source of domestic commercial rice is left to local private millers. These private millers become the focal point of regional producer-processor rice networks who are unable to improve the processing quality of local rice to attract market domestically and enhance its ability to effectively compete with the imported rice in the region (Becker & Yoboue, 2009).

The third factor of RVC vulnerability to economic globalization in SSA that has been addressed in the literature is market efficiency, or the degree to which markets minimize costs and match supply with demand (Rashid, Minot, Lemma, & Behute, 2010). Rashid et al. (2010) reviewed grain markets in SSA and concluded that "[overall, [...] grain markets are reasonably efficient given the difficult environment in which they operate, but they are constrained by poor infrastructure, administrative and tariff barriers, a high degree of risk and uncertainty, and limited information]" (p. 26). They identify several factors affecting the functioning of markets, including barriers to trade in agriculture (such as district-level taxes, checkpoints, tariffs, and non-tariff barriers to trade, which raise the cost of food in remote deficit areas and landlocked countries), access to information, effectiveness of the legal system, quality of transport infrastructure, regulation of the transport sector, unpredictable food purchases and sales by the government, and foreign exchange controls. These findings are consistent with studies aimed at improving the market competitiveness of Nigerian domestic rice (see Johnson and Dorosh 2015; Johnson, Takeshima, and Gyimah-Brempong 2013; Johnson 2016; Okodua 2017).

Studies in West Africa point to the deep segmentation of the rice market between local and imported rice, which results in the inability to forward price incentives to producers (Katic, Namara, Hope, Owusu, & Fujii, 2013; Mendez del Villar & Lançon, 2014). This is also evident in other areas, including lack of capital access and credit, a non-competitive market for rice, low quality of local milled rice, and price volatility (Katic et al., 2013).

In sum, the literature on RVCs in SSA has drawn attention to three factors that appear to affect the vulnerability of RVCs to economic globalization, as experienced, for example, through agricultural trade liberalization: limited government support for rice farmers, lack of investment in post-harvesting processes, and market inefficiency. The evidence suggests that these factors may affect the capacity of RVCs to respond to the pressure of global markets differently, as they hinder the development of technical, knowledge-based, and financial assets that would enable effective responses. In a context in which markets are often working inefficiently due to segmentation and unstable exchange rates, low capacity to respond to global pressures may favor a cycle of increasing marginalization of RVC operators, particularly producers, who find themselves locked in a poverty trap that makes them more vulnerable to climate change as well.

The level of exposure of RVCs to climatic and economic pressures can vary and in itself depends on economic policies adopted in different countries. Thus the academic debate on the vulnerability of RVCs to climate change and economic globalization in SSA bears a close relationship to the growing scholarship on rural and rice sector development policies in this region.

2.3.3 Development Policies and Vulnerability of Rice Value Chains

This review identified two main foci of research on rice sector development in SSA. First, scholars have debated the advantages and disadvantages of protectionist policies and, conversely, of liberalization measures for rural development and the rice sector. A second focus, concerns policies that, regardless of the broader protectionist or liberalized framework, aim to increase capacity and efficiency within rice value chains. In the terms of vulnerability that inform this review, the debate on liberalization and protectionism is relevant because these policies can affect the degree and nature of the exposure of RVCs to economic pressures. On the other hand, the debate on efficiency measures is also relevant because these measures may influence the capacity of RVCs to respond to multiple climatic and economic pressures. This section critically reflects on status of these debates and highlights the most relevant points of contention in relation to the resilience and vulnerability of rice value chains in the region.

In response to the advice of international organizations such as the World Bank and the International Monetary Fund, many governments in SSA have privatized the agri-food sector and have facilitated its opening to global markets as a strategy to increase competition, reduce food prices (especially in urban areas), and mitigate poverty. Various studies have examined such liberalization policies, and while some have shown the advantages of liberalization, others have highlighted its drawbacks. For example, Minot (2014) found that food prices were more stable in sub-Saharan countries that were less active in trying to stabilize them, which supports the notion that "regional and international trade can play a useful role in reducing food price volatility, and that traditional food price stabilization efforts may be counterproductive" (Minot, 2014:p. 45). In a study on Madagascar, Minten, Randrianarison, & Swinnen (2009) find that when the opening of an agri-food market is combined with intensive farm assistance and supervision, global food supply chains can stimulate technology and knowledge transfer through the requirement to comply with high quality and safety standards, which are not required in local markets. Farmers and other operators, therefore, can gain in technology, knowledge productivity, and income from trade liberalization. In Benin, Velde & Maertens (2014) report that contract farming increased production levels of local rice and had a positive impact on the welfare of rice-producing farmers. Similarly, in Nigeria, Animashaun, Titilayo, Muhammad-Lawal, & Amolegbe (2015) and Obi-egbedi et al. (2013) suggest that the implementation of a liberalized rice market policy such as opening the market, reducing tariffs and creating an attractive investment environment may encourage direct foreign investment and efficiency in the RVC system, and, in turn, improve the income and wages of smallholder farmers. In a study on Nigeria, Johnson et al. (2015) proposed an argument in favour of creating an enabling environment for the private sector to invest in rice processing. Moreover, van Oort et al. (2015) argue that while most sub-Saharan countries are far from being self-sufficient in food production, open markets and the expansion of imports will be necessary to fill the consumption-production gap.

However, other studies show the drawbacks of trade liberalization. Coady, Dorosh, & Minten (2009:p. 721) evaluated tariff reduction in Madagascar and found that "although lowering tariffs generates substantial efficiency gains, these accrue mainly to the top half of the welfare distribution, and poor net sellers are actually worse off." This view is shared by a study on Nigeria (Okodua, 2017). In a study of three West African countries, Moseley et al. (2010: p. 5774) argue that "although market reforms were intended to improve food production, the result was an increasing reliance on imported rice." On the other hand, some authors have argued with respect to West Africa that despite trade liberalization policies, there is still significant leverage for the protection of national agriculture, and that the withdrawal of agricultural support is due to internal (national and local) issues rather than an international set of players, rule s, and interests (Laroche Dupraz & Postolle, 2013).

In fact, protectionist measures, such as subsidies, tariffs and import duties, import restrictions, and import bans, have been widely adopted in SSA. The level of protection varies across countries and agricultural products, mainly with the aim to protect smallholders from being outcompeted by national and international commercial agriculture companies (Garmann, 2014; Katic et al., 2013; Nicita, Olarreaga, & Porto, 2014; Obi-egbedi, Okoruwa, Aminu, & Yusuf, 2012). Still, there is often a lack of consensus as to which policy can best reduce or control the exposure to stressors of RVCs in a country. In Nigeria, for example, Ogundere (2007) and Johnson and Dorosh (2017) recommends that to increase the competitiveness of local rice, the use of tariffs should be encouraged above quantitative restrictions. Yet, other studies have shown that high tariffs should reduce rather than increase. As imposition of high tariffs is rather an incentives for rice smuggling with negative impacts on rice RVCs' actors households across Nigeria (M. Johnson & Dorosh, 2015; M. E. Johnson & Dorosh, 2017; Okodua, 2017). In contrast, Ammani (2013) proposes that restricting rice imports will better improve the ability of smallholders to market rice. Conversely, Maduabuchi & Arene (2012) advocate the use of subsidies instead of an outright ban on rice imports, as this may go against a government's position to ensure free trade.

While protectionism and liberalization policies may alter the level and nature of the exposure of RVCs to global economic pressure, scholars have also discussed a different set of policies that address capacity and efficiency within RVCs. In the face of pressures (climatic or economic), these policies have the potential to intervene in the adaptive capacity, rather than in the exposure, of RVCs. In the long term, they may help reduce vulnerability and build resilience.

Calzadilla, Zhu, Rehdanz, Tol, & Ringler (2013) showed that an increase in agricultural productivity achieves better outcomes than an expansion of irrigated areas as an adaptation strategy for expected climate change effects in SSA. Demont (2013) and Demont & Rizzotto (2012) proposed a combination of supply- shifting investment, value-adding, and demand-lifting investment policies as options for achieving a self-sufficient rice supply in SSA. Supply-shifting investments address some of the concerns overlooked by both protectionism and liberalization policies. Common supply-lifting investment policies include investment in rice research and technology development, improving crop varieties or using varieties with a higher temperature sum, optimizing crop types, modifying planting dates, application of nitrogen fertilizers, and extending crop areas and irrigation. Out of these adaptive policy goals, various studies have consistently maintained that expansion or doubling of irrigated rice area (Calzadilla et al. 2013; Johnson, et al., 2013; Liersch et al. 2013; Liu et al. 2008; Nelson et al. 2009; van Oort et al. 2015); improving crop varieties (Johnson, et al., 2013; Liu et al. 2008; Lobell et al. 2008; van Oort and Zwart 2018) and modifying or shifting planting dates (Bosello et al., 2017; Daccache et al., 2015) remain variable adaptive policy goals to enable domestic rice production to respond effectively to climate change impacts and thus decrease the growing dependency on rice import.

These measures will increase rice production and reduce the region's vulnerability to climate change (Demont, 2013; Liu et al., 2008; Saito et al., 2014). They do so mainly by boosting the production of local rice through intensification and area expansion while simultaneously managing yield constraints such as climate change and soil infertility (Rodenburg et al., 2014). In several countries, such as Burkina Faso, Madagascar, Niger, Nigeria, and South Africa, technical and financial assistance may be necessary to reduce the pressures on rice production, especially from climate change. In these countries, policies geared towards investing in irrigation systems, rainwater management, improved crop records, and institutional change have been called for to minimize the vulnerability of rice production to climate change (Rowhani et al., 2011; Saito et al., 2014; Totin et al., 2012). Furthermore, in Benin, Cote d'lvoire, and Ghana, local institutional change, funding, and strengthening farmer group participation through input subsidies and micro-lending in RVC upgrades have all been suggested to enhance rice production, processing, and self-sufficiency (Becker & Yoboue, 2009; Mumuni & Oladele, 2012; Totin et al., 2012).

Value-adding and demand-lifting investment policies seek to enhance rice processing and marketing. According to Demont (2013), value-adding and demand-lifting investment policies include processing (milling and parboiling), storage capacity, quality upgrades, capacity building, governance, branding, labeling, identity creation, certification, value chain upgrades, market information systems, market infrastructure, linkages, promotion, advertising, communication, and awareness creation. These modifications are needed to tailor the intrinsic and extrinsic attributes of local rice to consumer preferences and to enhance its competitive ability in a market segmented between local and imported rice (Demont & Ndour, 2014). For example, in Burkina Faso, Badolo & Traoré (2015) suggest that investment in local rice industries will reduce the vulnerability of rice to the pressures of markets, whereas evidence from the Central African Republic shows that access to marketing along with agricultural extension services has increased the incomes of female households and their livelihoods (Mbétid-Bessane, 2014). In Nigeria, Tiamiyu et al. (2014) and Awoyemi (2004) suggest that the implementation of policies directed at the promotion of quality-enhancing technologies and investment in storage and processing will increase the quantity of locally processed rice and its ability to compete with imported rice in the Nigerian market. Similarly, in Senegal, Demont et al. (2013) reports that investment in post-harvest rice quality is considered a priority in the reversal of urban bias as well as an important step towards achieving the self-sufficiency of local markets. In Togo, on the other hand, Fiamohe et al. (2015) indicate that investment in quality enhancement is considered to make the consumption of local rice competitive.

In sum, the review of the literature on rice sector development in SSA allows us to make two observations. First, it is apparent that the academic debate on rice development policies, particularly the assessment of different policies and policy approaches (protectionism versus liberalization), strongly depends on the policy objective that is explicitly or implicitly set for rice development policies. Thus, scholars have analysed policies on improving the self-sufficiency of the national rice sector (van Oort et al., 2015), reducing price volatility (Minot, 2014), supporting low-income farmers (Nicita et al., 2014), or increasing efficiency along the value chain (Demont, 2013). These are distinct policy goals that may result in diverse policies, the assessment of which is therefore highly dependent on the development priorities set for the rice sector in a specific country or region. With respect to the contribution of rice development policies on the vulnerability or resilience of rice value chains in SSA, this literature review does not provide sufficient evidence in support of any specific policy or policy approach in this region. In other words, it is unclear whether and under what conditions the pursuit of a particular policy goal (such as price stabilization or increased efficiency) can contribute to building resilience along the rice value chain.

Second, and in strong connection to the point above, the review of the academic debate on rice development policies has shown that policies create an uneven landscape of “winners” and “losers.” In fact, policies may entail trade-offs between social groups or actors along the rice value chain, including between urban consumers and rural producers (Demont, 2013; Moseley et al., 2010); between small- and large-scale producers (Colen, Demont, & Swinnen, 2013); between farmers and other actors, such as processors, distributors, or retailers (Becker & Yoboue, 2009; Demont & Ndour, 2014); or between large and secondary cities (Minot, 2014). Again, the social and political prioritization of policy goals is therefore very important in determining who in the rice sector and along the rice value chain benefits from the effects of a particular policy. Thus, protective measures may shield low-income farmers from international competition, but may also result in higher food prices for consumers. Similarly, increasing competition in order to lower food prices may benefit consumers at the expense of other actors along the value chain. While there is often uncertainty around the effects of policies and there is the possibility of counterintuitive results (Garmann, 2014), rice development policies that create winners and losers may also create or reinforce an uneven landscape of capacity to respond to climatic and economic disturbances.

2.4 Conclusion

This paper examined the literature on rice value chains in sub-Saharan Africa with the aims of: (i) characterizing the existing research on the vulnerability of rice value chains in SSA; (ii) synthesizing the evidence on the vulnerability of rice value chains to climate change and economic globalization; and (iii) discussing agriculture and rural development policies and their likely effects on the vulnerability of rice value chains.

This review exposed the lack of research on the simultaneous impacts of climate change and trade liberalization on RVCs in SSA. While existing studies have investigated RVCs' vulnerability to individual disturbances, they have mostly failed to analyse how the pressures of climate change and trade liberalization combine and how RVCs respond to such exposures. This is a limitation that hinders the ability to inform policy-making effectively in a context in which RVCs are indeed exposed to multiple pressures. This review also showed the uneven focus on distinct components of RVCs. Studies on vulnerability to climate change mostly address rice production, while studies on trade liberalization tend to address rice production and marketing, giving relatively little attention to other value chain components, such as processing, distribution, and retail. Such an emphasis on production reflects a common bias in food security studies, and overlooks other value chain components that are equally essential in determining the food system outcomes. Future research in SSA should address the impacts of multiple simultaneous pressures on RCVs, while also focusing on all the components of the value chain. It is suggested here that a system approach can be an insightful manner to conduct such research. This would entail a solid conceptualization of the food value chain as a socio-ecological system, which will be useful for addressing multiple stressors for livelihoods and food security. Moreover, the adoption of dynamic and participatory modelling approaches, multidimensional conceptual frameworks, and transdisciplinary methodologies may help cross the disciplinary boundaries and build synergies among researchers in the region. All of these areas are almost totally lacking in current research on RVCs in SSA.

This review also showed that there are mixed projections of climate change impacts on RVCs in SSA. We saw that different studies estimate positive or negative effects on future rice production. However, the literature review demonstrated that both observed and projected impacts are greatly uneven geographically, with respect to production systems (especially irrigated versus rainfed systems), and the size of landholdings. Smallholders are expected to bear most of the negative effects of climate change due to their relatively higher sensitivity to such stressors, which is due to their predominantly rainfed production and to lower adaptive capacity caused by poor technological and financial assets.

Future research should address two important research gaps. First, it should focus on particular regions, as climate research is still rather weak across the SSA region. Second, it should examine parts of the value chain other than production. For example, extreme climate events may disrupt not only production but also food processing and distribution. In this respect, it should be reiterated that a system approach that addresses the entirety of the RVC has the potential to significantly improve our understanding of adaptation limitations and needs. Such limitations also characterise most of the structural models used in studies on vulnerability and adaptation of the rice sector in the region. Such models fail to acknowledge the multiple perspectives and interpretations of pressures of different stakeholders along the RVCs. The models also fail to accurately reflect society and individual actors and consequently, human behaviour, which should be an essential component in adaptation models (Dickinson, 2007).

For example, structural models fail to account for (e.g. quantify) a variety of autonomous and reactive adaptive practices, which different actors would commonly employ when faced with abrupt pressures (e.g. flooding, price crashes). Therefore they generally tend to concentrate on only a few quantifiable adaptations such as changes in planting date, irrigation, crop cultivation and fertilizer, tariffs) (Challinor et al., 2018) (see also Appendix 2.1). Most of these adaptations are hypothetical rather than reflect practices implemented on the ground, particularly among the poorly resourced stakeholders or actors along the RVCs.

Participatory system modelling (PSM) approaches are increasingly suggested as valuable tools to address these gaps (Henly-Shepard, Gray, & Cox, 2015; Mendoza & Prabhu, 2006; Schmitt Olabisi et al., 2018; K. Stave, 2010). By removing the emphasis on methodological novelty, and instead placing emphasis on the role of models in social learning processes, PSM approaches promote transparency, and account for diverse understandings and adaptation capacities thus promoting dialogue and social learning among different actors along the RVCs (Harrison et al., 2013).

With respect to economic globalization in SSA, this review found that the following themes have been investigated most extensively: limited government support for rice farmers, lack of investment in post-harvesting, and market inefficiency. It was suggested that these three themes correspond to three structural limitations that have contributed to RVCs' vulnerability to economic globalization in SSA, as manifested in the difficulty of the rice sector in SSA to respond to growing internal demands for quality rice and to compete in the global market.

Finally, this review identified two main foci of the debate in the literature on rice sector development, namely the debate on protectionism versus liberalization and the debate on value chain capacity and efficiency. These debates are connected to the literature on the vulnerability of RVCs, as they address issues of exposure to economic disturbances and of RVCs' capacity to adapt to climate and economic disturbances, respectively. While these debates are far from settled, it is apparent that development policies may entail trade-offs and generate uneven landscapes of winners and losers in the RVC, which can significantly affect the vulnerability of different components of the system to contribute to responding to disturbances. It is therefore important that future research on the development of the rice sector, and rural development policy in general, in SSA include considerations of vulnerability and resilience. Future studies can clarify to what extent and in what forms different development policies hinder or enhance the resilience of RVCs to multiple exposures.

Chapter 3

Methods

3.1 Introduction

This chapter outlines the research methods employed to achieve the objectives of the study, as outlined in Chapter 1. It defines the key concepts and describes the approaches and techniques used for data collection and analysis.

3.2 Description of key concepts

The core concepts employed in this study are those of rice value chains (RVCs), vulnerability, resilience, and adaptation.

3.2.1 Rice value chains

The concepts of agri-food systems and food value chains are closely related and complementary in their usage (Gregory et al., 2005; P. Gregory, 2005). In general, these concepts relate to a chain of interrelated activities that begin with food production and end with food utilisation and/or consumption (Ericksen, 2008). Similarly, Kaplinsky & Morris (2000:4), describe the concept of value chains (VCs) as “the full range of activities, which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use”.

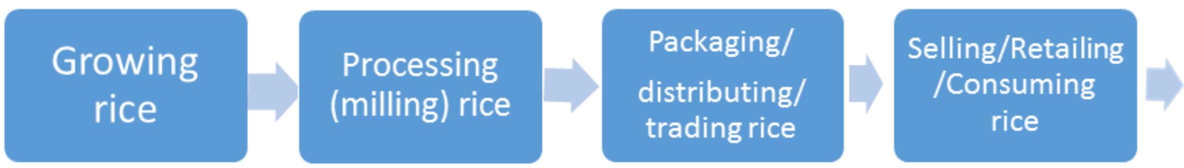


Figure 3.1. A Generic definition of the Rice Value Chains (RVCs)

Similar to this description of value chains, in the context of socioecological systems (SES), food systems have been broadly described as the interactions which occur between and within the bio-geophysical and human environment, and which give rise to a set of activities that relate to: (i) food production; (ii) food processing; (iii) packaging and distributing food; and (iv) retailing and consuming food (see Figure 3.1); with obvious outcomes of food, environmental, and socioeconomical security (Ericksen et al. , 2009; Ericksen, 2008a; Ericksen, 2008b; Ingram, 2009, 2010). In this study, rice value-chains (RVCs) are also considered SES, comprising of several components and processes, namely: production, processing, distribution and trading, and consumption (see Figure 3.1), manned by different actors along the chain. The interaction between the different components and processes (e.g., CCV rice productivity) and the various actors involved determines the RVCs' properties, including their vulnerability.

3.2.2 Vulnerability

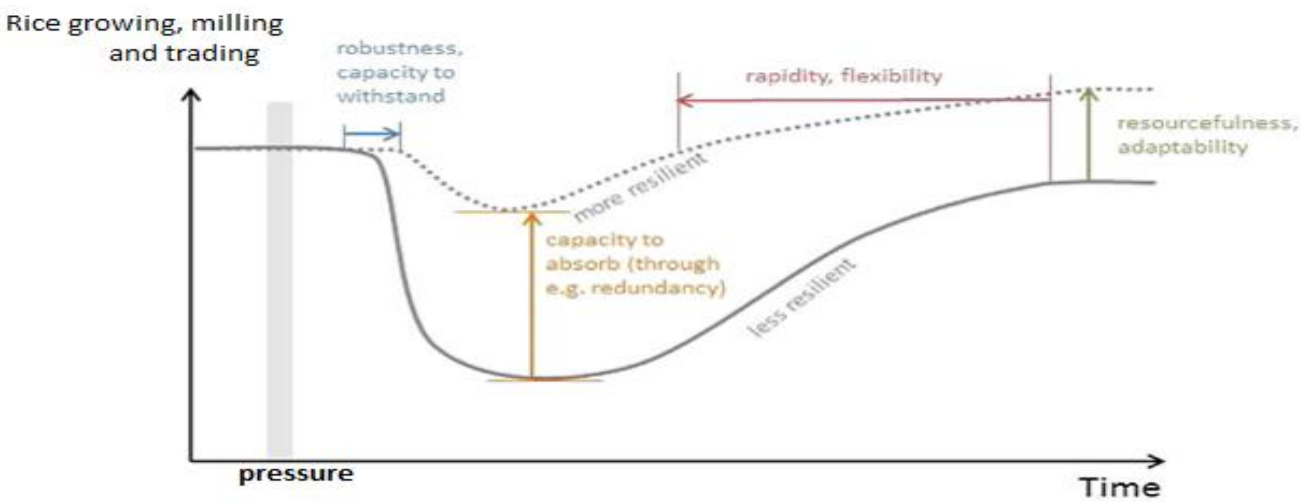
The concept of vulnerability has been used by many scholars in different disciplinary fields, including those associated with risk-hazard, political ecology/economy, pressure-and-release, integrated (hazard of place), and ecological resilience (W. N. Adger, 2006; Kelly & Adger, 2000). In these disciplines, vulnerability is either interpreted as a biophysical-outcome (endpoint vulnerability) or social-contextual (i.e. starting point vulnerability) (Brien et al. 2004; Füssel 2007; O'Brien et al. 2007). In the climate change field, vulnerability is defined here, following Adger (2006: p.269), as 'the degree to which a system is susceptible to and is unable to cope with adverse effects'. Operationally, vulnerability of the RVCs can be described as having three dimensions, namely exposure, sensitivity, and adaptive capacity (Adger, 2006; Füssel, 2007; Gallopín, 2006; Hufschmidt, 2011; McCarthy, et al., 2001). Exposure denotes how a system is situated with respect to potentially harmful events, while sensitivity relates to the degree of potential harm that systems can incur based on their internal characteristics, and adaptive capacity is the degree to which systems can mitigate the potential for harm by reducing exposure or sensitivity before, during, and after an event (Howe, et al 2013).

Drawing on this definition, vulnerability of the RVC system is caused by sources of pressure which may be external or internal to the System (Gallopín, 2006). For example, both flooding and imported rice, which competes with domestic rice in the market, are external sources of pressure to which rice production and milling are exposed, and to which they are sensitive. Meanwhile, internal pressures arise from poor milling technologies and infrastructure. However, for a system to be harmed or adversely affected by different pressures, from external or internal sources, those pressures must arise as a result of the inherent characteristics or quality of the system (Cutter et al., 2008). What this means is that the inherent characteristics of RVCs' actors determine their degree of exposure, sensitivity, and adaptation to both internal and external pressures, those characteristics include: type of rice grower, miller, or trader, i.e., small, medium, or large; system of rice farming practiced, e.g., rainfed lowland or upland rice; and, access to modern rice technology, among others.

Accordingly, small landholders using a rainfed upland rice system are very likely to experience rainwater shortages, while those using a rainfed lowland system, which is practised along river floodplains, will certainly experience occasional flooding. Further, a miller using outmoded technology to mill rice will definitely be exposed to the risk of, and thus be sensitive to, poor end milled rice quality, and will face competition from high quality milled rice more than the one using modern technology to mill rice that is better in quality. In this sense, vulnerability of the RVC is shaped not only by its exposure and sensitivity to pressures, but by the absence, or limited level, of adaptive capacity or coping measures (Gallopín, 2006; Smit & Wandel, 2006). Consequently, to assess vulnerability, an understanding of both the external and internal sources of pressures, as well as inherent characteristics of the system and the adaptive practices, is important.

3.2.3 Resilience

Like vulnerability, the concept of resilience has attracted the attention of scholars in many disciplines. For example, resilience has been studied in relation to: ecosystems (Walker, Holling, Carpenter, & Kinzig, 2004), individuals' and community's abilities to cope with extreme events or disasters (Cutter et al., 2008); and its impact on small and medium enterprises (SMEs) and farms (Darnhofer, 2014). In the literature on socioecological systems there are different, but related or complementary, positions and framings of resilience (Miller et al., 2010). Firstly, scholars have asked how resilience relates to adaptation and transformation (Gallopín, 2006; Olsson, Galaz, & Boonstra, 2014). Other scholars have asked whether resilience is a property or an attribute of the system, or an emerging process (Darnhofer, 2014; Folke, 2006). Thus, resilience of the RVC system is defined after Tendall et al (2015), as the capacity of the RVC and its components for growing, processing (milling), and trading rice at multiple levels (i.e., individual, regional, and national), to supply sufficient, quality rice to Nigerian consumers in the face of combined pressures from CCV and the economy.



Adapted from Tendall, et al. (2015).

Figure 3.2 RVC system resilience, the capacity of actors to keep growing, milling, and trading rice over time and despite the pressures faced

Figure 3.2 graphically illustrates the dynamic nature of the resilience of a food system. It highlights the properties and/or components that characterise the behavior of a more or less resilient RVC system over time (Tendall et al., 2015). These properties include the capacity of the RVC system to withstand or absorb shocks and to behave either in a more resilient way, whereby its functions of growing, milling, and trading rice are maintained, or to behave in a less resilient way, whereby its functions are lost. Another aspect of Tendall et al's (2015) definition, important to adaptation, is the flexibility required for diversification. This is a common adaptive practice that often involves engaging in more than one livelihood activity (e.g., trading rice and other crops such as maize or yam, among others), and helps spread the risks posed by pressures such as CCV and poor prices, especially on actors who depend on a single means of livelihood (e.g., rice milling).

Given the above definition of resilience as the capacity of an RVC to withstand or absorb pressures to enable it to keep functioning, thus, in order to build resilience it is important to know how resilient the Nigerian RVC system is to multiple, combined pressures (e.g. CCV, market price crashes, and others) at present. In order words, it is important to know if the current practices and processes of growing, milling, and trading rice are able to withstand external pressures (e.g., from CCV), or absorb internal pressures (e.g., poor milling technology). Or, if the current practices and processes of growing, milling, and trading rice are being reorganised and transformed to respond to pressure from both external and internal sources (e.g., competition from high quality imports and the use of poor quality seeds, among others). Thus, to understand how resilient the RVC is requires close examination of the adaptive practices undertaken by rice growers, millers, and traders to identify those who have the capacity to help the system withstand or absorb pressures. Clearly, it is not the adaptive practices that have the capacity to help the system respond to pressures, it is the actors themselves (W. N. Adger, Brooks, Bentham, & Agnew, 2004).

3.2.4 Adaptation

Adaptation in the context of agriculture and climate change refers to actions targeted at, or taken by, actors of a vulnerable system in response to actual, or expected, climate stimuli with the objective of moderating harm from climate change or exploiting opportunities (Füssel, 2007). It also involves changes in socio-ecological systems in response to actual and expected impacts of climate change in the context of interacting nonclimatic changes (Rickards & Howden, 2012), or it refers to adjustments in ecological, social, or economic systems in response to actual, or expected, climatic stimuli and their effects or impacts (Smit & Pilifosova, 2001, p. 879). The latter definitions show that adaption is closely related to the concept of resilience, defined above, and to the concept of adaptive capacity, which is "the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (McCarthy, et al., 2001:21).

Based on these definitions, adaptation or adaptive responses or practices are actions taken, or employed throughout society by individuals, groups, and governments which enable the RVC system and its actors to adjust to the above-mentioned pressures, including CCV and market dynamics (Adger, 2006; Howe, et al., 2006). Adaption practices are classified as long or short-term, depending on the duration for which they are employed (Smit & Pilifosova, 2001). They can also be viewed as planned, preventive, anticipatory, or strategic, when taken before the pressure occurs, or reactive, when the purpose is to cope with the pressure as it occurs (Smit & Skinner, 2002). Similarly, others regard adaptive practices on the basis of: the form they take, e.g., technological, behavioral, financial, or institutional; the number of people involved, e.g., autonomous or collective (Smit & Pilifosova, 2001); and, the degree of change required, e.g. incremental or transformational (Biagini, Bierbaum, Stults, Dobardzic, & McNeeley, 2014; Rickards & Howden, 2012). These different typologies of adaptation practices are important for this study in that they shed light on the manner by which rice growers, millers, and traders are adapting to current and expected pressures. This means that actors are regarded as vulnerable when they do not engage in any adaptive practice, or when they engage in practices which are not sufficient for any reason, such as not allowing time for practices to work, or not taking individual action when or before pressures occur.

3.3 Approaches to the assessment of vulnerability of rice value chain (RVC) systems

Vulnerability assessment approaches have evolved over the years from being narrow in focus, as in the examination of the impacts of a single stressor or hazard on a single system, to being much broader, as in the consideration of the combined effects of pressures or stressors on a coupled human-environment, also called socioecological systems (Polsky, Neff, & Yarnal, 2007; Schröter, Polsky, & Patt, 2005). Accordingly, this study adopted a research approach that can assess vulnerability in a complex system, paying special attention to the three dimensions of vulnerability: exposure; sensitivity; and, adaptive capacity. The approach combined VSD and PSM, descriptions of which are provided in the sections that follow.

3.3.1 Vulnerability scoping diagram (VCD)

The key elements in vulnerability assessments are that they are either more or less place-based, or that they tend to focus more or less on selected variables. The latter are concerns and specific sets of stressors about which assessors collaborate with stakeholders to learn their perspectives, knowledge, and concerns in depth, doing so through the examination of multiple, combined, and interacting stresses or pressures, to account for different adaptive capacities (Cutter et al., 2008; Luers et al., 2003; Moreno & Becken, 2009; Schröter et al., 2005). Here, the assessment seeks to address the concerns outlined above. In doing so, it employs the VSD framework developed by Polsky, et al (2007) and used for the purpose of visualization and comparisons of vulnerability assessments performed at different places and times, and to provide a starting point for understanding the details of vulnerability in a single exposure unit that can be examined in greater detail using additional research. The framework is fitting for this study because it is consistent with the vulnerability definition used, and it is applicable to SES, including agriculture (Polsky et al., 2007; Schröter et al., 2005). For example, the VSD framework has been insightfully applied in a number of vulnerability assessments, including water community systems (Howe, et al., 2013; Polsky, at al., 2007), coastal tourism industries (Moreno & Becken, 2009), winegrowing industries (Nicholas & Durham, 2012), and commercial fisheries management (Tuler, Webler, & Polsky, 2013).

To scope vulnerability using VSD, Polsky et al. (2007) highlighted five research elements that must be specified. These include: (1) the hazard and the associated outcome(s) of interest; (2) the exposure unit; and the (3) dimensions, (4) components, and (5) measures of the vulnerability process in question.

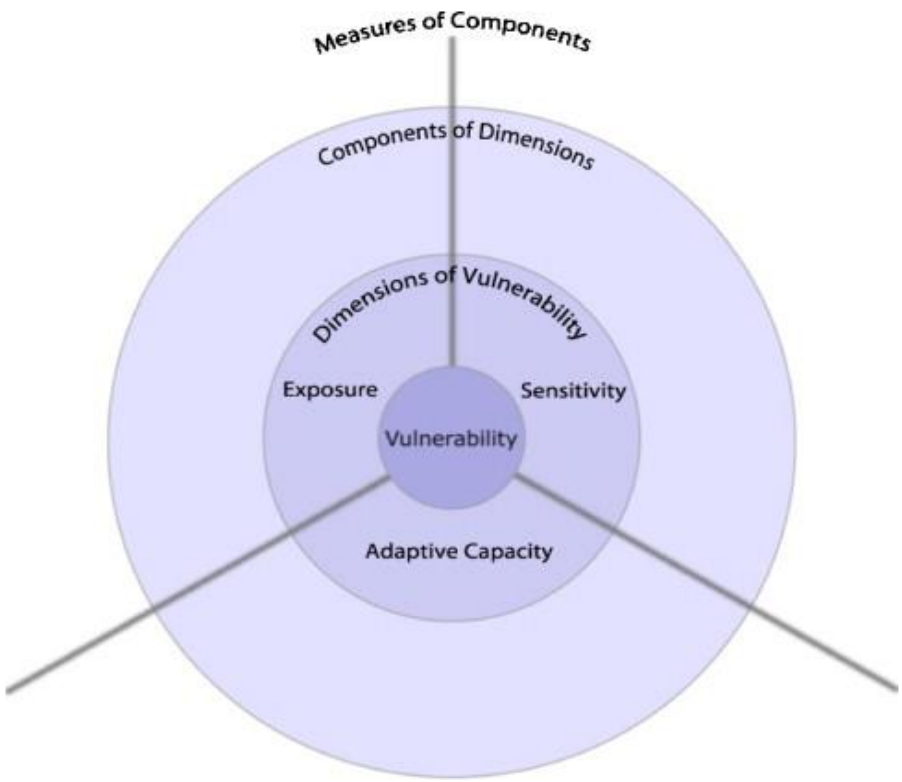


Figure 3.3. General form of the VSD (Hazard & Exposure Unit Unspecified) adopted from Polsky, et al. (2007)

Figure 3.3 presents the template of the VSD. Vulnerability of the system in question is represented at the centre of the diagram. In the centre ring, vulnerability is divided into its three fundamental dimensions: exposure; sensitivity; and adaptive capacity. The next ring represents the components of those dimensions, or the features on which they are evaluated. The final, outer ring highlights the measures of the components, i.e., the observable characteristics of each of the three dimensions.

3.3.1 Participatory system mapping (PSM)

PSM is employed here to complement the VSD. PSM relies on system thinking, which is the ability to see the world as a complex system, in which everything is connected to everything else (Meadows, 2008). According to Stave (2010), it is one of the approaches of system dynamics modelling used for to engage stakeholders in problem analysis. PSM helps portray the components of a system and its environment (Nicholas, 2010). In addition, PSM (using stock and flow maps, and causal loop diagrams) has been often used as a transition between the creation of mental models and formal simulation models, occasionally it stands alone to inform diagrammatic reasoning, including clarifying assumptions, structuring a problem space, or identifying unexpected implications of unplanned disturbances or international policy interventions (Henly-Shepard et al., 2015; Mendoza & Prabhu, 2006; Stave & Kopainsky, 2015). Thus, in this study also, PSM tools are used alone to elicit mental maps with a view to uncovering the distinctive perspectives of RVC systems held by the different actors along the chain.

In different parts of the world, and in different disciplinary domains, PSM has proved helpful in facilitating participants learning about the system, promoting social learning among participants, and building social capital to enhance management and to support decision-making on wide-ranging issues (Henly-Shepard et al., 2015; Stave, 2010). These include: intellectual disability care (Duryan, et al., 2014) ; sustainable environmental management (Stave, 2010) ; sustainable forest management (Mendoza & Prabhu, 2006) ; community health management (Sarriot et al., 2015); and, watershed-based soil salinity management in agriculture (Inam, et al, 2015). More recently, PM has been applied to study how improvements could be made in household food security in rural Mali (Rivers III et al., 2017), and to identify sources of climatic risks in West Africa (Schmitt Olabisi et al., 2018).

3.4 Research design

The study employed a cross-sectional design with case study elements to explore vulnerability of the RVC system to multiple pressures (Bryman, 2016). The cross-sectional design enables the investigation of more than one case at a single point in time. This makes it is possible to examine the relationships between cases and to account for possible variations across them.

In addition, this type of design informs an in-depth study and takes a holistic view which, prospectively, allows valuable insights to be gained on issues which are based on the experiences and perspectives of those affected (Bryman, 2016; Denscombe, 2014). This also works well as the design supports the main aim of the study, i.e., to assess the vulnerability of the entire RVC system, rice growing, milling, and trading, to multiple, combined pressures.

Moreover, the design allows multiple data collection techniques to be used, such as structured, semi-structured, unstructured, and workshop interviews**,** and again, each works well for this study (Bryman, 2016; Denscombe, 2014)**.** While cross-sectional design could be helpful in understanding patterns of association among cases under investigation, in most studies using quantitative data, the design tends to examine relationships only between variables because the features of experimental design are not present, this makes the researcher uncertain about the direction of causal influence (Bryman, 2016). However, this limitation is addressed in qualitative studies as its techniques allow elucidation of the experience and perspectives of participants in response to a given research problem (See Nicholas & Durham, 2012).

3.5 Selection of the study sites

The study sites were selected as follows. Firstly, the areas with a well-established rice farming, milling, and trading history were identified in the different climatic and ecological belts of Benue State. This resulted in the pre-selection of five prospective study sites, namely: Makurdi; Utukpo; Gboko; Katsina-Ala; and Adikpo in Kwande. Secondly, from the pre-selected study sites those where the biggest functioning rice mills were situated near market centres were then selected. Based on this criterion, Katsina-Ala and Utukpo were excluded. Therefore, Makurdi in the south, Gboko in the centre, and Adikpo in Kwande in the north, were chosen as the study sites and are from where the sample population was drawn (Figure 4.1). The rationale for these choices lies in the possibility they allow differences in exposure, sensitivity, and adaptive practices of RVC actors to be uncovered across the geographical divides of Benue State. Moreover, these study sites were easily accessible and the security situation at the time was good. In addition, the language at the three selected study sites is Tiv, this reduced the burden of transcribing two additional languages, Idoma and Etulo, should Utukpo and Katsina-Ala have been selected for the study.

3.6 Methods of data collection

3.6.1 Exploratory fieldwork

Exploratory fieldwork was carried out between July and August, 2015. The aim was to acquaint myself with the study area, Benue State, interact with stakeholders in the RVC sector, gain initial understanding of the RVC system, establish relations and contacts, and determine modalities for the collection of both secondary and field interview data. The information sources visited included:

(i) Agricultural and Rural Development Authority (BNARDA) (Figure 3.4a);

(ii) National Bureau of Statistics (NBS), State Office, Federal Secretariat, Benue State (Figure 3.4b below);

(iii) Ministry of Agriculture and Natural Resources (MANR), Makurdi, Benue State (Figure 3.4c);

(iv) National Bureau of Statistics, Abuja;

(v) MIKAP Nigeria Limited, Makurdi, producer of Miva rice brand(Figure 3.4d);

(vi) Rice Growers Association of Nigeria (RIFAN), Makurdi;

(vii) Nigerian Meteorological Agency (NIMET), Makurdi;

(viii) Modern Market, Makurdi;

(ix) Wadata and Wurukum Markets, Makurdi;

(x) Gkoko and Adikpo Markets; and

(xi) Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

During these visits, secondary statistics on rice value chains, which were not available electronically, were collected. For example, data on the status of rice production in Benue State, such as annual rice output/total quantity of rice harvested, area under cultivation or harvested for rice, and average rice yield in Benue State, were all collected.

Figure 3.4. Exploratory field visits to: BNARDA, (A); NBS, State Office, (B); MANR, Makurdi, (C); and, MIKAP Nigeria Limited, Makurdi, (D).

Lastly, interviews with key informants were conducted. These informants included:

(i) The Director of the RVC of the BNARDA;

(ii) Secretary of RIFAN;

(iii) Production manager of MIKAP, Miva rice;

(iv) Marketing managers of MIKAP, Miva rice;

(v) Farm manager of Lobi farms;

(vi) Resource person for the International Fund for Agricultural Development (IFAD);

(vii) Men and women leaders of Wurukum and Wadata Rice Mills, Makurdi; and,

(viii) Women and men leaders of Leaders of Adikpo, Gboko, and Katsina-Ala Rice Mills.

3.6.2 Data needed to populate the VSD and to generate the PSM

As two approaches were employed in the study, VSD and PSM, two sets of data were relevant to each approach. In terms of the VSD, data on present exposure, sensitivity, and adaptive practices of the three key actors, i.e., rice growers, millers, and traders, to multiple, combined pressures was needed to populate the two rings of each of the three sectors of the dimensions of vulnerability (see Figure 3.3, above). This data was collected using semi-structured interviews.

With regards to the PSM approach, mental map data was elicited from the different actors along the chain. These data included individual and consensus lists of RVC systems' components, identification of linkages between different components of the RVC system, and general insights into the mental maps generated. These data were obtained through a series of exercises implemented during the workshop interviews.

3.6.3 Sampling procedures: snowballing sampling

Participant selection adopted snowball sampling, a technique by which one or more participants refer the researcher to other potential participants (Schutt, 2012). This sampling technique was found helpful in the selection of participants for a similar study on multiple exposure and dynamic vulnerability in the grape industry in Okanagan Valley, Canada (Belliveau, et al., 2006). In the first step, growers, millers, and traders of milled rice in the three study locations formed the list of prospective participants. However, in addition to the difficulty of drawing out a sample population, it was even more challenging to draw an actual sample illustrative of all actors. For example, when reaching out to the stakeholders (e.g., Federal and State departments of agriculture and the Rice Growers Association of Nigeria (RIFAN), it was discovered that a reliable list of actors from which the participants could be selected was nonexistent.

Snowball sampling was also useful in this study to overcome issues of trust in the field. Small landholder growers, millers, and retailers are notoriously suspicious of researchers, whom they believe to be representative of discredited government agencies. Similarly, medium and large landholder growers, millers, and traders who have accessed government loans are notoriously suspicious of researchers, whom they believe to be undercover government officials seeking to control them for repayment of their loans. Therefore, snowball sampling enabled participant selection in a rather hostile environment by introducing the researcher via an informant, or an insider well-known to the target population, who could assure participants that the study was genuine academic research.

3.6.4 Sample size

The study used a small sample which is exploratory in nature and tends to be associated with qualitative research strategies and the case study design employed here (Bryman, 2016; Denscombe, 2014). Bryman (2016:416) argues that there is considerable variation among scholars about what the minimum number should be for an adequate sample in a qualitative interview study, but that most writers recommend between 20 and 60. Therefore, a total of 72 samples for this study is on the high side, but over 20 for a specific location is considered adequate as similar studies have used the same size of sample (Table 3.1 below). For example, Belliveau, et al., 2006) used a small sample size (n=22) in a study of vulnerability in the grape industry, and Nicholas and Durham (2012), who used VSD, also relied on a small sample (n=20) to study adaptation and vulnerability of winegrowing to environmental stress.

Table 3.1. Number of interviewees sampled

RVC actors	Makurdi	Gboko	Adikpo	Total
Growers	11	9	10	30
Millers	7	7	7	21
Traders	8	8	5	21
Total	26	24	22	72

A total of 90 participants were initially enlisted for the study, 30 for each site, comprised of: small landholders, millers, and traders; and medium/large landholder growers and small/medium millers and traders. Following Lowder, el. (2016), growers with 0-2 hectares of land were considered small landholders, while growers with >2-5 hectares were understood here as medium landholders, and those with >5 hectares were regarded as large landholders. The latter were generally few, and therefore this group was merged with the medium landholders. In terms of millers, since the number of commercial rice mills were many, but only one industrial mill was operative in the study sites, all commercial mills were categorised as small or medium mills, while the only industrial mill was regarded as a large mill. Lastly, all wholesale traders were considered as medium or large-scale traders, while all retailers were viewed as small-scale traders. From these, a total of 72 participants were involved in the study across the three study sites, 26 in Makurdi, and 24 in Gboko and 22 in Adikpo (see Table 3.1 above). Information on the lists of participants (e.g. growers, millers and traders) across the three study sites, including their social demographic profiles can be found in appendices 5.1, 6.1 and 6.2 respectively.

3.6.5 Interviews

Semi-structured interviews were carried out with rice growers, millers, and traders between December, 2016, and February, 2017, in order to gain an in-depth understanding of the dynamics that make the RVC system vulnerable. The interview guide was organised into four sections (see Figure 3.5-3.8 below). Questions in the first section aimed to understand the background of individual participants, their rice farming, milling, and trading activities, and the challenges they faced in carrying out their respective activities. The remaining sections focused on understanding exposure, sensitivity, and adaptive practices in the face of economic and climatic pressures.

Figure 3.5. Interview with upland rice growers **Figure 3.6. Interview with rice millers**

Figure 3.7. Interview with lowland rice growers **Figure 3.8. Interview with rice traders**

Particpants were asked to share their experience of extreme events, and how they reacted and/or responded to such pressures over the past 5-10 years (see interview guide in Appendix 3.1). While this is a cross-sectional study and focuses on activities and processes such as growing, milling and trading that tend to vary on a seasonal basis (i.e. one year), the exposure, sensitivity and adaptive capacity depend on barriers and facilitating factors that build up in a longer time frame. Thus, the time frame 5-10 years was considered appropriate to enable an examination of RVCs vulnerability in three study sites. This time frame is consistent with a similar study (see Belliveau et al. 2006). Furthermore, as discussed by Risbey et al. (1999) and Barrett et al (2017), to consider a longer timeframe allowed to capture not only operational (i.e. daily) and tactical (i.e. seasonal) adaptation practices, but also longer term – strategic- ones.

Moreover, questions were adapted to suit the actor under consideration in that given situation (see Appendix 3.1 for interview guide). Polsky et al.(2007) emphasised that while populating a VSD, the hazard and the associated outcomes of interests should be specified. However, in this study, interview questions were left open to invite discussion about different types of pressures, rather than to suggest or limit the focus to those related to climate and markets. This was an important step to gaining a broad, holistic perspective on recent pressures to which participants along the chain are exposed.

Accordingly, 72 interviews, each lasting up to 90 minutes or more, were conducted across the study sites. The interviews were recorded using an Olympus Digital Voice Recorder VN-741PC with the agreement of the participant. In addition, notes were taken with the help of two research assistants, which served as a starting point for a discussion of the interviews at a later research stage.

3.7 Participatory Rice Value chain (RVC) system mapping workshops

Participatory workshops were held for two purposes. Firstly, to elicit the mental maps of the RVC system from different actors along the chain, and secondly, to validate the VSD generated (Figure 3.9). Thus, a total of six workshops, one each with rice growers, millers, and traders, were held in Makurdi and Adikpo, each one lasting for one day. The workshops were conducted during the first and second week of March, 2017. The key highlights were identification and listing of components of the RVC and the establishment of links between them. Moreover, participants could use the mental maps generated to draw insights into the RVC system, to identify the weak spots, and to suggest possible actions to strengthen the system. Further, participants were to give their thoughts and comments on how they see the mental maps of the system they generated and whether the maps had challenged their views of the system, perhaps reinforcing or confirming their beliefs about the RVC (see workshop protocol in Appendix 3.2). Figure 3.9 below shows phases in the participatory mental mapping of the RVC system conducted with different actors in the two study sites. The remainder of the approach and the process of the mapping workshops, beginning from selection of participants (i.e., identification of stakeholders and salience) are discussed in the sections that follow.

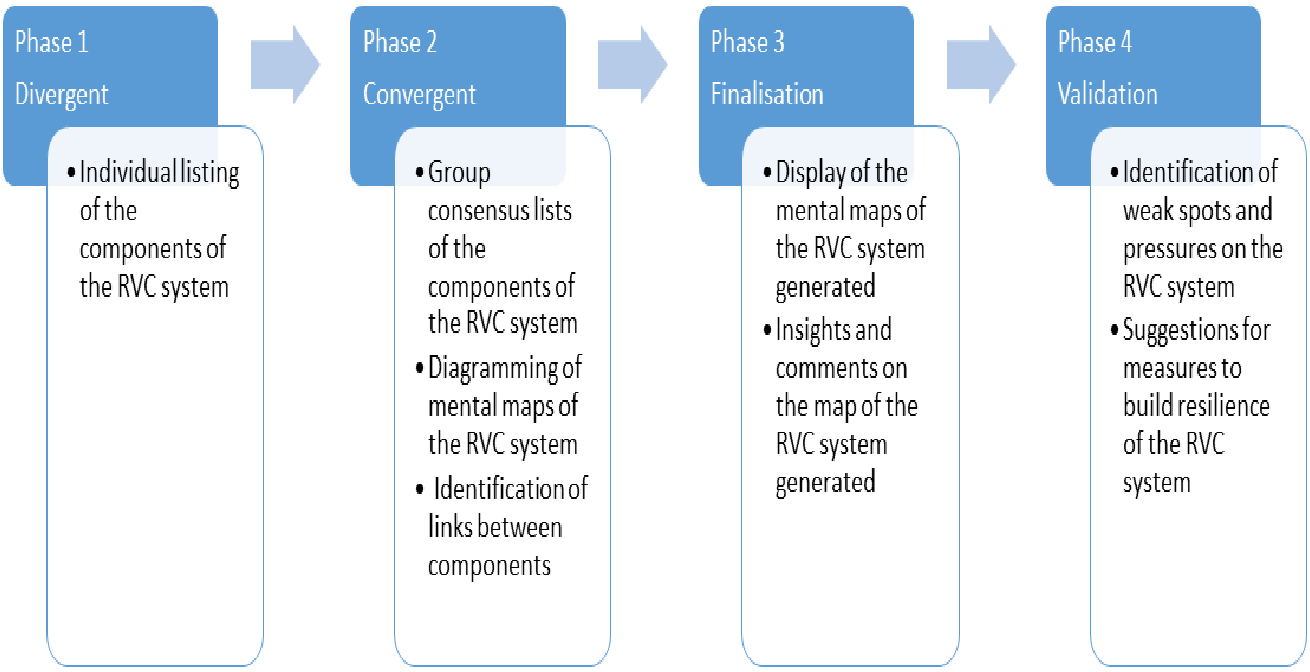


Figure 3.9. Diagram of phases in the participatory mental mapping of RVC system process. Adapted and modified following Howe, et al., 2013.

3.7.1 Stakeholders' identification

Therefore, for each group of stakeholders, a mixed number of small, medium, and large landholder rice growers, small and medium or large rice millers and traders, comprised of men and women, were invited to attend the workshops. In all, a group of seven rice growers and millers and five rice traders participated in three workshops held for each group in both Makurdi and Adikpo (see Table 3.2 below).

This manageable number of participants (i.e., between five and seven) was important to enable the workshop convener to follow up the discussion later. This number also enables effective facilitation (Vennix, 1999) that supports participants to easily work as a team (Hovmand et al., 2012), while also reducing the challenge of managing the group dynamics, including the power relations which come with hosting a larger group. Lastly, when a small group is used costs are lowered, as is the number of facilitators required.

Table 3.2. Number of participants at workshops

RVCs' actors	Makurdi	Adikpo
Growers	7	7
Millers	7	7
Traders	5	5

3.7.2 Workshops

The development of the mental maps of the RVC by different actors along the chain was the next step. Thus, scripts developed by Andersen & Richardson (1997), and used by Luna-Reyes et al. (2006) and Hovmand et al. (2012), were adapted and modified to match the objective of the study. Scripts are a generic exercise that can be adapted to any group model-building workshop. There are six most important scripts: (i) hopes and fear, used to set group expectations); (ii) variable elicitation, used to identify variables related to the problem); (iii) graph over-time, used to elicit dynamic stories; (iv) structure eliciting, to elicit causal structure; (v) concepts model, to introduce system dynamics); and, (vi) ratio, to find where capacity and demand meet (Andersen & Richardson, 1997; Hovmand et al., 2012).

As the main objective here is to use the perspectives of different actors of the chain to develop the mental map of the RVC system, two out of the six scripts identified above were found relevant, and were thus prioritised. The aim of the two scripts, variable and structure elicitation, was to identify RVC components, as well as the linkages and interaction between the major and sub-components. Usually four tasks or activities characterise these scripts, these include: divergent; convergent; evaluation; and presentation activities (Luna-Reyes et al., 2006).

In the first 20 minutes of each workshop participants were welcomed and group relations established, after which the need to map their understanding of the RVC components and their interaction with them was put forward as the overall objective of the study. The next step was elicitation of RVC components.

Individual and group elicitation of RVC components was carried out in two phases, the divergent thinking and convergent brainstorming phases (Andersen & Richardson, 1997). The main activity carried out during the former was to individually list the components of the RVC. Participants were asked to work individually for up to 20 minutes and to generate a list of their perceptions of the main and sub-components of the RVC. An exercise booklet and a pen was provided to each participant for this purpose.

After individual lists were completed, participants converged for a plenary session for the convergent brainstorming phase. At this point they worked in a group to cluster the components and to agree on those they considered to be the major and sub-components of the RVC in Benue State. After a discussion that lasted for about 60 minutes, a compromise was reached, following intervention by the facilitator, and the participants reached a consensus for the list of RVC components. The consensus list revealed some initial perspectives of the RVC by all types of participants/actors, although further insights as to why the growers decided on each component is discussed in Chapter 7, along with the diagramming of the RVC system.

After individual listing and clustering of components was completed, diagramming of the mental maps was the next step. To proceed, a large sheet of paper was placed on the table in a plenary session (see Figure 3.10 below). Then, participants were asked to present the major and sub-components of RVC on which they had agreed, by either writing directly on the paper, or by writing on a sticker and sticking it to the paper on the table (see Figure 3.10). A facilitator coordinated and organised the presentation of the components in an orderly way. Booklets, pens, and markers were provided for participants to write notes about their insights and to use in carrying out the activities.

After all components were written on the paper, participants were asked to proceed with identification of links and relations between the major and sub-components.

Figure 3.10. Mental maps diagramming with different rice value chain actors

At the end of the process, the components and the links were represented as stock and flow maps. Stock and flow maps are used to adequately represent each element of the system captured from participants' cognitive or mental perception of the RVC system. Stocks are represented by rectangles, while arrows that flow into the stock represent inflows. On the other hand, arrows that rise from certain stock represent outflows. Furthermore, valves represent flows and clouds represent the sources or sinks for the flows. The source represents the stock, from which the flow arises, and sinks represent the stocks into which the flows flow (Sterman, 2001).

3.8 Data analysis and presentation

3.8.1 Transcription

The audio recorded interviews and workshop proceedings were transcribed from Tiv to English and saved as Microsoft Word documents. Field and workshop notes were used during the process to complement the audio recordings. Two assistants, both native speakers of the Tiv language, one with an MSc degree in English Language, and the other with an MSc degree in Geography, assisted the researcher who also has good knowledge of the Tiv language. The process lasted from February to April, 2017.

3.8.2 Coding

After interview and workshop transcriptions were completed, a computer-assisted qualitative data analysis software, NVivo 11 (QSR International, 17; Bazerley & Jackson, 2013), was used to code the data. Content analysis was used to identify emergent themes and patterns and the underlying meaning in the data (Denscombe, 2014). Codes were generated progressively and adjusted or combined as the analysis of the interview transcripts proceeded. Moreover, codes thought irrelevant to the emergent themes were eliminated until the final lists of codes for each question were generated.

The next step was to check and verify that the initial list of codes generated conveyed the essential message that explained the three dimensions of vulnerability. Then, all the codes were categorised following the themes of exposure, sensitivity, and adaptation practices, which correspond to the three dimensions of vulnerability. This procedure was replicated for the analysis of the workshop data in which the various actors generated mental maps of the RVC system based on their perceptions. Lastly, simple percentages were calculated and the data was presented in bar charts or graphs and tables to help visualise the composition or comparison of values or results.

3.8.3 Validation of results

To judge validity, the results of the interview analysis were compared with the results of the workshop analysis. Where both methods give the same, or overlapping, results, it could be concluded that the findings are solid. However, where the two results differ we reflect on why this is the case (Brydon-Miller and Dingwell, 1997).

3.9 Limitations

The limitations of this research were the result of a number of factors, including the context and the expectations of the qualitative research strategy, access to data, and time. First, it was the expectation of this study to use probability sampling techniques, but the lack of an existing liable sample population to start with made it impossible to use this technique given the length of time needed to initiate and complete such a study. Second, and similar to the point above, this study initially sought to use a large sample, however, using semi-structured interviews to gather data from a large sample is very expensive and time consuming. Third, the issue of a lack of trust of researchers and the perceptions held by participants that they are representatives of government, made the use of data collection techniques other than snow-balling challenging. Fourth, because of limited funds and time, this study was limited to three study sites, where more sites would have provided more data. A further issue was that of language as data were transcribed from Tiv to English. Capturing participants' expressions and translating them exactly was challenging, however, with the help of the two native speakers, the process was completed seamlessly.

In addition to the limitations highlighted above, this research problem could have been tackled by a full system dynamics model, which in the interim was not feasible due to time constraints and lack of sufficient background data and understanding of the system. However, this is an avenue for future research. Lastly, a longitudinal design would have been suitable for this study as vulnerability is dynamic, but because this would require conducting fieldwork repeatedly over a number of years, it was not feasible given the time and resources available for this study. Therefore, a cross-sectional design with case study elements, often employed in situations where it is impracticable to employ a longitudinal design, was practical at this stage (see Feola, et al., 2015). However, future research of a longitudinal design will be considered in a follow up study.

3.10 Ethical issues

Before the field data collection was carried out ethical clearance was sought from the University of Reading Research Ethics committee (see Appendix 3.3 for ethical clearance). This ensured that the study design made appropriate measures to protect the interests of participants across the study sites. After providing a detailed field data collection plan, the plan was vetted by the University Research Ethics Committee, and was allowed to proceed. During the field data collection, participants were given a letter of introduction which disclosed the full purpose of the research so they understood what the research concerned before they agreed to take part. The key message of the consent letter emphasises commitment to privacy issues of the participants. It states that "the University of Reading will keep any information you supply in a secure place until the end of the study, when it will be destroyed. Nothing that you tell us in this research project will be disclosed to anyone other than my dissertation supervisors and markers. All information will be treated in the strictest confidence." In addition, the consent form which participants were expected to sign stated that participation is voluntary, hence a person is free to choose whether or not to take part. Therefore, whenever participants give their consent, they sign a consent form as evidence that they have consented to participate in the research.

3.11 Positionality

Throughout this research project, I was aware of my and my assistants' positionality in terms of ethnicity, gender, age, class, education status and previous knowledge of the environment. The participants remained at the forefront of the field data collection process and analysis of data. Bourke (2014) posited that in most qualitative research process, the identities of both researcher and participants potentially introduce biases through which both the researcher and participants presume to gain insights into how we might approach a research setting, members of a particular group, and how we might seek to engage with participants. This view was considered in this study in a number of ways.

Firstly, I am a young adult Nigerian male PhD student whose has links to Benue State, and who had lived and studied in Nigeria for most of my life. Prior to embarking on a PhD programme in Reading for which this research is based, I had worked and carried out a few studies with smallholding farmers in Benue State and other parts of northern Nigeria. My two research assistants were also young male adults, born, raised, and educated settled for most of their adulthood in Benue State.

Therefore, as I planned to engage RVCs' actors (e.g. growers, millers and traders) and stakeholders in a field data collection, I initially presumed that my positionality and that of my research assistants give us adequate knowledge of the culture (i.e. language) and environment that could aid in connecting well both personally and professionally with RVCs' actors across the study sites. However, I soon realized that I needed to negotiate my position in more challenging ways. Most RVCs' actors and stakeholders were generally hesitant to be engaged in an in-depth interview and to grant me access to secondary data. For example, while the medium/large landholders were rather suspicious of us as being representatives of government or corporate bodies in disguise to trap them for defaulting in making loans repayments, the leaders of governments, smallholders, small-size millers, traders and leaders of government agencies and farming associations regarded us as outsiders who came to do research for personal economic gains. Moreover, other participants had seen their hopes frustrated failed government interventions and unmet promises of assistance. These participants were reluctant to engage in research which they often perceived as an additional government initiative.

Further positionality issues that emerged during the research relate to my educational level, and the supposed financial capacity (which was assumed as I was studying at a foreign university). Participants with low educational level distrusted university-educated researchers and did not take them seriously, and various public servants expected an economic compensation for their participation or for granting access to secondary data.

The issues briefly described above can be traced back to an underlying negotiation of my insider/outsider position (Bourke, 2014; Merriam et al., 2001). While I felt I was an insider, many participants perceived me and my research assistants as outsiders (Bourke, 2014), which resulted in distrust, reluctance to participate in the study and the attempt to take advantage of my supposed financial capacity.

To overcome the above mentioned issues, I built on my insider status (Merriam et al., 2001), and especially my ethnicity and that of my assistants, and my previous experience of working with smallholders in Benue State. Thus, in my interactions with potential and actual research participants, I built relations on the basis of those elements that were recognized by those participants as signs of being an insider, which enabled me to build trust and participants to open themselves. Critical to this approach was the use of a snowballing sampling technique (see sub-section 3.6.3), by which participants became gatekeepers for other participants and therefore helped reduce or eliminate the barriers mentioned above. By approaching participants on these grounds, I would be perceived as *one of them* and the research a possibility to contribute to solving persistent problems, and to make the participants' voices heard beyond Benue State and Nigeria.

3.12 Conclusion

This chapter has described the overall research strategy and design, including approaches and techniques of data collection and analysis and presentation of data and findings. The following chapter presents the case study. It describes the study area of Benue State, Nigeria, and characterises the RVC in detail, pointing out the challenges that give rise to its vulnerability**.** Chapter 5, 6, and 7 then present the results of the data analysis based on the methods described in this chapter.

Chapter 4

Case study: rice value chains in Benue State, Nigeria

4.1 Overview of Benue State

This chapter first presents an overview of Benue State, it describes its geographic and socioeconomic settings, and then it characterises the RVC and climate change in Nigeria broadly, and in Benue State in particular, to help illustrate the dynamics within which the RVC activities and processes operate.

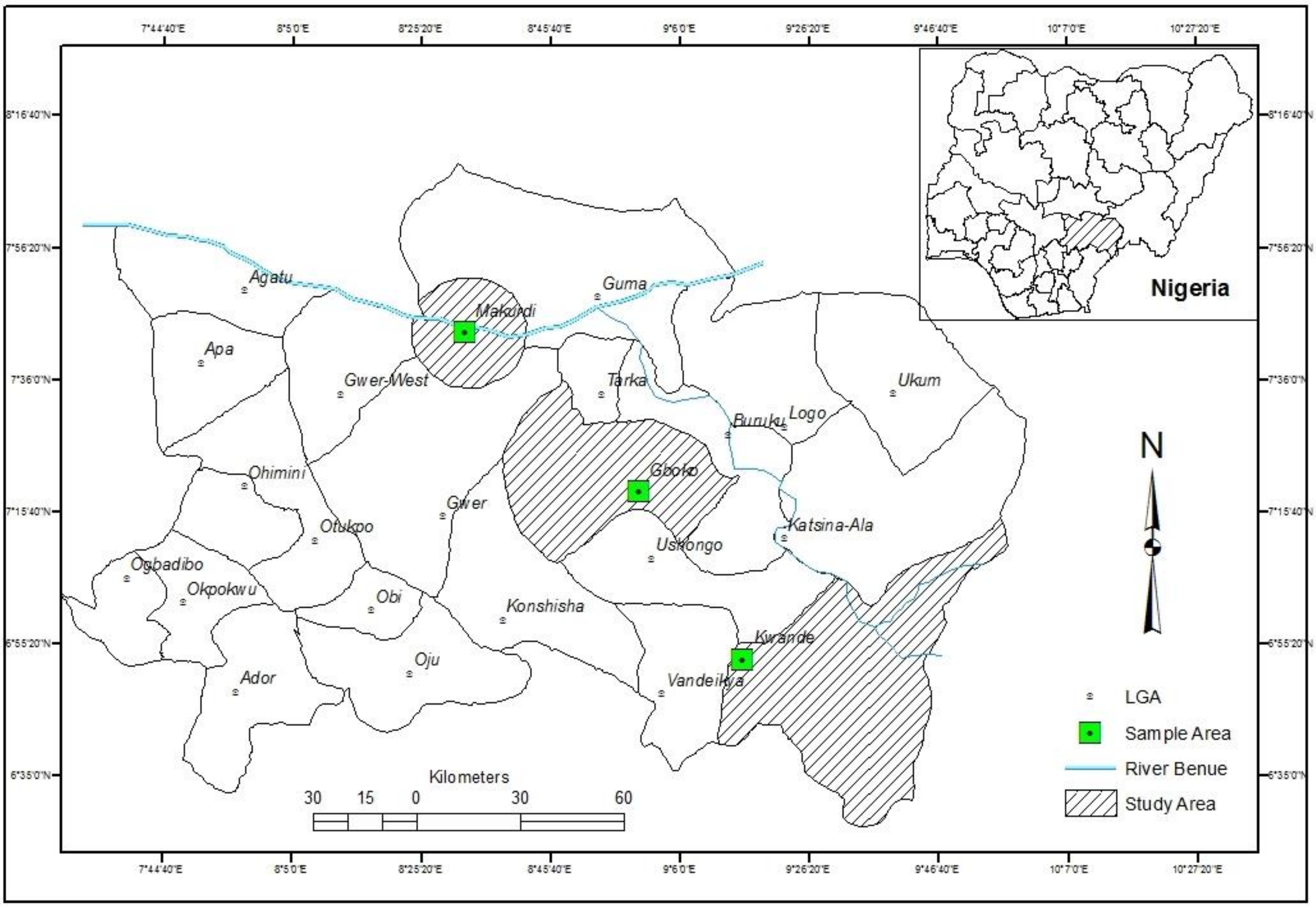


Figure 4.1. Map of Nigeria showing Benue and the study sites (source: generated from GIS Lab, Federal University Dutsinma, Katsina, Nigeria)

4.1.1 Geographical settings

Benue State is located in the North-Central region of Nigeria (see Figure 4.1 above), a region known for its production of the bulk of the domestic[2] rice produced in the country overall (Akpokodje et al., 2001; Erenstein, et al., 2003). Geographically, Benue State lies between latitudes 6^0 25’ N and 8^0 8’ N of the equator, and between longitudes 7^0 47’ E and 10^0 00’ E of the Greenwich meridian. It is bordered by five other states: Nasarawa in the north; Taraba in the east; Cross-River in the south; Enugu in the south-west; and Kogi in the west. Benue State also shares an international boundary with the Republic of Cameroon on its southeastern corner. The state has a total land area of 30,800 sq. kms (National Bureau of Statistics, 2010).

4.1.2 Geology, relief, and soil

Benue State is situated in the middle of the Benue trough, which is an elongated trough-like basin. Geologically, the state is underlain by a sedimentary basin to the northeast and by a basement complex in the north and south (Obiora, Ajala, & Ibuot, 2015).

The relief, or topography, of the state is generally low lying. The southern part of the Benue valley, around Makurdi, is gently undulating, interspersed with low hills and slopes with an elevation of about 305 feet (93 meters) above the sea level (Ojanuga & Ekwoanya, 1995). The same relief pattern is found around Gboko in the central part of the state, although the rolling hills are relatively steeper than in the southern parts. However, towards Adikpo-Kwande in the north-eastern area, the highland- and lowland-like topography is stepped-up with some elevations measuring up to about 1000 feet (304.8 meters) above the sea level (Effiong, Igwe, Okoro, Maduka, & Ojonugwa, 2015).

The drainage pattern of the state, especially in north, is dendritic, it consists of smaller rivers that meander into the Katsin-Ala River, a tributary of Benue River, from both the north and south (Effiong et al., 2015; Obiora et al., 2015). The rivers are characterised by alluvial deposits, called “fadama”, in the floodplains on either side of the Benue River (Effiong et al., 2015). The soils in the region (e.g., uplands and lowlands) are formed from the parent materials that originate from both sedimentary and basement complex rocks; the lowland alluvial soils of the floodplains, especially in the south, are flanked by cretaceous sediments from the Makurdi sand stone (Ojanuga & Ekwoanya, 1995). The location of the state, in a trough-like basin with a low lying topography interspersed with large and small rivers, is one reason for the recurrence of seasonal flooding.

[2] The terms domestic rice or milled rice and local rice or milled rice mean the same thing. Also, internal produced rice or milled rice production are all meaning the same thing.

According to Ojanuga and Ekwoanya (1992), the alluvial soils of the flood plains, regardless of being heterogeneous, are better for agricultural use in general, and rice growing in particular, than the adjoining upland soils. The former are generally heavier in texture than the upland soils, and hence, are classified as Eutric Fluvisols, Luvisols (Orthic and Vertic subgroups), Nitosols, and Cambisols (Gleyic and Vertic subgroups). Moreover, the alluvial soils have higher capacity for the retention of water and nutrients. In addition, the higher inherent fertility and availability of moisture in the horizons above the water table in the dry season makes the floodplain fields (i.e., the fadama lands) suitable for all year-round cultivation, including rice growing, under wide ranging growing systems.

4.1.3 Climate and vegetation

According to the the Koppen Classification Scheme (Peel, Finlayson, & Mcmahon, 2007), Benue State falls within the Aw Climate. It has a Sub-Humid Tropical Climate characterised by distinct rainy/wet and dry/harmattan seasons. Both these seasons are shaped by the seasonal interaction of three air masses, namely: the warm, moist southwesterly air mass, also called the tropical maritime (TM) air mass; the warm, dry northeasterly air mass, also known as the tropical continental (TC) air mass; and, the equatorial air mass (Abiodun, et al., 2013). The first of these, the TM air mass, is a rain-carrying wind that brings about the rainfall during the rainy season, which often lasts for about eight months, but effectively occurs from March to October (see Figure 4.2). The second air mass, the TC, ushers in the dry/harmattan season, a period of no rainfall which is dominated by boisterous, dry, dusty winds coming from the Sahara Desert (i.e., the harmattan wind), sometimes from November to February or March. These first two air masses meet along a front called the Inter-Tropical Discontinuity (ITD). The third, which comes from the east, flows into the upper atmosphere and when it occurs it undercuts both the TM and TC along the ITD and gives rise to squall lines, i.e., a narrow band of storms and high winds, or dust devils, (also known as whirlwinds) (Abiodun et al., 2013).

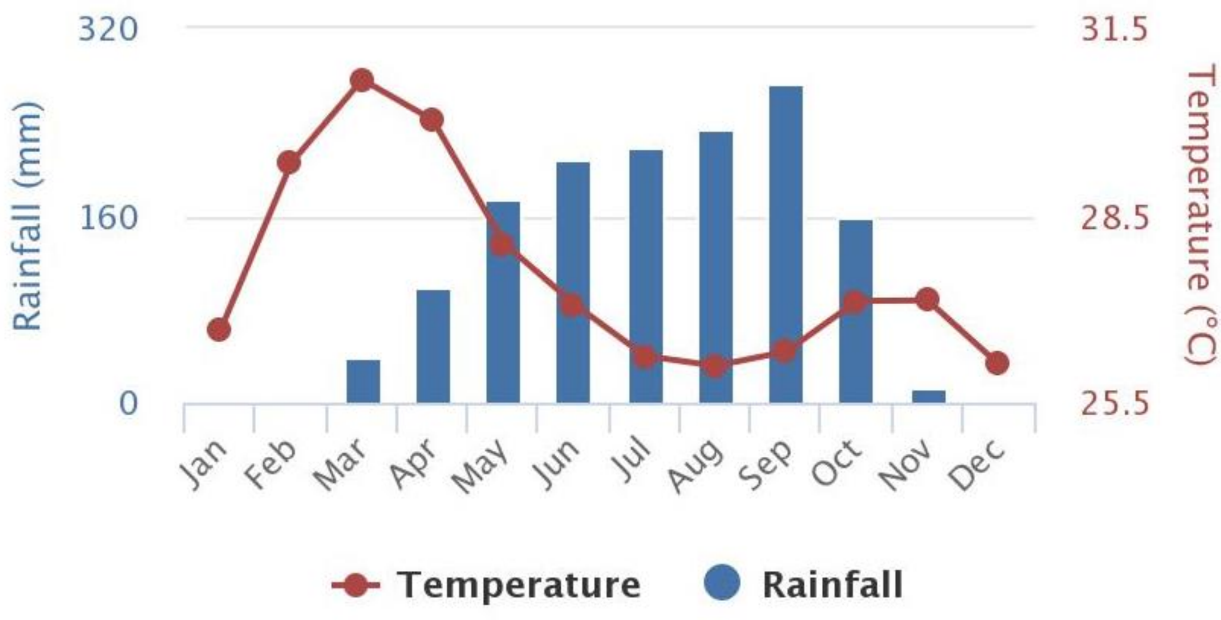


Figure 4.2. Average Monthly Temperature and Rainfall for Benue State from 1901-2015 (Source: http://sdwebx.worldbank.org/climateportal/. Last accessed on 12/05/2018).

The monthly distribution of rainfall in Benue state is bimodal (Ojanuga & Ekwoanya, 1995) and varies significantly from the north to south, with the annual total averaging between 1200 and 1400 mm (Ogungbenro & Morakinyo, 2014). The temperatures are constantly high throughout the year, averages range from 23^{0}C - 32^{0}C (Figure 4.2). The vegetation in the State is typical of that of the southern Guinea Savannah biome, which is the dominant vegetational belt of central Nigeria. According to Hulu (2010), the vegetation is presently characterised by sparse grasses and numerous heterogenous species of scattered trees. However, over the years the vegetation has been over-exploited through illegal lumbering activities and harvesting of wood for fuel, as well as suffering from a lack of conservation activity. Moreover, the persistent use of farming practices, such as bush fallowing and the slash and burn system, has exacerbated the clearance of the vegetation. This has resulted in the dissipation of common trees species, such as Khaya senegalensis (mahogany), Linnea, and Isoberlina doka ("akovol"), which were mostly found along the stream courses in the rice fields in the north-eastern and northwestern parts of the State, and has given rise to the present regrowth and parkland vegetation seen today (Hulu, 2010).

4.1.4 *The political, cultural, and economic settings*

Politically, Benue State operates a three-tier system of government comprised of the state government, the local government, and the judiciary. It has 23 local government areas (LGAs), or authorities, with a total population estimated at 4,780,389 (National Population Commission, 2006). The state is multicultural and can be divided into four main linguistic or cultural groups, the Tivs, Idomas, Igedes, and Etulos. Among these groups, the Tivs are the dominant linguistic group, found in up to 14 of the 23 Local government areas (LGAs), the Idomas are found in up to five LGAs, the Igedes in up to three, and the Etulos in just one.

In terms of economy, Benue State can be described as an agrarian society. It is known as the “food basket of Nigeria”, well over 70% of its population depend on agriculture and produce, mainly: grain (rice, soybeans, groundnuts, maize, and millet); fruit (oranges and mangoes); vegetables (tomatoes and peppers); and tuber crops (yams, cassava and potatoes). Although the majority of growers are small landholders, in recent years, medium or large size private commercial and industrial farms and processing industries have begun to emerge in the State capital, Makurdi. The remainder of the population is believed to be engaged in commercial activities, such as trading of different goods and services, transportation, and civil services in state and local government capitals where most market institutions, banks, telecommunications, and government institutions are situated.

4.2 Characterisation of rice value chains in Nigeria and Benue State

4.2.1 *Rice growing[3] ecologies, systems, and seasons*

Rice is grown in Nigeria under five different ecologies or systems (see Table 4.1), these are: rain-fed upland (RU); rain-fed lowland (RL); irrigated lowland (IL); deep inland water (DIL); and mangrove swamp (MS). Longtau (2003) defined the five rice growing systems as follows:

- RU is the type of rice grown in free draining soils; because it is not in an aquatic environment the water does not constantly flow, hence it is also called dry uplands rice.
- RL rice, on the other hand, is grown in soils with a shallow or medium ground water table, often in an aquatic condition (e.g., rivers and streams, floodplains, and wet lands); because water covers the soils completely at some stage in the growing season it is called “fadama”, or shallow swamps.

[3] Rice growing or farming mean the same thing.

- IL rice is grown in the same soil condition as RL, however, the water is supplied and often controlled.
- DIL rice is also a rain-fed system, but is grown in soils with deep water tables and, as a result, the rice floats at some stage. These are also referred to as deep fadamas, or floodplains.
- MS rice is grown at the coast or in swamps in the high rain forest.

Table 4.1. Geographical distribution of rice growing ecologies in Nigeria and their characteristics

	Agro-climatic zone	**Agro-ecological zone**	**Length of growing season (Days)**	**Annual Rainfall (mm)**	**Rainy Season**	**Rice growing system**
1	Arid	Sahel	<75	<550	Jul-Aug	IL, DIW
2	Semi-arid	Sudan savannah	75-150	550-900	Jul-Sept	IL, RU, RL, DIW
3	Sub-humid	Northern Guinea savannah	151-180	900-1200	June-Oct	RU, RU, RL, DIW
4	Mid-altitude	Moist savannah	181-270	1200-1500	April-Oct	IL, RU, RL
5	Sub-humid	Southern Guinea savannah	181-200	1200-1500	April-Oct	IL, RU, RL, DIW
6	Sub-humid	Derived savannah	211-270	1500-2000	March-Oct	IL, RU, RL, DIW
7	Humid	Humid forest	>270	>2000	Mar-Nov	IL, MS, RU

IL=Irrigated Lowland, DW=Deep Inland Water, RU=Rainfed Upland, RL=Rainfed Lowland, MS=Mangrove Swamp. Source: Adapted and modified from Longtau, (2003).

The geographical distribution of the rice growing systems described above is influenced by the annual distribution of rainfall across the agro-climatic and ecological zones of Nigeria (see Table 4.1). Accordingly, Benue State is located in the Sub-humid agro-climatic zone and the Southern Guinea Savanah agro-ecological zone, in a trough-like basin with good drainage, and with rainfall characteristics of between 1200-1500 mm, which give the state an added advantage over other state and huge potential for growing rice in most of the systems (Table 4.1).

Table 4.2. Key features of Nigerian rice growing systems

Rice growing system	Major states covered and potential rice fields	Estimated share of national rice area	Share of total domestic rice production
Rain-fed Upland	Ogun, Ondo, Abia, mo, Osun, Ekiti, Oyo, Edo, Delta, Niger, Kwara, Kogi, Sokoto, Kebbi, Kaduna, FCT, & Benue.	30%	17%
Rain-fed Lowland	Adamawa, Ondo, Ebonyi, Ekiti, Delta, Edo, Rivers, Bayelsa, Cross-River, Akwa Ibom, Lagos, all major river valleys, e.g., shallow swamps of the Niger basin, Benue basin, Kaduna, and inland swamps of Abakiliki & Ogoja areas.	47%	53%
Irrigated Lowland	Adamawa, Niger, Sokoto, Kebbi, Borno, Benue, Kogi, Anambra, Enugu, Ebonyi, Cross River, Kano, Lagos, Kwara, Akwa- Ibom, Ogun	17%	27%
Deep Inland Water	Flooded areas of the Rima valley – Kebbi State & deep flood areas of Ilushi Delta State	5%	3%
Mangrove Swamp	Ondo, Delta, Edo, Rivers, Bayelsa, Cross-River, Akwa Ibom.	1%	1%

Source: Adapted from Akpokodje, et al., (2001); Ezedinma, (2005).

4.2.2 Rice growing activities and processes

In Benue State, RL and RU are the dominant rice growing systems practised by majority of the rice growers. Rice growing activities and processes are spread over three different cropping seasons within a growing calendar (e.g., 12 months). The main rainy season usually lasts for about five months, from April to October (see Table 4.3), during which time the RU and RL rice are grown. However, in recent years the desire to increase production has led to intensification, so that growers grow rice both in the dry season and out of the main rainy season (see Table 4.3). As a result, the rice growing calendar is highly irregular and nonuniformed across the State.

Table 4.3. Rice growing calendar in Benue State

Cropping season	Planting	Duration	Variety planted and maturing time	Rice growing system	Average yield/ha	Potential yield/ha
Dry season	Early	January-April	EMV (<90–100 days)	RL	2.2 MT	5 MT
				DIW	1.3 MT	2.5 MT
	Late	February-June	EMV (<90–100 days)	RL		
Main rainy season	Early	April-July	EMV (<90–100 days)	RU	1.7 MT	3.5 MT
		May-October	LMV (>120 days)	RL	2.2 MT	5 MT
			LMV (>120 days)	DIW	1.3 MT	2.5 MT
	Middle	June-October	MMV (100–120 days)	RL	2.2 MT	5 MT
	Late	July-October	EMV (<90–100 days)	RL	2.2 MT	5 MT
Out of main rainy season	Early	August-Nov	EMV (<90–100 days)	RL	2.2 MT	5 MT
				DIW	1.3 MT	2.5 MT
	Late	Sept-Dec	EMV (<90–100 days)	RL	2.2 MT	5 MT
				DIW	1.3 MT	2.5 MT

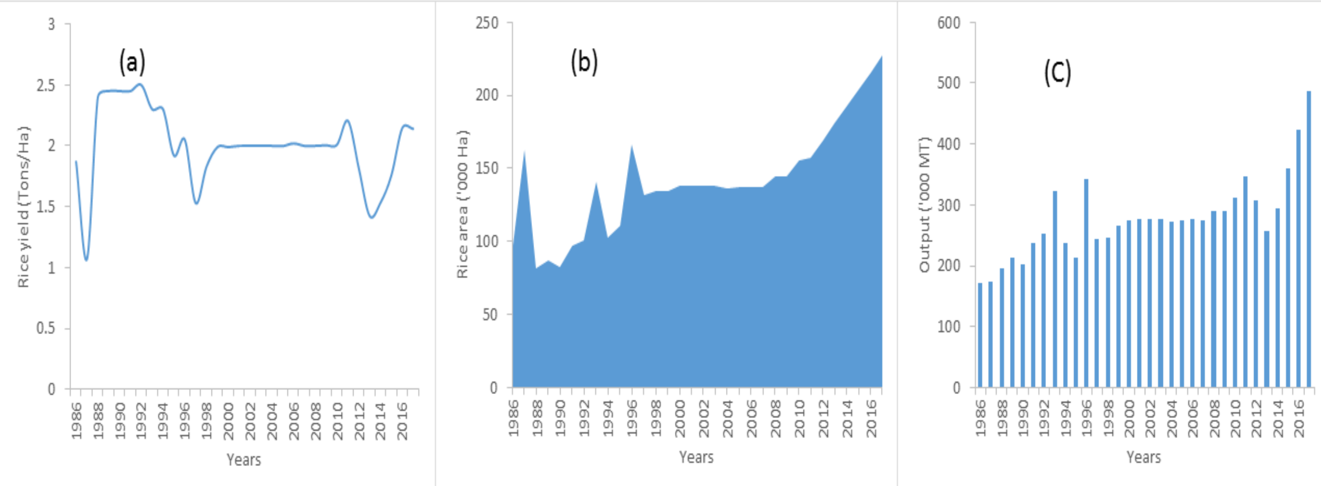
DIW=Deep Inland Water, RU=Rain-fed Upland, RL=Rain-fed Lowland; Planting, EMV= Early maturing varieties, MMV=Medium maturing varieties, LMV=Late maturing varieties.

*Information in the table above was adapted from different sources and modified following interviews with rice growers, as follows: rice variety maturing time (F.E. Nwilene et al., 2008) rice growing system (Longtau, 2003), average yield per hectare (Akpokodje, et al., 2001), and potential yield per hectare (Ezedinma, 2005).

Three types of rice grower can be identified in Benue State: small, medium, and large landholders. Small landholders are the dominant group, growing nearly 90% of the rice produced in Nigeria (USAID, 2009). This group consists of resource-poor and weakly organised local subsistence and small growers who grow rice on relatively small fields or land area, usually about 2 hectares maximum, they sell nearly 80% of their total produce and consume the remaining 20% (USAID, 2009).

Some of the common characteristics of small landholder rice growers are the use of poor yield strategies, a result of limited access to inputs, including chemical fertilisers, improved seed varieties, and crop control and protection. As result, average rice yield (see Figure 4.3a) has remained low, far below the potential yield for the state (see Table 4.3). In addition, mixed, medium, or large landholder rice growers are only emerging in the state as contractors or out-growers, hence much of their impact will be felt in the coming years. Unlike the small landholders, this group has increased access to mechanisation and enhanced rice farming technologies, including better access to inputs and high yielding seeds. However, this group constitutes only a small proportion of the growers in the state.

4.2.3 Trend in average yield, area harvested and production/output in Benue State



(*missing values on area cultivated from 2012-2016 and output for 2015 and 2016 interpolated)

Figure 4.3. Trend in average yield (a), area harvested (b), and annual production of unmilled (paddy) rice (c) in Benue state from 1986-2017. (Based on data from Benue State Agriculture and Rural Development Authority (BNARDA), Federal Ministry of Agriculture and Rural Development (FMARD) and Olawale Ajimotokan, (2018).

The trend in average annual rice yield in Benue State from 1986 to 2017 is presented in Figure 4.3. While the average yield in certain seasons has increased up to 2.5 tons/ha, the overall trend is slowly declining to about 0.0085 tons/ha (see Figure 4.3a), despite the growing importance of rice for national food security. However, since 1986, increasing trends in both the annual rice area (3.229 Ha) and output (5.38 MT) are witnessed (see Figure 4.3b and c). This indicates that the output of rice in Benue State in recent years is associated with an annual expansion in the area of rice grown, rather than on increased yield.

4.2.4 Rice aggregation

After rice is grown and harvested, it is aggregated or assembled by unmilled (paddy)[4] rice buyers and traders, sometimes referred to as village buyers (USAID, 2009). Most of these buyers are intermediaries (middlemen) and speculators (locally known as Branda), and some are agents of outsourcing rice milling companies, or of small or large rice mills. This group of actors plays a significant role in linking rice growers to millers and, as such, could manipulate the rice market, including prices. The key functions of this group of actors include, buying, assembling, storing, and transporting paddy to the processors (i.e., the millers). In Benue State there are two market systems where unmilled rice aggregation or assemblage takes place. The first is the traditional periodic market[5] (i.e., also called the open market) system, where rice is sold at a designated point/location, also called the market square, on a particular weekday. The common characteristics, and perhaps a challenge which pressures rice growers, is that formal scaling or weighing systems (e.g., where rice is measured in kgs or tons) are not used during selling or buying of unmilled rice and prices are neither regulated nor controlled. Instead, the use of sacks which differ in size by several inches is commonplace, the practice is intended to cheat growers by gaining more volume, or quantity, for the buyer than accurate and consistent measures would provide. The second market system is the programme, network, or contract market, where, in most cases, growers enter into an agreement with a certain buyer, miller, or company to sell their rice at the end of a harvesting season. Unlike the traditional system, this market system uses formal scaling or weighing systems, such as kgs and tons, for selling and buying the rice.

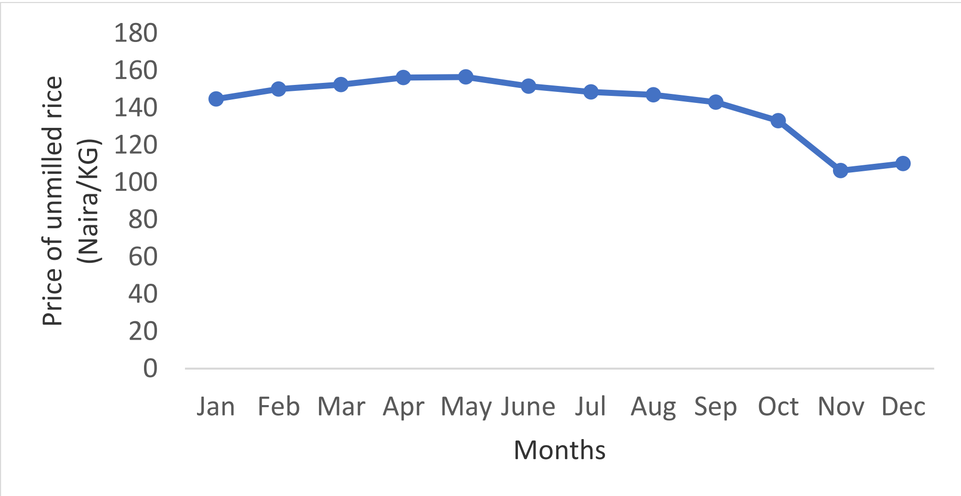


Figure 4.4. Trend in the price of unmilled rice in Makurdi, 2017. (Based on field observations of prices in the market)

[4] Both 'unmilled' and 'paddy' are used in this study to mean rice that is harvested but not yet milled.

[5] Periodic or open market systems are the same.

The market prices of unmilled rice in Benue State (see Figure 4.4) are a function of availability (e.g., supply), but other factors have some impact, such as rice quality, variety, and sometimes market location and distance. Prices also vary with the season in some years. Usually, the prices are low and often crash between November and December when the main season rice is being harvested. However, prices soon improve towards the end of December when the Christmas festivities set in (Figure 4.4). Then, the prices peak between May and June when stocks are completely sold out.

4.2.5 Milled rice production

Generally, milling[6] of rice in the state is carried out under either of two major milling arrangements, namely, through the conventional commercial rice mills or through the industrial, integrated, mills. The first is comprised of small and medium sized mills, and the second the larger, modern mills. MIKAP Nigeria Limited is a prominent, viable, large rice mill operating in Benue State. However, small and medium commercial rice mills are by far the most dominant in the industry in the region. These mills are comprised of thousands of millers in Benue State, and around Nigeria, and mill well over 80% of the domestic rice produced (USAID, 2009). The large mill processing system is comprised of industrial millers who seek to enhance the quality of the domestic rice to match the high quality of imported rice.

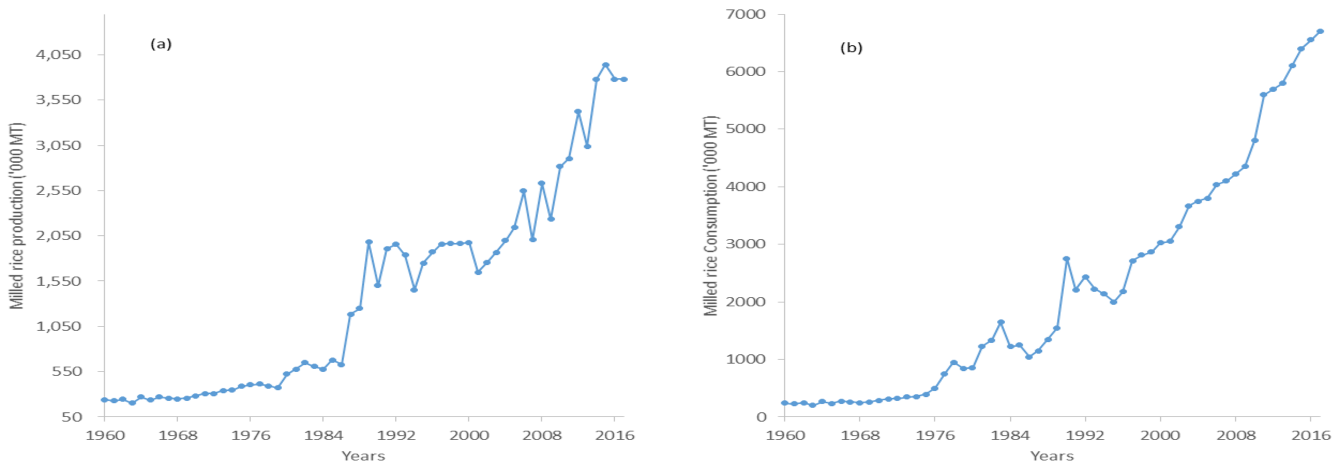


Figure 4.5. Trend in annual milled rice production (a), and consumption (b), in Nigeria[7] from 1960-2016. (Source: Based on data from USDA, 2018)

[6] Milling and processing refer to the same operation, i.e., the processes or activities, such as soaking, parboiling, drying, and dehusking of the rice. These activities deliver milled rice ready to be cooked and consumed.

[7] Data on annual milled rice for Benue State is unavailable, therefore data for Nigeria is used instead since Benue contributes significantly to the national rice production output.

The trend in milled rice production in Nigeria experienced an increase from the late 1960s to 2016 (Figure 4.5a). For instance, in the period 1960 to 1977, milled rice production generally grew from 239,000 MT to 412,000 MT, oscillating with no clear pattern. However, within the same period, the consumption of milled rice grew much faster, at the rate of 110.02 MT (Figure 4.6b), outpacing milled rice production, and hence creating a difference over the years.

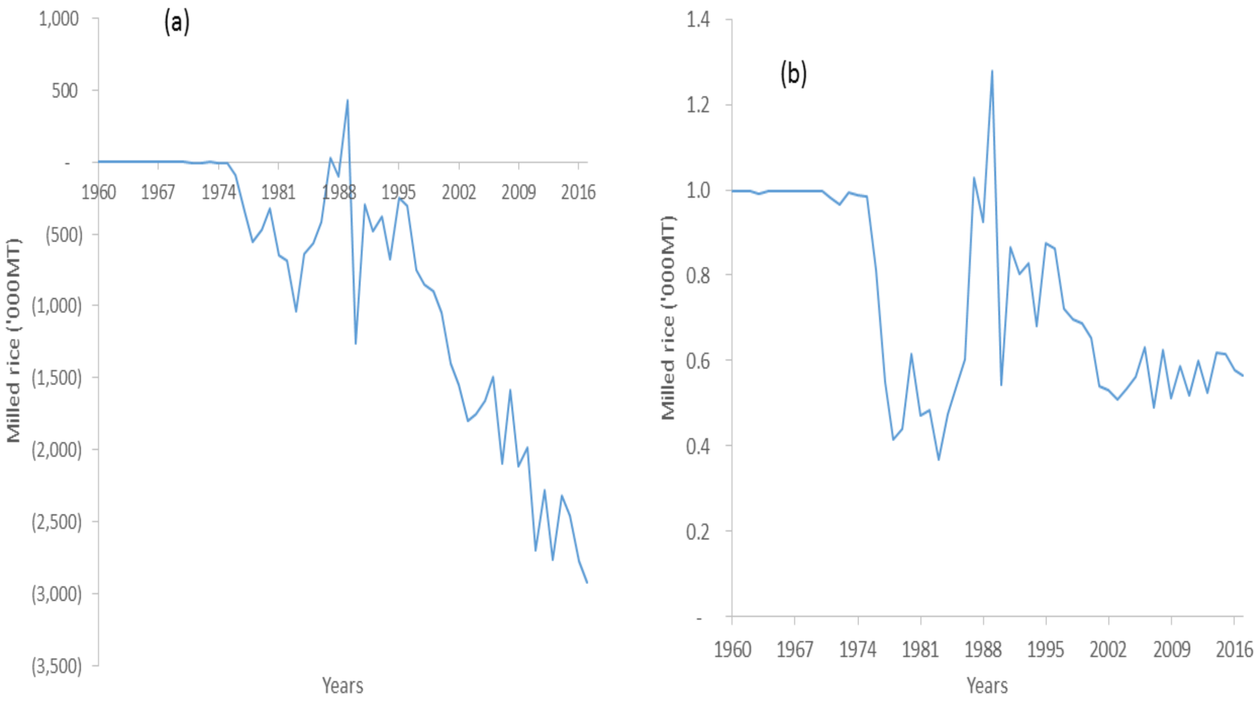
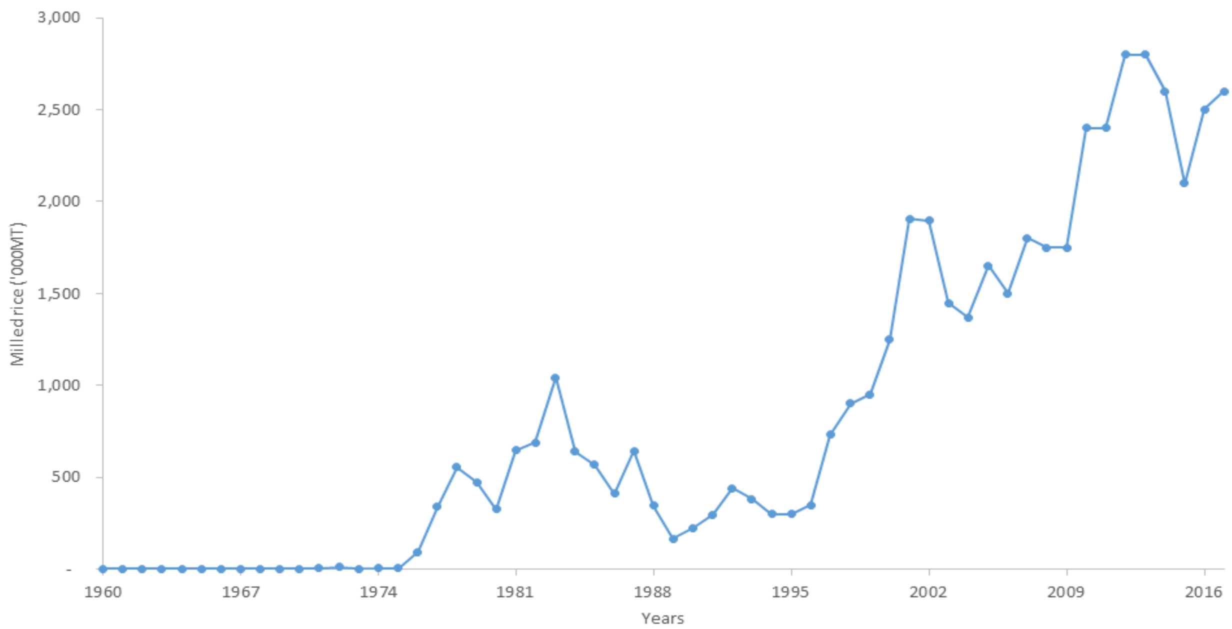


Figure 4.6. The difference (a), and the ratio (b), between milled rice production and consumption in Nigeria from 1960-2017. (Source: Based on USDA data, 2018)

From 1960 to 1974 the difference between annual milled rice production and consumption was low, this occurrence makes it impossible to act as a buffer against shocks, and hence to safeguard the RVC system and create stability. Figure 4.6a above shows that the size of this buffer (i.e., the difference between annual milled rice production and consumption) in some years (e.g., from 1975 to 2016) is almost nil, or actually negative. Furthermore, the ratio between rice production and consumption from 1960 to 2016 indicates similar negative trends (see Figure 4.6b). The ratio of 1.0 represents the balance between rice production and consumption. Based on the figures above, the only period when there was a consistent balance between milled rice production and consumption in Nigeria was from 1960 to 1974. During this period, both annual milled rice production and consumption grew relatively slowly and match each other. From 1975 to 2016, with the exception of 1983 and 1985, the ratio has been less than 1.0, this indicates that milled rice production to consumption has been in deficit, except between 1986 and 1990 when production surpassed consumption. The situation has created a supply deficit that requires annual importation to guarantee steady supply.

4.2.6 Rice importation

As local production of rice did not increase sufficiently to guarantee its availability for local consumption, importation became necessary. As Figure 4.7 shows, rice imports into Nigeria started gradually in the 1960s and remained stagnant at 1 MT throughout the decade. However, by 1970, rice imports grew slowly for a period of five years, between 1970 and 1974, and then grew relatively quickly from 1975 to 1998, until they reached the current period of very high volumes of imports, in the millions of metric tons, from 1999 to 2016 (Figure 4.7). At the same time, rice smuggling became rampant due to the failure of the government to secure its porous borders (Akpokodje, et al., 2001; Longtau, 2003).



Source: USDA data, 2018

Figure 4.7. Trend in milled rice importation in Nigeria from 1960-2017

Instability in milled rice production had its roots in the 1966 shift in the Nigerian economy, from agriculture to oil, and in the 1980s this instability became more obvious as a result of the introduction of an open market rice trade policy. Thus, rice imports increased from 94,000 MT in 1975 to 950,000 MT in 1998, and then from 1,250,000 MT in 1999 to 2,500,000 MT in 2015 (Figure 4.3). The continuous dependence on rice imports is considered a risky and unsustainable strategy for Nigeria. Firstly, should any significant pressure occur to decrease the stock of rice on the international market, this will cause a rice crisis (Dawe, 2010). Secondly, dependence on imports is believed to have hindered investment in the domestic RVC, and this has led to the consistent failure of the internal milled rice production to meet the rising demand for quality rice in urban centres (Akande, 2001; Akpokodje, et al., 2001).

The volume of foreign imported rice increased in Nigerian markets, increasingly outcompeting the locally milled rice which consumers considered inferior, but it remained on the market. To address the challenge of rising imports, which characterised the RVC sector in the mid-70s and early 80s (see Figure 4.7), the Nigerian government responded by enacting a policy of an outright import ban in 1986. This was followed by the adoption of a Structural Adjustment Policy (SAP) in the same year (T. Akande, 2001), with which government policy on price control was scrapped. As a result, the production of milled rice soared in 1987 to 1,184, 000 MT (see Figure 4.5 above) and continued until it reached 1,839,000 MT in 1993.

However, during the period of the import ban, the Nigerian government faced mounting pressure to fully implement the Open Market Trade policy from the International Monetary Fund (IMF), the World Bank, and the World Trade Organisation (WTO) (Emodi & Madukwe, 2008). Then in 1995, the liberalised rice import policy was fully re-introduced by the Nigerian Government. As a result, rice imports grew steadily to reach 3,400,000 MT in 2011, the highest since 1960.

4.2.7 Distribution, trading, or selling of milled rice

The milled rice traded or distributed in Benue State, and across Nigeria, is sourced from both the domestic production and import channels, as highlighted above. Key actors, such as wholesalers, retailers, and paddy traders, drive the distribution, trade, and sales activities. The milled rice supply channels, or outlets, facilitate the flow of milled rice products to end-users in supermarkets, shops, stores, and periodic markets in villages, towns, and cities across Nigeria.

The domestic channel supplies rice products to rural households in villages and small towns, institutional markets, and low-end urban domestic markets (USAID, 2009). The imported channel supplies high quality foreign milled rice to urban and city markets across Nigeria. As a result of different supply sources, consumption of milled rice is segmented between imported rice, mostly consumed in urban centres among medium and high-income households, and domestic rice, mostly consumed among low-income and poor households. Nonetheless, with the establishment of improved processing plants, the consumption of domestic rice is increasing.

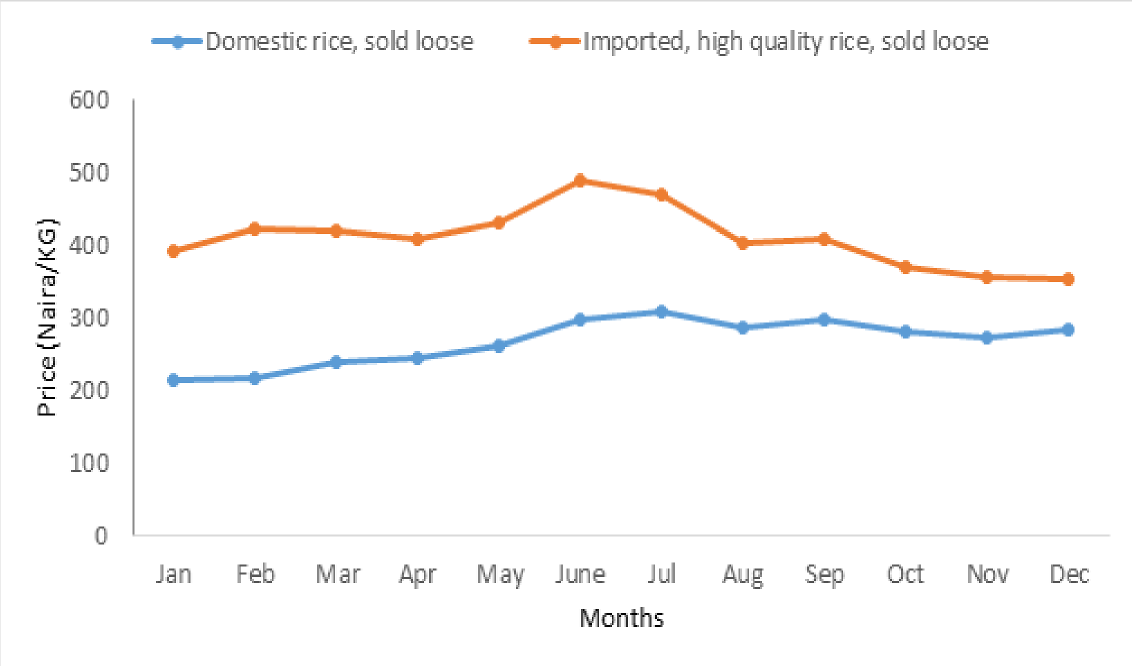


Figure 4.8. Trend in the price of imported and domestic milled rice in Makurdi, Benue State. (Based on data from National Bureau of Statistics, Federal Republic of Nigeria, 2017)

Due to market segmentation, price differences depend on the source and quality of the rice. Imported rice is generally regarded superior in quality, and thus priced higher than domestic rice, regarded to be of lower quality (see Figure 4.8). Despite this, the annual price trend of both the imported and domestic rice is influenced by seasonality. The highest retail price for imported rice in Benue State in 2017 was recorded in the month of June, while that of domestic rice was recorded in the month of July. These are months when the supply of domestic milled rice is at its lowest in the state.

4.3 Political economy of rice in Nigeria and Benue State

Building on Bernstein (2017), this section presents a political economy analysis of rice value chains (RVC) in Nigeria through the examination of four social relations among actors in the Nigerian RVCs, namely: (i) modes of rice production, and access to means of production, (ii) divisions of labour across socio-demographic profiles, (iii) distribution of proceeds of labour, and (iv) its uses in reproduction.

4.3.1 Mode of production, access to land and capital

4.3.1.1 Mode of production [8]in the Nigerian RVCs

Across Nigeria and Benue State, there are three overlapping modes of rice production. These are the subsistence, commercial and industrial mode of rice production (Table 4.4). Among the modes of production described above, the commercial mode of rice production is predominant, supplying over 80% of the domestic rice to the market (USAID, 2009).

Table 4.4. Modes of rice production in Nigeria and Benue State

Rice production modes	Key definitions
Subsistence	Subsistence mode of production emerges from traditional rice farmers who largely produce for personal consumption but sell their surpluses to the rural village market (USAID, 2009)
Commercial	Commercial mode of production relates to rice produced mainly to sell on rural market towns and the middle-end urban market (USAID, 2009).
Industrial	Industrial mode refers to rice produced targeting at import substitution (USAID, 2009)

Because of the growing importance of rice as a commercial crop in the past two decades (Ajewole, et al., 2016; Akande, 2001), the subsistence mode of production has gradually transformed into the commercial mode of production across Nigeria, although, its relics still exit across farming communities in Benue State. As Table 4.4 shows, under the commercial mode, rice is grown and milled mainly for commercial purposes. For example, Adikpo, Gboko, Wadata and Wurukum, and Utokpo rice mills are common examples of mills operating a commercial mode of production in Benue State. The actors that drive the commercial mode comprise mainly of a group of loosely organized small and medium landholders and small size millers and traders (USAID, 2009). Lastly, the industrial mode, which primarily aims at import substitution and export (if surpluses exist) comprises a more coordinated network of large landholders, including contract farmers/outgrowers, commercial rice milling and trading companies such as Olam, Veetee, Mikap and Stallion Group (M. Johnson, Takeshima, & Gyimah-Brempong, 2013).

[8] Mode of production as used here is not only referring to farming or growing rice but encompasses all activities and processes leading to milling and trading of rice. In orders words, all economic activities that deliver the rice consumed in households.

While there are no hard statistics on the specific contributions of each of the rice production mode to Nigeria economy, it is reported that agriculture (to which rice production, milling and trading are key component) contributes about 21.06% of Nigeria's GDP in 2017 and employ about 70% of its active population (The Federal Ministry of Agriculture & Water Resources (FMAWR), 2009; National Bureau of Statistics Nigeria, 2017). While in the rice sector, the bulk of the jobs are reported to have been concentrated within the commercial mode of rice production (USAID, 2009).

4.3.1.2 Access to land

According to The Federal Ministry of Agriculture & Water Resources (FMAWR) (2009), Nigeria has a total of 79 million hectares of arable land, of which an estimated 4.6 million hectares are suitable for rice production, but only about 1.8 million hectares (or 39% of land suitable for rice) is currently farmed. Despite such a seeming underutilization of land, access to farm land is still constrained. This is because under the Nigerian Land Use Decree (Number 6) of 1978, all rights over land are conferred to the States Government to hold in trust for the people of the state (Akpokodje et al., 2001; Ike, 1984). By this law, farm land is considered a collective property of the natives of the state and as a such, the control of land ownership rights in Nigeria is highly centralized (Nwachukwu, 2017).

Thus, among the Tiv people of Benue State, land is traditionally the property of the kin-group, and as such it is not easily sold or rented out without due consent of the whole clan (Nwachukwu, 2017). This practice has not only locked farm land but also makes accessing it challenging for non-natives.

Consequently, communal land is predominantly used both by small and medium landholders across Benue State. Under the communal land ownership system, the land is owned by the clan (Nwachukwu, 2017). The clan divides the lands among families. The families, in turn, divide the land among its male members who are expected to use the land and pass it on to future generations. In the 1960s, when the size of the population of Nigeria was smaller (45.1 million) than it is today (195.8 million) and the level of mechanization in agriculture was low, the communal land tenure system proved successful as it guaranteed male members of the rice growing families an unconditional access to a share of the community farm lands by virtue of birth (Ike, 1984). This access to land was crucial to sustaining rice growing families' household economies.

However, as the population and the need to grow rice increased, the communal land tenureship became a limiting factor for rice farming in at least two ways. First, it prevented growers who would have the capacity to scale up production from acquiring more land (Nwachukwu, 2017).

Second, it encouraged generational fragmentation of rice fields (Kakwagh, Aderonmu, & Ikwuba, 2011). Land fragmentation is a cause of inefficient use of resources, and hinders mechanization and increases production costs (Nwachukwu, 2017; Ogundari, Ojo, & Ajibefun, 2006). This has further resulted in unprofitability of farming, which disincentivizes engagement in agriculture and encourages out-migration to other economic sectors (Biyi Daramola, 2005).

Another known drawback of communal land ownership system is that it reinforces uneven power relations and promotes exploitation of the less privileged members in the community by the most powerful ones (Akpokodje et al., 2001). The terms of land ownership are often biased towards certain age (e.g. young adults), or gender (e.g. female) groups, and against disable and physically challenged persons, widows and orphans. For example, the "lords" (e.g. traditional chiefs, elder community members) define terms of land ownership such as who should get what share of the community land, and at what age (Ike, 1984). Thus, often due to the patriarchal nature of most Benue communities, female members are usually denied access to land.

Despite the drawbacks of the communal land access highlighted above, the need to commercialize and industrialize farming is gradually introducing changes and flexibility in the land relations in Benue State (Nwachukwu, 2017). This has made the informal land rental markets very vibrant because their administration is less bureaucratic compared with formal land access, hence it gives both the small and medium landholders the opportunity to easily increase their landholding for a short-term, usually for a single, double or triple farming season (Ikejiofor, 2006).

In addition to the communal lands, there are a few government developed rice fields and unused big expanse of lands that are in some parts of Benue and other northern states in Nigeria (USAID, 2009). Such lands are usually rented by medium or large-scale growers, who produce under the commercial and industrial mode. Four (about 13%) of growers sampled for this study rented government developed rice fields (see also appendix 5.1).

Unlike the communal land, the rights to rent the government developed rice fields or unused lands are only granted either by the state government or local government authorities where the lands are found (USAID, 2009). However, legal procedures on land access are tedious and complex to follow and, in some instances, could require a bribe to facilitate quick processing of land papers from state and local authorities (Ikejiofor, 2006).

4.3.1.3 Access to capital

To grow, mill and trade quality rice requires substantial capital investments to acquire and develop land, machinery, inputs, and other production factors. However, over 90% of the Nigerian small landholders, small size millers and traders lack access to formal credit systems (e.g. loans, microfinance) (FMAWR, 2009; Tunji Akande & Ogundele, 2009; Coker, Akogun, Adebayo, & Mohammed, 2018; Nwachukwu, 2017). Consequently, they depend on informal credit systems, which are inadequate to finance the investments require to make the domestic RVCs competitive (Coker et al., 2018; M. Johnson et al., 2013).

The Nigerian Government under the National Rice Development Strategy (NRDS) has set as one of its goal to increase access to credit for smallholders, and small size millers and traders through the provision of new funds, with the aim to boost rice production and support the establishment of new rice processing companies in the country (FMAWR, 2009). The Central Bank of Nigeria (CBN)' Anchor Borrowers Programme (ABP) on rice production was thus established on November 17, 2015 as part of that strategy but proved generally unsuccessful for various concomitant reasons (Ibekwe, 2018).

First, in some states, the funds were given to people who only pretended to be farmers (Ibekwe, 2018). Second, access was based on political patronage (e.g. friends or cronies of the ruling political class). In the words of a rice farmers: *"The loan was disbursed indiscriminately. It was given to those who don't farm, they don't do anything pertaining farming and they were given the money in cash*," he said. *"Assuming now the local government chairman will say his people have not been taken care of. Party chairman will come and say his people are not taken care of. Member of the state assembly will say his people have not been taken care of. Senators, members House of Reps. Tell me, what can you do?"* [Premium Times]: (Ibekwe, 2018)

Third, the fund administration was flawed. For example, many growers and millers complained that the loans were not given to them at the time they needed them, while others reported that they were not given the right amount they were entitled to (Coker et al., 2018). Moreover, some socio-demographic profiles (especially the poor, physically impaired, women and young adults in the growing, milling and trading sectors) were reportedly excluded from the programme (Ajadi, Oladele, Ikegami, & Tsuruta, 2015; Anderson, 2018; Coker et al., 2017). The reason being that due to their limited assets ownerships, they failed to meet the farm land holding requirement of between 1 and 5 hectares set as a condition for assessing ABP and other credit facilities (Coker et al., 2018; Ibekwe, 2018).

4.3. 2. Labour

4.3.2.1 Labour regimes in Nigeria and Benue State

RVCs' operations such as rice growing (e.g. land clearing, ploughing, planting, weeding, fertilizer applications, harvesting and threshing) and milling (pre-cleaning, steaming, parboiling, drying, dehusking or dehulling, bagging, and others) are labour intensive (Akpokodje et al., 2001). In Benue State, three labour regimes are commonly employed in carrying out various tasks along the RVCs, either manually or mechanically. These are: family, hired (e.g., part-time or permanent), and exchange labour (e.g., sharecropping, tenancy) (Akpokodje et al., 2001; Nwachukwu, 2017; Tashikalma, Giroh, & Ugbeshe, 2014).

In most parts of Nigeria, family labour is predominant among the small and medium landholders, and small and medium size millers and traders, operating under the subsistence or commercial mode of production (USAID, 2009). This is because it is a non-wage paid labour, by which members of the nuclear or occasionally extended family are drawn (by the head of the family) to work on the rice farms, mills or market (Chambati, 2011). In Benue State, family labour is usually mobilized from family members residing within a particular compound (Nwachukwu, 2017). The head of the family (Or ya as referred to in Tiv) pays remuneration in-kind by catering for the needs of the family members residing in the compound (e.g., food, clothing, education costs, among other things).

To complement family labour, RVCs' actors often employed hired labour, either on a part-time (daily, per activity or season) or permanent basis. Unlike family labour, hired labour is remunerated through wages. It is used especially by the majority of medium and industrial RVCs' actors (e.g. growers, millers and traders) in most parts of Nigeria, particularly, to carry out more demanding or time consuming operations, technical and skilled tasks (e.g. mechanisation and herbicides use during land preparation and weeding) (Akpokodje et al., 2001; Tashikalma et al., 2014). The skilled labour comprise a wide spectrum of workforces (e.g. men and women alike), most of which are mobilized seasonally from neighbouring communities and villages (rural-rural migrants) and urban centres (urban-rural migrants) (Nwachukwu, 2017).

Exchange labour sources such as sharecropping and tenancy labour are equally used by RVCs actors in many parts of Nigeria and Benue State. The main difference between family and exchange labour is that the labour force is not only drawn from family members of the family but also from the community, including seasonal migrant labourers (Nwachukwu, 2017). Like family labour, exchange labour practices are common among subsistence and commercial rice producers in Benue State.

Using this type of labour simply requires that RVCs actors enter into an agreement to carry out certain tasks (e.g. weeding, drying or conveying rice to market or exchange a service (e.g., hire drying slap, milling machines) at a given time for a certain share of harvested or milled rice (Akande & Ogundele, 2009).

4.3.2.2 Division of labour

In Benue State, while it is the culture that men, women, young adults and teenagers living in the confines of a family compound to collaborate in carrying various tasks, there are distinctive lines of labour in RVCs' activities (Nwachukwu, 2017). Most of them are based on gender, age, and acquired skills. While it is the norm in Benue State that all family members , except children, collaborate to do certain tasks such as land clearing at the start of a farming season, the women occasionally step back for men to carry out certain tasks, except when absolutely necessary (Adeoti & Adeoti, 2008; Nwachukwu, 2017). For example, women are usually hired for tasks that are less physically demanding and require care and patience such as planting of weeding, winnowing and selling on the market, while men are considered for arduous tasks such as land preparation, threshing, bagging, loading and storing rice (Chambati, 2011).

With regards to age, the teenagers are often hired for certain unskilled tasks such as conveying load (e.g., rice harvest or milled) to storage and market for sale, while adults engage with tasks that require more experience and skills such as fertilize applications. Furthermore, there is clear difference in amount of work done by RVCs' actors between men and women and the varying age sets (Nwachukwu, 2017). For example, women do more of tasks that are painstaking which means they spend more time than men, who do more of tasks that physically demanding like tilling rice fields but demand less care. Conversely, older men do less physically demanding tasks, while the younger adults who are considered to be of full strength do energy sapping jobs.

4.3.3. Distribution of proceeds of labour from rice production, milling and trading

In Nigeria and Benue State, wages in the RVCs and agricultural sector more broadly are generally poor for various reasons. First, there is competition with foreign rice, therefore market segmentation, and Nigerian rice is in the lowest segment, where the profit margin is little. Hence wages are low (Biyi Daramola, 2005; Demont, 2013). Moreover, unabated smuggling of cheap foreign rice on Nigeria rice market has compounded this challenge (Animashaun et al., 2015; Ibekwe, 2018; Johnson, Takeshima, & Gyimah-Brempong, 2013; Johnson & Dorosh, 2017). Furthermore, there is little capacity to invest and there are market fluctuations, plus there are many seasonal jobs (for the very nature of the business); therefore, most jobs are temporary, and informal.

As a result, part-time labour is commonly contracted by day, task and season (Erenstein et al., 2003). The contracts are either on permanent or part-time basis. Wages are usually paid by cash (i.e. money) or in kind (i.e. food). While monetary payments are commonly made by majority of medium, large landholders, and industrial millers and traders, the in kind payments such as raw food (e.g. rice) and cooked meals are usually paid by small size actors for the use of family labour either independently or in combination of money (Erenstein et al., 2003). The amount to be paid is usually agreed on by both parties at the commencement of the daily or seasonal tasks. Across Benue State, wages paid for daily labour vary depending on tasks (e.g. time and strength required for finishing the tasks) and season (e.g. dry or wet). For example, operations such as land preparation and weeding are physically demanding and painstaking, hence attract the highest wages. Moreover, certain tasks are more challenging to carry out in certain seasons. For example, harvesting and threshing rice in the rainy season is more challenging than in the dry season, so as a result attracts higher payments than doing the same tasks in the dry season.

4.3.4 Uses of proceeds of rice labour by RVCs' actors

Bernstein (2017), highlighted three major aspects of reproduction in an agrarian class society that relates to RVCs' actors in Benue State. These include: consumption, replacement and ceremonial. Thus, among the subsistence and commercial RVCs' actors (e.g. small land holders, small size millers and traders), the large share of benefits and wages generated from rice trade and labour are often used for meeting basic households' needs (foods and clothing) (Ajewole et al., 2016; Okodua, 2017). Occasionally, if there is surplus, it will be used to attend to other needs such as covering of children educational costs, improving on housing quality and purchasing of electronics, among other things (Akaakohol & Aye, 2014). At most times, only a fraction of the income is used for the replacement of farming tools (e.g. hoes, cutlasses, rice threshing and drying mats, rice parboiling drums and rice measuring basins and bowls) (Okodua, 2017).

Moreover, during wedding and burial ceremonies, savings are used to cover costs of traditional rites. For example, marriage dowries, cultural displays during marriage and annual festivals, burial rites and other rituals on the behalf of the immediate families and the in-laws (Hilhorst, Van Liere, Ode, & de Koning, 2006).

While among most of the industrial RVCs' actors (who also double as higher income classes), the proportion of their income spent on household's consumption is lower than that spent by majority of subsistence and some commercial RVCs' actors (Johnson & Dorosh, 2017). This group of actors has access to government loans, which most of small landholders and millers are unable to access (Coker et al., 2018). As a result, they are able to invest in intensive rice farming (e.g. use of high inputs and mechanisation, expansion of existing land areas) and acquisition of more advanced rice milling technologies which enable them achieve more substantial profit margins (Adjognon, Liverpool-Tasie, & Reardon, 2017).

4.4 Rice value chains systems' boundary in Benue State

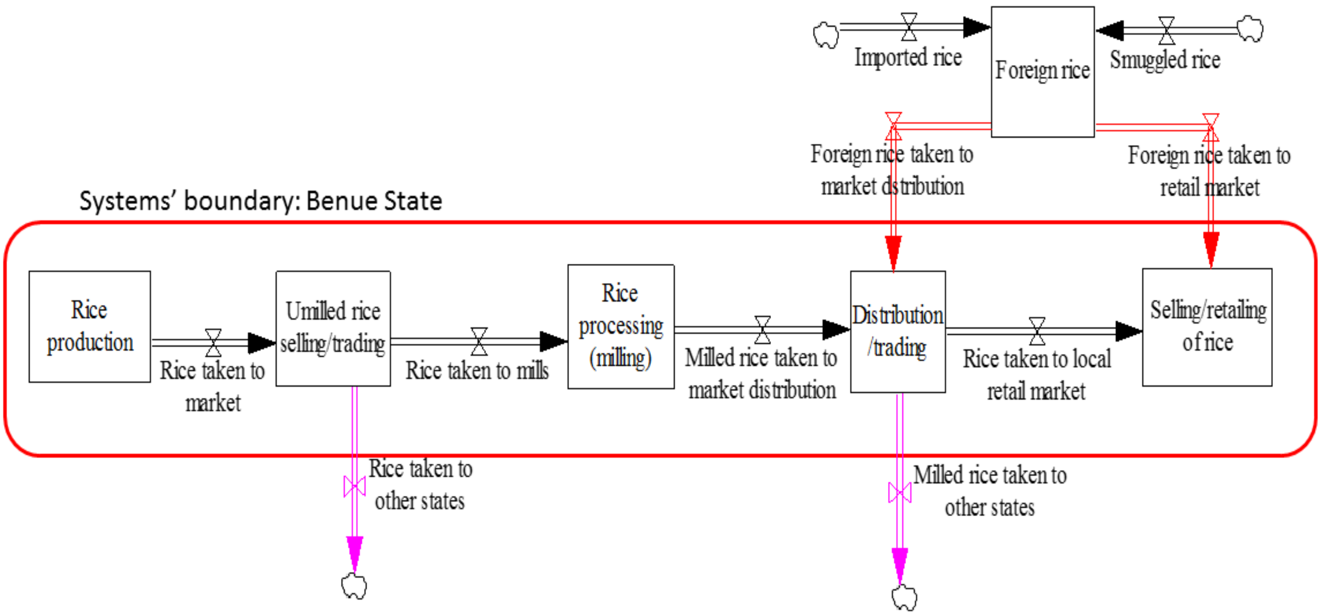


Figure 4.9. Rice value chains systems' boundary in Benue State[9]

The RVC systems' boundary examined in this study comprises rice produced and aggregated for milling, rice processed (milled), rice distributed, and traded and retailed for consumption in Benue State (Figure 4.9). This system is also partly influenced by in- and out-flows. Specifically, there is an inflow of rice to the system, which arises mostly from foreign sources such as rice imported and smuggled into Benue State. Similarly, the out-flow of rice from Benue State happens at two points. The first being during the trading and aggregation of unmilled rice and the second during the distribution and trading of milled rice. This study includes the effects of those in- and out-flows on the RCV in Benue State, but does not investigate their origins or destinations, nor any other characteristics, conditions or impacts beyond the system boundary (Figure 4.9).

[9] Arrow indicates in- and out-flow of rice within and without the systems' boundary

4.5 Characterising climate change and variability in Nigeria and Benue State

To characterise climate change and variability in Nigeria, observed and projected changes in precipitation and temperature are highlighted below. Since rice production in Benue State is generally rain-fed, both sufficient rainfall and favourable temperatures are required to grow and mill it. This makes rainfall and temperature the two most crucial climate and weather elements in the aim to understand the vulnerability of RVC system.

4.5.1 Observed changes in temperature trends

The Nigerian Climate Review Bulletin (NCRB), (Nigerian meteorological agency (NIMET), 2012) reports that, since the mid-20th century, an increasing trend in mean temperature has been observed in most parts of Nigeria. The mean temperatures in Nigeria have increased from 0.2 to 0.5°C in the high ground areas of Jos, Yelwa, and Ilorin in the north, and in Shaki, Iseyin and Ondo in the southwest, and from 0.9 to 1.9°C in the rest of the country. Furthermore, extreme temperatures, e.g., temperatures warmer than normal, by between 0.5°-2°C, were experienced in the 2012 cold season (Figure 4.9a), and temperatures colder than normal, by 1.1°C, were observed during the hot season (February - April) (Figure 4.9b), when compared to the 1971-2000 long term values reported in specific locations, such as in Makurdi and parts of other central states (Nigerian meteorological agency (NIMET), 2012).

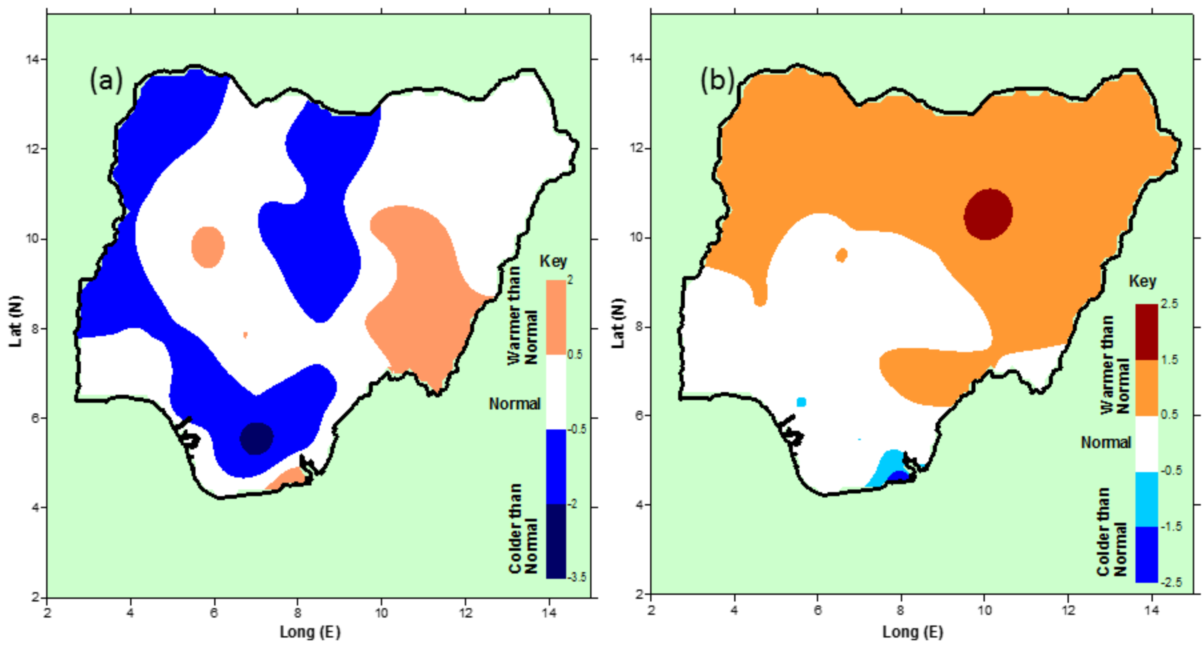


Figure 4.10. 2012 temperature anomaly (a), cold season minimum temperature (b) hot season maximum temperature adapted from Nigerian meteorological agency (NIMET), 2012.

The observed temperature trends in Nigeria highlighted above are not very far from those reported by the IPCC AR5 for most of Africa where temperatures have increased by 0.5 ^{0}C or more in the last 50-100 years. Particularly in West Africa and the Sahel, the IPCC AR5 reports a significant increase of between 0.5°C and 0.8°C in near surface temperatures over the last five decades, from 1970 to 2010. In addition, changes in the number of extreme temperature events have been observed, the number of cold days and nights have decreased, and the number of warm days and nights have increased in the region between 1961 and 2000.

4.5.2 Observed changes and variability in rainfall trends

Concerning rainfall, while the IPCC AR5 made the case for a lack of robust observational data to draw conclusions on changes in the trend of annual precipitation over the past century, changes in onset and cessation of the rainy wet season in Nigeria between 1941 and 1970 showed very clear signals of climate change. The question as to whether those signals fall within the bounds of climate change or natural variability remains a contestable one. However, according to the Nigerian Meteorological Agency (NIMET), 2012), onset and cessation of rainfall during this period was mostly from “early to normal” (Figure 4.10a), except in small pockets around Sokoto, Maiduguri, Owerri, Port Harcourt, and Calabar, where late onset of the rainy season was experienced. In recent years, the situation has gradually changed as late onset of the rainy season was experienced over vast parts of Nigeria between 1971 and 2000 (Figure 4.10b).

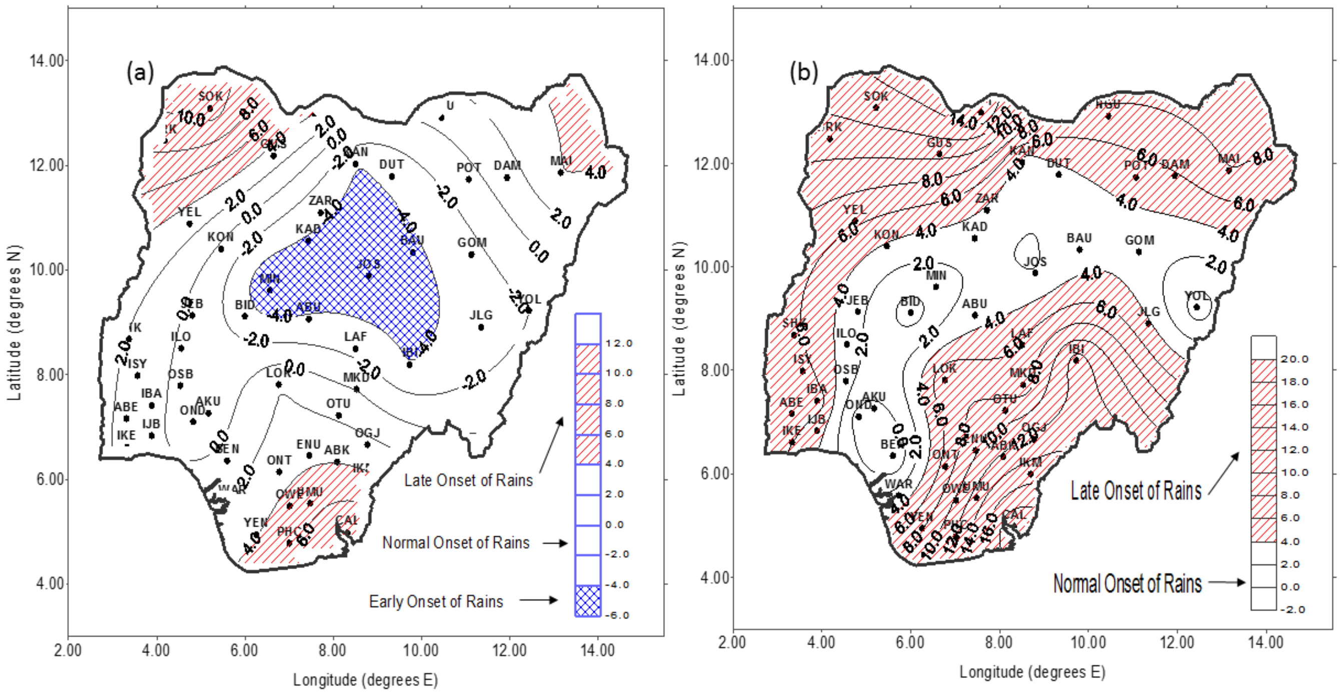


Figure 4.11. Anomaly of the dates of the onset of the rains in Nigeria: from 1941-1970 (a), and from 1971-2000 (b), adapted from NCRB, NIMET, 2012

On the other hand, cessation of the rainy season has generally shifted from being “normal” between 1941 and 1970 (see Figure 4.11a), to “early cessation” between 1971 and 2000 (see Figure 4.11b). As a result, the duration of the rainy season in Nigeria has reduced from what was considered normal in 1941, with a shift signaled in 1971 to late onset and early cessation.

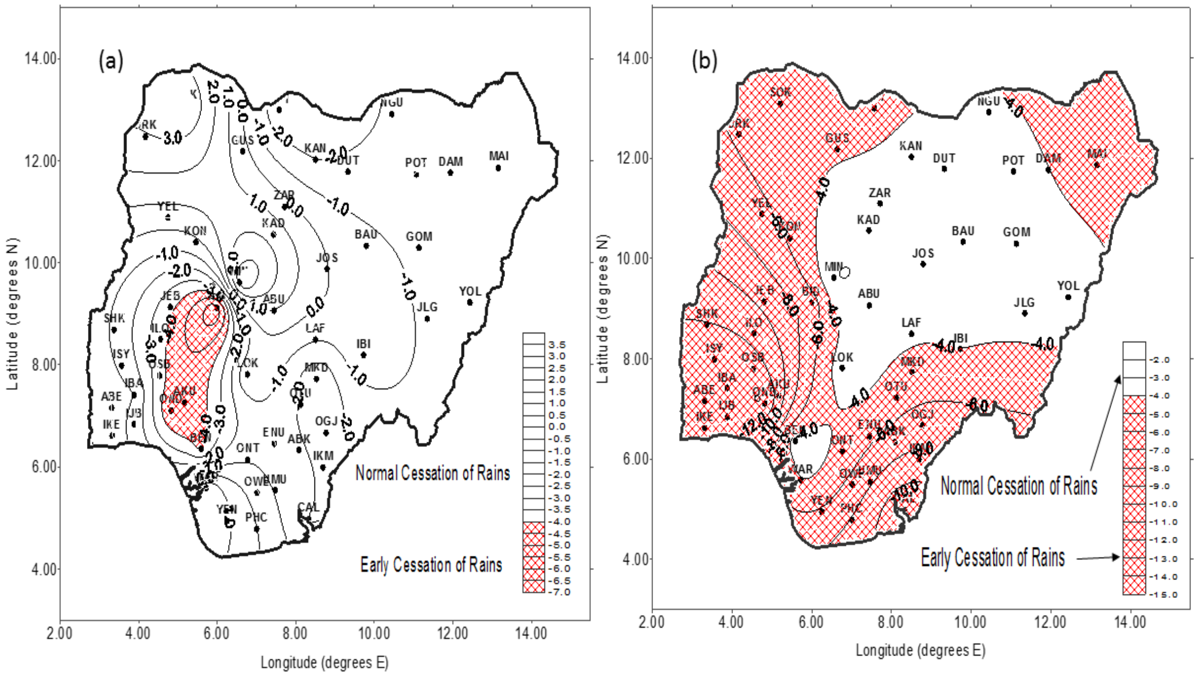


Figure 4.12: The anomaly of the rain cessation dates in Nigeria from 1941-1970 (a) and from 1971-2000 (b), adapted from NCRB, NIMET, 2012

4.5.3 Projected changes in temperatures

Projected changes in temperature using both individual and ensemble CMIP5 models for any of the IPCC 5AR’s four Representative Concentration Pathways (RCPs), namely the RCP2.6, RCP4.5, RCP6 and RCP8.5, show an increase in temperature of varying degrees over Benue State. Between 2020 and 2095, monthly temperature in the state is projected to change by 4.4^{0}C or more (see Figure 4.12a). These projected monthly temperature changes fall within the warming range of between 3°C and 6°C projected for West Africa at the end of the 21st century from both the CMIP3 GCMs (SRES A2 and A1B scenarios) and CMIP5 GCMs (RCP4.5 and RCP8.5), by the IPCC AR5 (Niang et al., 2014).

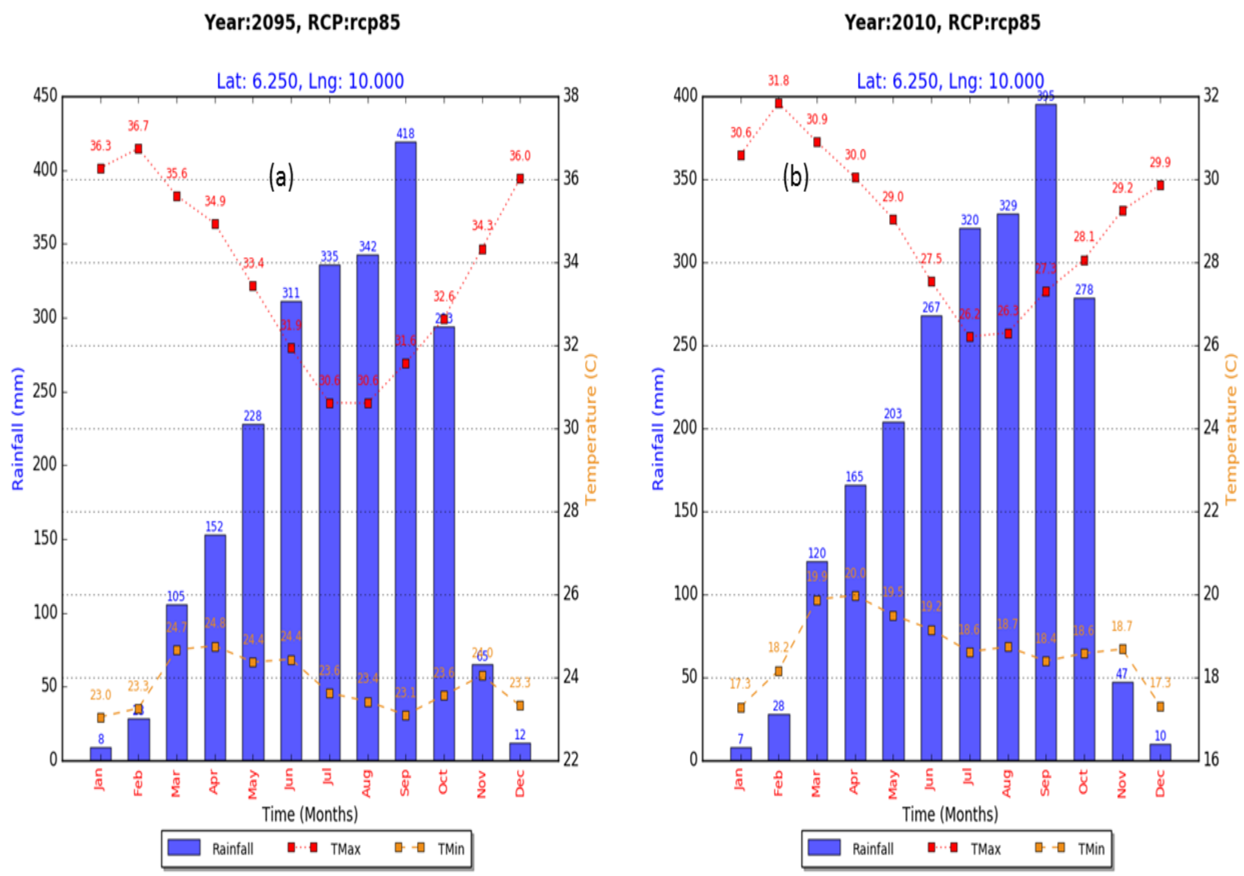


Figure 4.13: Monthly temperature and rainfall for Benue State Nigeria: projected changes for 2020-2095 (a), and historic, observed changes for 1985-2010 (b), based on HadGEM2-ES model[10] (source: **generated from** MarkSim web version for IPCC AR5 data (CMIP5); http://gismap.ciat.cgiar.org/MarksimGCM/**).**

4.5.4 Projected rainfall change and variability

While unprecedented changes in temperature are projected for Benue State, and across Nigeria and West Africa, precipitation is projected to remain unchanged at the end of the 21st century. However, in most parts of the state, a slight increase in monthly rainfall (see Figure 4.12a) compared to the historical pattern (1985-2010) is likely (see Figure 4.12b). Such a projected increase is similar to IPCC AR5's many CMIP5 models which indicate a wetter core rainfall season for West Africa with a small delay to the rainy season by the end of the 21st century.

[10] The HadGEM2-ES model is developed by the Met Office Hadley Centre. It is preferred here because the historical temperature and rainfall pattern are somewhat similar to Makurdi, Benue State.

4.6. Implications of the observed and projected changes in climate for the RVC

These projected and observed changes in temperature and precipitation make Nigeria, and thus Benue State, highly vulnerable to climate change with a severe impact on rural livelihoods (Niang et al., 2014). In terms of rice production, as temperatures keeps rising and warmer than normal days occur in the cold seasons, the number of heat wave days are likely to increase. This also means that a decline in the maximum daily assimilation rate, at a daytime average temperature above 37^0C, is likely, with special impacts on rice yields (van Oort & Zwart, 2018). Moreover, the shift in the onset and cessation of rainfall from normal (early) to late (abnormal) means the length of growing season is shrinking, while the annual amount of rainfall remains unchanged, according to the above projections. The situation will further create disruptions in the rice growing calendar (see Figure 4.3 above), thereby making timing of rice planting much more difficult, particularly for growers who practise double or triple cropping systems, and for those using marginal wet rice fields. Furthermore, geographical distribution of rice growing ecologies (see Table 4.1 above) in Nigeria will be affected, and the potential to practise virtually all rice growing systems (see Table 4.2 above) in Benue State will be reduced.

In addition, in the face of unchanging annual rainfall totals the shrinking growing season means that rice planted early or late, or even in middle of a growing season, is likely to experience rainwater shortage or flooding at some stage of its growth. Not only this, other RVC processes, such as soaking and parboiling, which require large volumes of water, will equally be affected by water shortages. Moreover, the quality of domestic milled rice will increasingly be reduced as the challenge of managing moisture content, both in unmilled and milled rice, may become much more complicated. Already, a recent study has shown that the shrinking growing season is the main cause of the declining rice yields from all rice systems and ecologies in Africa, including along the Benue River valley (van Oort & Zwart, 2018). Another recent study by Bosello, et al. (2017) also showed that changes in temperature and precipitation in Nigeria will result in significant production losses owing to declining rice yields in the Guinea Savanna agroecological zone (AEZ), where Benue State is situated, and prices of domestic rice are likely to increase.

4.7 Conclusion

In this chapter, the geographical, socioeconomic, political, and cultural settings within which the RVCs operate in Benue state have been described, and the RVC activities and processes of growing, processing (milling), and trading rice characterised. Starting with rice growing ecologies and systems, the chapter showed how different growing systems are practised under different growing-periods within a growing season (e.g., a calendar year). The chapter also highlighted the status of rice yield, area harvested, and output or quantity produced, including that of milled rice, consumption, and the price of unmilled, milled, and imported rice in Nigeria and Benue State by presenting annual trends over time.

In addition, the difference and/or ratio between annual rice consumption and production were highlighted to show how RVCs, not just in Benue State, but across Nigeria, have performed in the past nearly 58 years. This information attests to the idea of vulnerability or resilience of the domestic rice production. Lastly, this chapter has characterised climate change and variability by pointing both to the observed and projected climate change and variability in Benue state and Nigeria, and particularly to its numerous implications for the RVCs.

Drawing on the status of the RVC described above, there is no doubt that RVC activities and processes are experiencing tremendous pressure from all sides; on the farm from climate change and variability, and in the market from frequent price crashes, with implications for declining yields, prices, and quality. Thus, it is imperative to understand how the entire system, not just one component, is presently exposed and sensitive to pressures, and how the practices employed by actors along the chain respond to those pressures. The chapters that follow analyse how rice growers, processors, and traders experience the pressures they face, how sensitive they are to these pressures, and the practices they employ to meet them.

Chapter 5

Vulnerability and adaption of rice growers to climate change and variability, and agricultural market dynamics in Benue State, Nigeria

5.1 Introduction

Many scholars have called for context-specific assessments of the impacts of multiple, simultaneous pressures on rice value chains in sub-Saharan Africa (SSA) (e.g., Benzie & John, 2015; Shackleton, et al., 2015; Terdoo & Feola, 2016). This chapter responds to such calls with an investigation and analysis of rice growers' vulnerability to combined climate change and variability (CCV), and to agricultural market dynamics in three study sites in Benue State, Nigeria.

The chapter documents current CCV and agricultural market pressures faced by rice growers and the strategies growers have employed in response. To do so, a Vulnerability Scoping Diagram (VSD) is applied to examine the components of rice growers' exposure, sensitivity, and adaptive capacity in detail. The VSD also helps to compare the existing differences between the three study sites, and therefore highlights uneven vulnerabilities.

The chapter answers four research questions:

I. What pressures are rice growers in Benue State exposed to at present, and how sensitive are rice growers to such pressures?

II. What practices do growers employ to respond to climatic and agricultural market pressures?

III. How do rice growers' exposure, sensitivity and adaptive capacity vary across the study sites?

IV. What are possible entry points for the reduction of vulnerability in the study sites?

The chapter is organised into two major sections, the first discusses vulnerability of rice farming, and the second discusses vulnerability of unmilled rice trading. Each of the two sections is sub-divided into four sections as follows: first, the exposure component of growers' vulnerability is explored; this is followed by a section which addresses the sensitivity component; then the adaptation of growers is unpacked; finally, the findings are validated and discussed in light of current adaptation theories and experiences in SSA and other regions.

5.2 Vulnerability of rice farming in Benue State, Nigeria

Components and measures of vulnerability to combined CCV of rice growers in Makurdi, Gboko, and Adkipo, are illustrated in Figure 5.1 while the differences and similarities are presented Table 5.1.

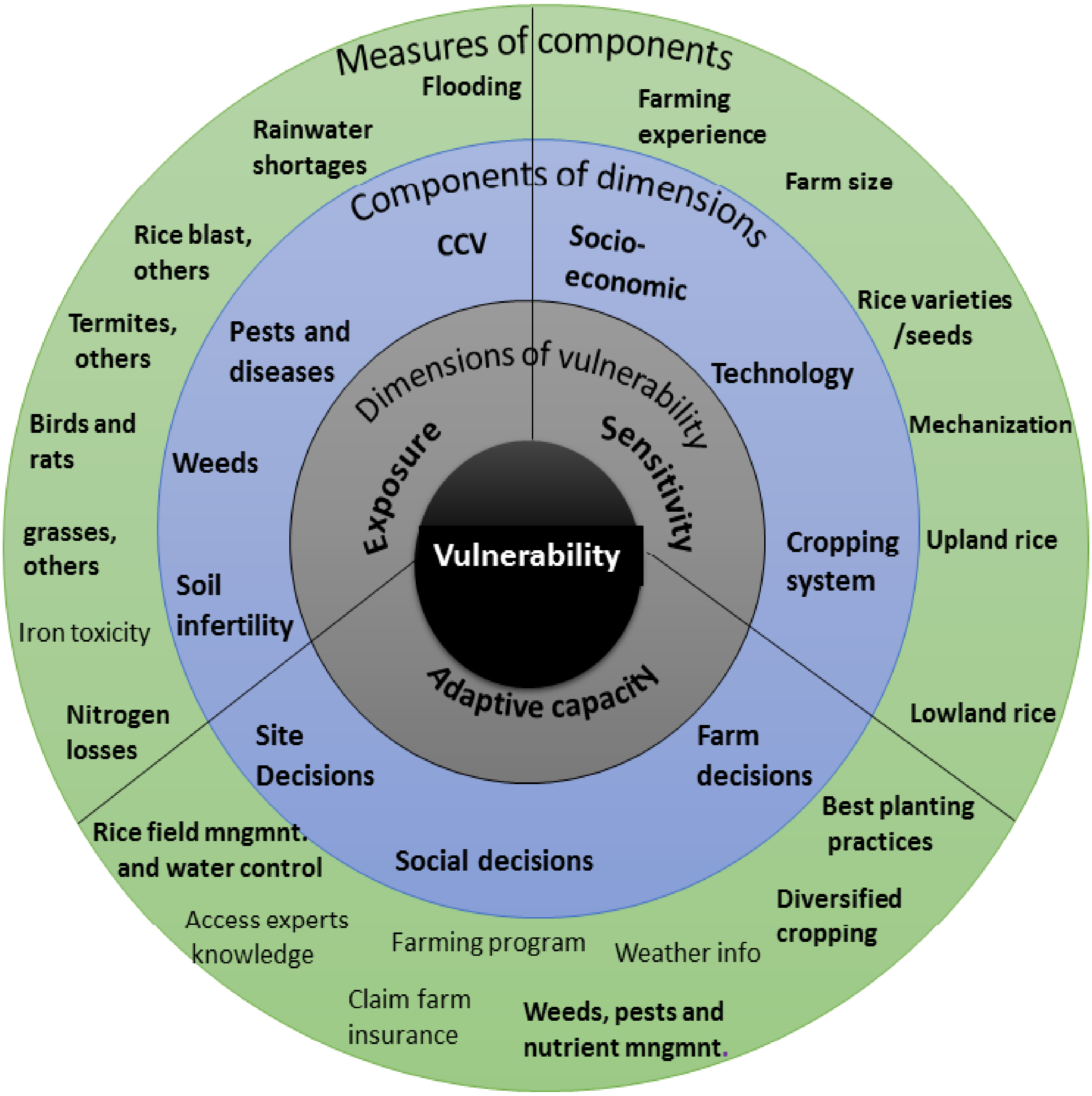


Figure 5.1. Vulnerability scoping diagram for Makurdi, Gboko and Adikpo, Benue State, Nigeria[11].

[11] Factors highlighted in bold were mentioned by at least 33% of rice growers.

Table 5.1. Differences in exposure, sensitivity and adaption highlighted by the VSD across sites

Sites	Makurdi	Gboko	Adikpo
Exposure to CCV	No difference	No difference	No difference
Sensitivity to CCV	No difference	No difference	No difference
Adaptive responses to CCV			
Crop insurance	√	X	x
Farming programme	√	X	x
Expert knowledge	√	X	x
Weather information	√	X	x
Diversified cropping	√	Less practiced	√

√=denotes the presence of adaptive practice in the site while x=denotes absence

5.3 Exposure to climate change and variability (CCV)

5. 3.1 Exposure to CCV

Annual flooding and rainwater shortages have been widely perceived by rice growers as the two greatest pressures to confront their production of rice in recent years (Figure 5.2).

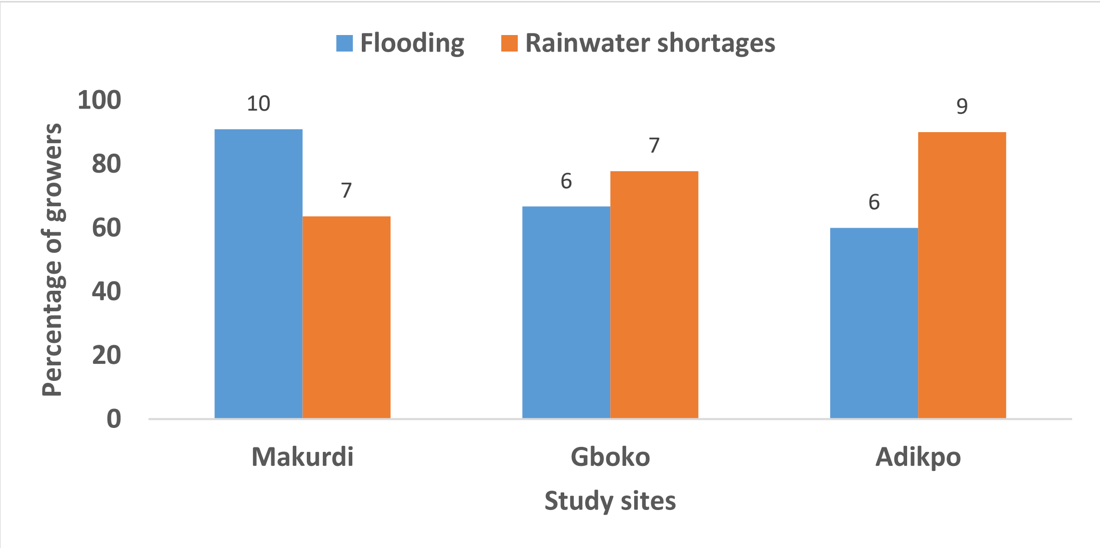


Figure 5.2.[12] **Percentage of growers who identified different climate change and variability pressures in the three study sites**

[12] On this and the subsequent bar-charts, bars denote percentage of respondents who identified different CCV pressures while the figure by each bar denotes the number of respondents who identified different CCV pressures in the study sites.

The sub-sections that follow address the three components of vulnerability, namely exposure, sensitivity and adaptive capacity, and highlight the differences across the study sites. Thus, following the conceptualisation of vulnerability as the degree of susceptibility of the RVCs to multiple pressures and the incapacity of the RVCs to adapt to adverse effects, the remainder of this section focuses on conditions that adversely affect rice growing across study sites in Benue State. Thus, pressures were analysed (e.g. coded) topically, depending on their main driver (e.g., CCV, non-CCV). For example, upon every reference made to various sources of water stress to rice plants (e.g. droughts, early cessation of rainfall, dry spell, etc.) was considered as one group, which is broadly described as *water shortages.* In the same vein, every reference to excess water (e.g. too much rainwater, etc.) was described as *flooding*.

The analysis of data was complimented by an examination of exposure as well as sensitivity and adaptation to pressures on basis the sociodemographic characteristics of the RVCs actors, namely: gender, age, educational level, income class, farm size, labour access, and the number of years engaged, as RVCs' actor (e.g., grower, miller and trader) (Table 5.2 below). In addition, because the total number of respondents "N" is small for each group of actors (e.g. growers, millers and traders), the sociodemographic characteristics interpreted in this study only suggest the trends and pattern in exposure, sensitivity and adaptation practices among different groups or classes of actors in Benue State, Nigeria.

Table 5.2. Types of CCV-related pressures by sociodemographic characteristics of rice growers

Source of pressure	Gender		Age			Education level				Income class			Farm size			Years engaged as rice grower			Labour access		
	Male *(n-28)*	F *(n=2)*	20-39 *n=4)*	40-49 *(n=15)*	50-89 *(n=11)*	None *(n=4)*	Prim *(n=10)*	Sec. *(n-7)*	High *(n=9)*	Low *(n=21)*	Mid. *(n=7)*	High *(n=2)*	Small *(n=18)*	Med. *(n=7)*	Large *(n=5)*	1-10 *(n=11)*	11-20 *(n=11)*	>21 *(n=8)*	Family (n=17)	Hired (n=4)	Hired/Family (n=9)
Flooding	24(86)	1(50)	4(100)	13(87)	8(73)	3(75)	8(80)	7(100)	7(78)	19(90)	5(17)	1(50)	16(89)	5(71)	4(80)	11(100)	9(82)	5(63)	15(88)	3(75)	7(78)
Rainwater shortages	19(68)	2(100)	3(75)	12(80)	6(55)	4(100)	6(60)	6(86)	5(56)	14(67)	5(71)	1(50)	13(72)	4(57)	3(60)	9(82)	6(55)	5(63)	14(82)	1(25)	6(67)
Weed infestations	14(50)	2(100)	1(25)	7(47)	8(73)	4(100)	5(50)	3(43)	4(44)	11(52)	4(57)	1(50)	9(50)	4(57)	3(60)	7(64)	6(55)	3(38)	10(58)	2(50)	4(44)
Diseases and pests	10(36)	2(100)	1(25)	7(47)	4(36)	3(75)	2(20)	4(57)	3(33)	9(43)	2(29)	1(50)	8(44)	2(29)	2(40)	5(45)	5(45)	2(25)	7(41)	1(25)	3(33)
Soil infertility	8(29)	2(100)	1(25)	5(33)	4(36)	2(50)	4(40)	2(29)	2(22)	8(38)	2(29)	-	8(44)	2(29)	-	6(55)	1(9)	3(38)	6(35)	2(50)	2(22)

Cells show (n) number of growers and, in brackets, within group percentage

Regarding the sociodemographic characteristics (Table 2 above), this study does not provide an adequate data base to draw conclusions on any role of gender in determining differences in exposure to CCV-related pressures between growers, since the number of female growers are generally very small (N=2). Given the political economy of rice in Benue State and Nigeria (see 4.3.2.1. Division of labour), certain rice farming operations, particularly those performed manually (e.g. rice field clearing and land preparation) are physically demanding thus culturally viewed as 'manly'. As a result, only a few women are hired to carry them out.

Furthermore, Table 5. 2 shows that the age of growers makes no substantial difference in exposure to CCV pressures among the three group of growers, namely: the young (ages 20-39), middle age (40-49), and older (>50) growers, hence indicating that the vulnerability of growers cut across age groups.

In contrast, Table 5.2 reveals that the years engaged as rice grower, which show the extent of farming experience, including the educational level of growers, income and source of labour accessed, all appeared to make a difference in growers' exposure to pressures. Thus, suggesting that the longer they have been engaged as growers and the more educated growers they have become, the less they are exposed to CCV.

Moreover, the results (Table 5.2 above) equally indicate that low income growers and those using family labour seem more exposed to CCV pressures than middle and high income growers, using either hired labour or mixed (family and hired) labour. This is because these classes of growers are unable to engage hired labour, hence they tend to depend on family labour, which is often unskilled. In addition, they are unable to access inputs and technologies that could reduce their exposure, sensitivity and enhance their adaptive capacity to CCV pressures as revealed in the subsequent sections.

Across the three study sites, many growers recounted their experiences of flooding and rainwater shortages and their effect on rice production in their respective locations (Table 5.3 below).

Table 5.3. Highlights of growers' exposure to flooding and rainwater shortages across study sites

Pressures	Grower's experience	Reference
Flooding	... Flooding comes more regularly than before. Before, when flood water came occasionally, even then it went away after a few days, so it was not really a worry, but now it has become a yearly event. Moreover, the floodwater of today is very different. For example, before we used to have annual floods during the peak of the rainfall in September, and by October everything becomes normal again, but just this year we had some floods in June and July which lasted for weeks until every rice plant was completely rotten under the floodwater…	[Grower 8]
	...In between the rainy season, I do experience flash floods. A short period of excessive rainwater resulting in floods. This covers my rice farm completely and, in most cases, the floodwater brings sand and fills my rice farm so much that nothing can be seen in the area. This causes the rice to rot…	[Grower 23]
	…. Heavy rainfall comes at the time the rice plants are still tender and destroyed most of them. While last year, the rainfall was delayed before it came and flooded many parts of our region…	[Grower 2]
Rainwater shortages	…On the other hand, floods also affect me, but I do manage it locally by creating drainage channels to get rid of the water. Therefore, I can say that we are able to handle floods to some extent, but we do not have control over drought that affects yields. For me drought is worse than floods…	[Grower 21]
	… The overall effect of these weather changes on my farm in recent years is that there is not enough rainfall during the maturing of the rice; the grain quality is affected. In addition, weeds and diseases spread during rainfall shortages further affecting my rice farm adversely…	[Grower 1]
	…later on in the farming season, when the rain resumes, my rice farm became yellowish as an indication of acute water shortage and did not do well again. In fact, the yield was very poor…	[Grower 15]
	…My farm was growing and expanding but this year I lost a lot to water shortages. That was also my experience this year, but it is better to have too much water than to experience shortage of rainfall…	[Grower 25]

For social demographic characteristics of growers, refer to appendix 5.1

Growers in Makurdi have the worst reported experience of river flooding, for them, in good seasons[13], flooding lasts for weeks, or even months, from July to September, during which time rice fields are either completely or partially submerged. This either destroys the rice or drastically reduces yield in substantial portions of the fields which are flooded (see Figure 5.3 below). Meanwhile, in Adikpo and Gboko growers experience flash floods. Unlike the river floods in Makurdi, flash floods only last for a very short time, sometimes a day or two, during which rice fields are destroyed (see Table 5.3 above). The analysis revealed difference in the flood situation across the three sites (Table 5.1), which may be explained by the nature of the system (e.g. lowland rainfed) and geographical context, such as geological and relief features and rainfall characteristics (for a description of these features in Benue State see the case reported in Chapter 4).

Figure 5.3. Flooded rice field (A). Rice dying as a result of flooding (B). Rice fields experiencing rainwater shortages (C&D)

[13] Good seasons are farming years with favorable weather conditions when rains start on time and spread throughout the year without causing any severe flooding or rainwater shortages capable of disrupting farming activities, including destroying rice on the fields or reducing its yields.

In addition to floods, rice growers in the state also experienced rainwater shortages (see Figure 5.3). According to growers, in-season rainwater shortages are a result of prolonged rainfall variation during the growing season and this may occur in various forms, such as: delayed onset of the rain; early cessation of the rain; reduction in the number of rain days; droughts; and dry spells (see Table 5.3 above). Each has a different effect on rice production, including crop failure and reduction in both the yield and the grain quality of the final harvest. However, in places such as Adikpo, where some growers still engage in upland, double, or triple rice cropping systems, farmers felt worst off due to the susceptibility of such cropping systems to rainwater shortages (see Figure 5.2). In general, growers expressed concerns about the nature, extent, frequency, and magnitude of the impact of flooding and rainwater shortages on rice farms in the state, thereby emphasising that these pressures have become extremely changeable and less predictable in recent years than in the past (Table 5.3).

5.3.2 Exposure to other pressures

This section presents pressures where CCV is not the main driver, but where its effects on rice production can be triggered or amplified.

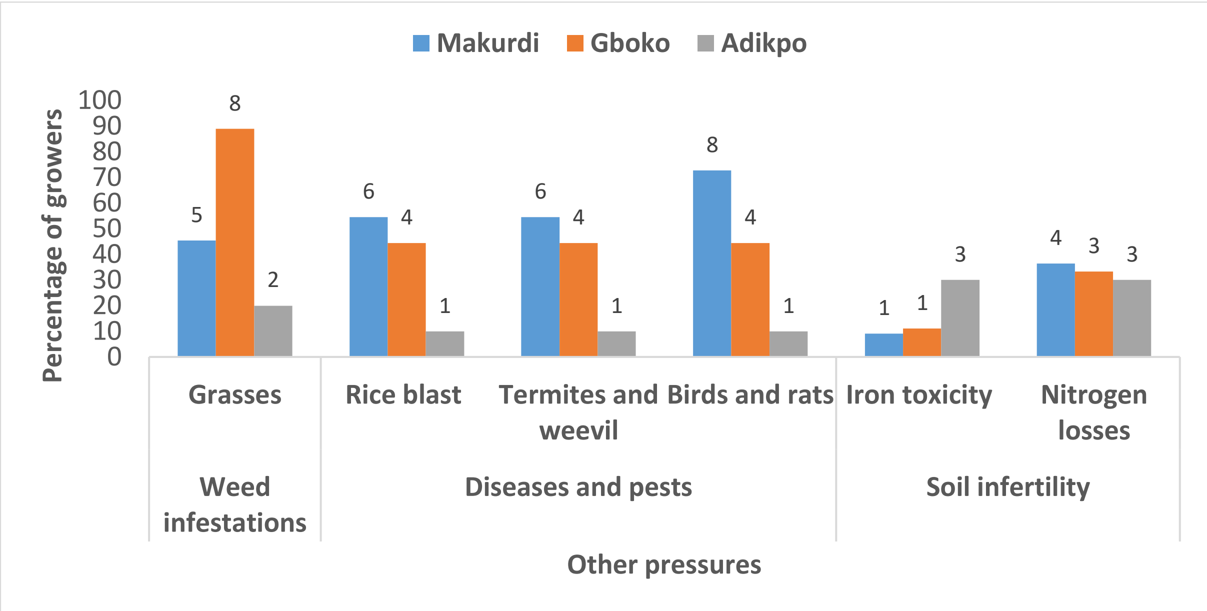


Figure 5.4. Percentage of growers who identified different types of pressures in the three study sites

The rice growers at the study sites further identified weed infestations, diseases and pests, and soil infertility as other pressures to which they are currently exposed (see Figure 5.4).

Table 5.4. Highlights of evidence of rice growers' exposure to other pressures across study sites

Pressures	Grower's experience	Reference
Weed infestations	... I experienced weeds in my rice field… and the grasses usually spread fast when rainfall is less and heat/or temperature rises …. When the grasses have grown they attract insects, diseases, and rodents…and when these are not managed or controlled they destroy substantial portions of the rice fields…However, an attempt to manage the weeds increases production costs... In addition, if I allow weeds to grow they increase the difficulty of harvesting rice and even after the rice is harvested … the rice is not clean. This results in poor quality and price…	[Grower 1]
Diseases and pests	…These insects attack rice that starts shooting up very well and they destroy it…	[Grower 6]
	…If, in July, my rice matures too early then it is certainly going to be attacked by birds because then the weeds may not have produced seeds for the birds to feed on and they will resort to feeding on the early-matured rice…	[Grower 3]
	... then we experienced diseases which are a result of the shortage of rains…when I finally harvested the rice…and it was taken for processing, the end quality was very bad to look at in the first place…	[Grower 17]
Soil infertility	Another pressing challenge is soil infertility… As you can see, up here I have iron toxicity [locally called Nduran). What I can only say is that red thing coming out of the soil is permanently there so any time I farm rice it does not produce well, except near the stream where water is continually flowing…	[Grower 29]

For social demographic characteristics of growers, refer to appendix 5.1

Table 5.4 above highlights the various ways in which rice growers in the state have experienced pressures as a result of problems other than climate change. Rice growers and crop experts have identified grasses, including broadleaf and sedges, as common weeds that affect rice crops in the field (see Figure 5.5 below). These weeds affect rice plants by competing for moisture, nutrients, and light, and because they are generally more efficient in utilizing the soil nutrients. According to growers, when weeds are not controlled, they often leave rice plants in worse condition, significantly constraining the plants' ability to produce quality grain (see Table 5.4). In each study location, poor land preparation and direct seeding (dribbling) were mentioned as reasons for weed infestation in the rice fields. In Gboko, for example, where more cases of weed infestation were reported (see Figure 5.5), improper soil tillage, as a result of the use of manual farming implements (e.g., hoes and cutlasses), was common, especially among small landholders. However, growers associated the rapid propagation of weeds in rice farms to frequent periods of rainwater shortages and high temperatures (see Table 5.4).

Figure 5.5. Rice infested with weeds (A), and with grasses (B) (broadleaf and sedges)

In addition to weed infestations, insect pests (e.g., termites and rice weevil), rodent pests (e.g., birds and rats) and diseases (e.g., rice blast and brown spots) were perceived by growers as harmful to rice, both in the field and after harvest (see Table 5.4). In Makurdi, the majority of the respondents, comprising small and medium landholders, reported high incidences of insect and rodent pests, while high incidences of brown spot and rice blast diseases were reported in Gboko (Figure 5.4). Across the study sites, pests and diseases were also associated with changing rainfall patterns, rising air temperatures, and extremely warm days, but also with poor crop protection practices which keep the surroundings of the rice field bushy (see Table 5.4). These factors have the potential to alter host plant/insect interactions, which in turn contribute to a proliferation of insect populations on the rice farms.

Lastly, growers identified two aspects of soil infertility as challenges to the production of rice. First, nutritional deficiency, such as nitrogen losses, and secondly, “nduran”, a local name for iron toxicity, as explained by a soil expert at the Benue State Ministry of Agriculture and Rural Development, Makurdi. For example, growers in Adikpo reported that the challenge of iron toxicity in the rice field is pressing as it results in yields below the field’s potential (see Table 5.4). In contrast, more cases of nitrogen losses in the soil were reported in Makurdi. As a result of nitrogen loss, which leads to poor rice yields, some of the small landholders without access to fertiliser now see farming unfertile soil as a waste of time (see Table 5.4). Consequently, leaving farming for other livelihood activities is becoming more common, especially among the youth. This situation is dangerous to the quest for expansion of domestic rice production, not just in Benue State, but also in Nigeria as a whole.

5.4 Sensitivity to Climate Change and Variability

The potential effects or harm of pressures the RVCs’ can incur (i.e., its sensitivity) depends on the characteristics of the system. Here, this section focuses on the sensitivity component of rice growers’ vulnerability to CCV and other related pressures presented in Figure 5.1 above. In addition, the sensitivity of rice growers to CCV-related pressures by their sociodemographic characteristics is presented (Table 5.5).

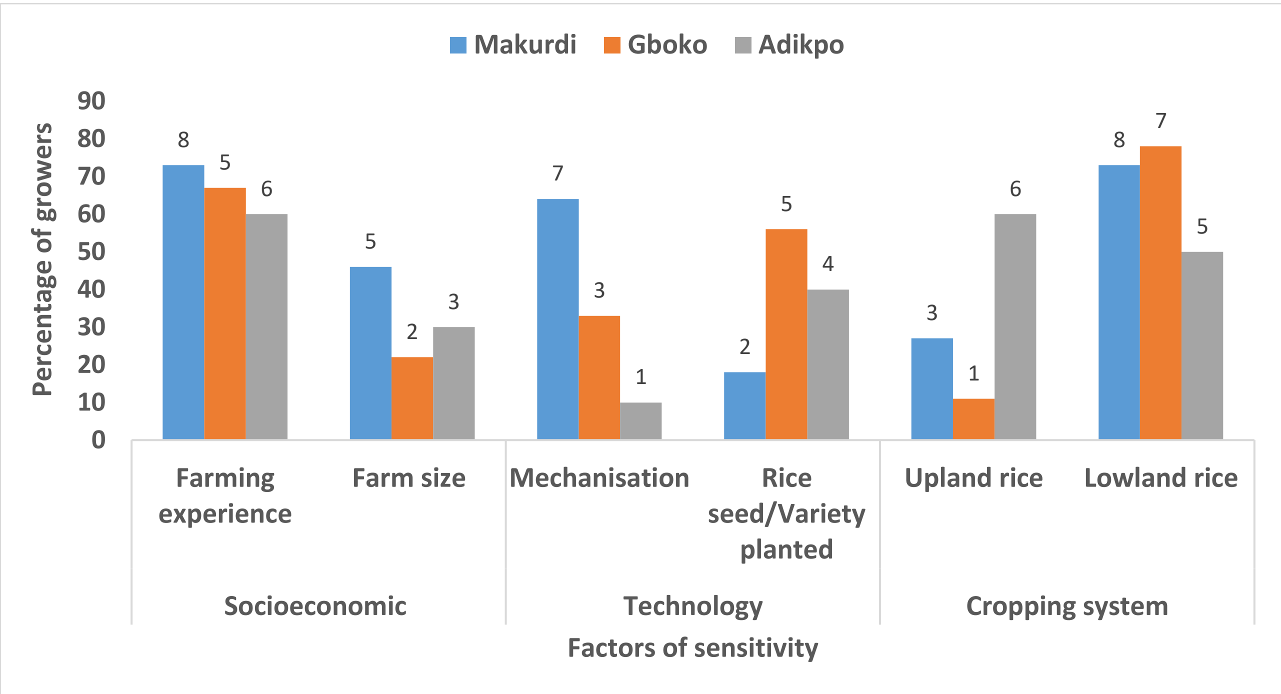


Figure 5.6. Percentage of growers who mentioned different factors related to their sensitivity to CCV and other pressures in the three study sites

Table 5.5. Factors of sensitivity to CCV-related pressures by sociodemographic characteristics of rice growers

Factors	Gender		Age			Education level				Income class			Farm size			Years engaged as grower			Labour access		
	M (n-28)	F (n=2)	20-39 n=4)	40-49 (n=15)	50-89 (n=11)	None (n=4)	Prim. (n=10)	Sec. (n-7)	High (n=9)	Low (n=21)	Mid. (n=7)	High (n=2)	Small (n=18)	Med (n=7)	Large (n=5)	1-10 (n=11)	11-20 (n=11)	>21 (n=8)	Family (n=17)	Hired (n=4)	Hired/Family (n=9)
Mechanisation	11(39)	-	1(25)	6(40)	4(36)	-	3(30)	3(43)	5(56)	4(19)	5(71)	2(100)	4(22)	4(57)	3(60)	6(55)	3(27)	2(25)	4(24)	3(75)	4(44)
Improved rice seed/variety	11(39)	-	2(50)	4(27)	5(45)	-	3(30)	5(71)	3(33)	6(29)	3(43)	2(100)	6(33)	3(43)	2(40)	6(55)	2(18)	3(38)	4(24)	3(75)	4(44)
Upland rice system	9(32)	1(50)	2(50)	3(20)	5(45)	1(25)	3(30)	4(57)	2(22)	7(33)	3(43)	-	5(28)	2(29)	1(20)	1(9)	2(18)	2(25)	7(41)	1(25)	2(22)
Lowland rice system	18(64)	2(100)	2(50)	12(80)	6(55)	3(75)	6(60)	6(86)	5(56)	14(67)	6(86)	1(50)	13(72)	4(57)	3(60)	10(91)	8(73)	2(25)	10(59)	4(100)	6(67)

Cells show (n) number of growers and, in brackets, within group percentage

Across the study sites, rice growers explained their sensitivity to CCV and other pressures in relation to three factors, namely: socioeconomic status, e.g., farming experience and farm size; access to technology, e.g., mechanisation and rice seed/variety planted; the cropping system, e.g., upland or lowland rice (see Figure 5.6), and their sociodemographic characteristics (Table 5.2). Expressions of their experiences with each of these factors are presented in Table 5.6 below.

As can be seen in Table 5.6, the first issue that growers highlighted in relation to sensitivity is farming experience, which is acquired by long years of growing rice. Table 5.5 above indicates that the longer growers have been engaged in rice production the less sensitive to pressures they may likely to be than those who are new to rice growing. These findings were supported by a number of growers. According to them, adequate farming experience helps them make informed farm management decisions. For example, the selection of a rice variety that suits different conditions (i.e., weather and soil), as well as decisions made as to when to plough, plant, weed, and fertilise. These issues are crucial for the reduction of the sensitivity of rice plants to CCV and other pressures, such as those which arise from weed infestation, pests and diseases, and soil infertility.

The second issue highlighted by growers was farm size (see Figure 5.6). While the results on Table 5.5 appear to show no clear difference in sensitivity to pressures with respects to different farm size (e.g., small, medium and large land holders), evidence from the interviews with growers (Table 5.6) did reveal that in Benue State, a large farm size is usually an important criterion for access to bank loans and crop insurance, and for enrolment in a farming programme. Such agricultural production services do not only provide unhindered access to farming inputs, mechanisation, and better access to markets, but also have the potential to buffer, or cushion, the extent to which growers are affected by the pressures which arise from CCV and other issues, including poor market prices. Thus, farm size explains why certain groups of growers (e.g., small landholders) are particularly vulnerable to both CCV and other related pressures.

For example, small landholders across the sites reported that due to their small farm size they are left on their own without access to a formal credit system or the opportunity to enrol in a farming programme, especially to source inputs, which are expensive. Hence, they often depend on local cooperatives (e.g., Bam and Adashi), and family as major financial sources. These financial sources, apart from being unreliable, are especially challenging to access in time of need, generally at the onset of farming season, as too many people depend on them at the same time.

Table 5.6. Highlights of evidence of grower's sensitivities to pressures across study sites

Factor	Grower's experience	Reference
Farming experience	…. My knowledge of certain varieties of rice and weather conditions that I have acquired over the years helps me to decide as to what time to plough, plant, apply herbicides, make profiting decisions, and avoid too many losses…	[Grower 2]
Farm size	… because of my farm size, I cannot access inputs like fertiliser and herbicides from the government, just from our local cooperative, but sometimes one has to be on the list for months before accessing money … and by the time it is my turn it's too late to buy and apply certain inputs, such as fertiliser or herbicides…	[Grower 15].
Mechanisation	Because I use manual labour due to my inability to finance the costs of tractors I often experience weeds in an unprecedented manner…	[Grower 2]
	…Using manual labour to plant increases my challenges… I usually end up planting or harvesting late… sometimes when there is too much water [i.e., floods) … and because of this, my rice grains often go bad on the farm during planting or harvesting…	[Grower 12]
Rice seeds/variety planted	… in situations where this [fields prone to flooding or rainwater shortage) is not avoidable, I usually plant a tall and late maturing variety called FARO 4 [Mai Ruwa], otherwise known as a water loving variety. While for fields prone to droughts, another thing I do is plant early maturing varieties, like Supi [FARO 44] …	[Grower 16]
Upland rice	For me upland rice is more open to water shortages than the lowland system since rice is highly sensitive to water shortages, I don't practise upland rice.	[Grower 4]
Lowland rice	… My system of rice farming is upland. This system is highly open to the effect of droughts, but this year it was not only drought but also flash floods…	[Grower 24]
	…I cultivate my rice in a lowland [Fadama) area… it is a place liable to flooding… It is a problem for me, but that is the only field I have…	[Grower 13].

For social demographic characteristics of growers, refer to appendix 5.1

Figure 5.7. Local rice farming implements: (A) rice harvesting using hand knives; (B) Metal drum used as rice threshing equipment; (C) Threshing of rice using metal drum; (D) Rice threshing mat

Furthermore, rice growers cited access to mechanisation, such as tractors, harvesters, and threshers, as the third factor that explains their sensitivity to pressures (see Table 5.6). Mechanization is important to achieve intensification, e.g., increasing the area under cultivation or the size of the rice field. Despite this, access to mechanisation was still limited to medium and large landholders in Makurdi. Meanwhile, among small landholders, financial constraints and fragmentation of rice fields, which creates smaller farm sizes, were highlighted as the major hindrances to wide spread mechanisation. As a result, the majority of small landholders depend on basic farming equipment or implements, such hoes, cutlasses, knives, and drums, for their daily farming operations which include preparing the land, planting, harvesting, and threshing the rice (see Figure 5.7 above). This has implications for rice production generally. According to growers (see Table 5.6), the use of manual farming equipment results in delayed harvesting and threshing, so these activities often occur in months that are susceptible either to flooding or to rainwater shortages, a direct result of the slow pace of human labour, and with subsequent huge losses. This also contributes to an increase in poor land preparation practices and poor-quality rice harvest because the manual equipment is not able to separate whole grains from broken ones, or from other foreign matter such as straw, stones, sand, chaff, and weed seeds.

In addition to factors identified above, rice growers cited rice seeds and the variety planted in relation to their sensitivity to pressures, especially climatic ones like floods and rainwater shortages. In the three study sites, three major rice cultivars were widely adapted by growers (see Table 5.7).

Table 5.7. Rice seeds/varieties widely planted by growers across Benue State

s/n	Rice variety name	Maturing duration	Other agronomic characteristics
1	FARO 44 (Sipi-local name)	Early-maturing variety that lasts between 90 and 100 days	Semi-dwarf plant type which can cope under mild water stress conditions
2	FARO 52 (OC-local name)	Medium-maturing variety, lasting between 100 and 120 days	Semi-dwarf plant type which can also cope under mild water stress conditions, but requires more water than FARO 44
3	FARO 4 (Mai Ruwa -local name)	Late-maturing variety that lasts more than 120 days	Tall plant type which can tolerate flood water conditions

Source: Table based on interviews and validated after Nwilene, et al. (2008).

In addition to the differences in the duration of maturity, other agronomic characteristics, especially height and ability to withstand water pressure, make these varieties sensitive to seasonal weather changes, especially to rainwater availability, which, in turn, determines the number of times a certain variety is planted within a growing season. According to growers in Adikpo, for example, where an upland rice based cropping system is practised, but where the planting of rice twice or thrice within a season (e.g., a year) in a lowland rice system is common among growers, a short maturing duration variety (e.g., FARO 44) is widely planted by the majority of growers (see Table 5.7). Whereas, in Makurdi, in fields with much rainwater where growers usually produce once in a season, medium or long duration maturing varieties (e.g., FARO 52 and 4) are preferred (see Table 5.7). Moreover, in rice fields susceptible to droughts and rainwater shortages, FARO 44 (Sipi) is generally favoured, be it in a lowland or an upland field.

The last factor highlighted by growers in relation to their sensitivity to pressures was the rice cropping system, namely rain-fed lowland or upland. For example, the lowland rain-fed system, called 'fadama', is the predominant rice system used in the state. This system is practised mainly in the flood plains, along rivers and streams. As a result of their location near water sources, rice fields under this system enjoy an abundance of water and the fields remain wet throughout the year (see Table 5.6 above). However, the system can be highly susceptible to flooding, especially during the peak rainfall season from August to September. Conversely, the upland system is highly susceptible to rainwater shortages because it depends entirely on seasonal rainfall, therefore any fluctuation or prolonged variability can create shortages which are detrimental to the rice crop.

5.5 Adaptation to Climate Change and Variability, and other pressures

This section presents the adaptive component of rice growers (see Figure 5.1, above). Rice growers employed a number of practices, both in the short-term (i.e., tactical) and long-term (i.e., strategic) to adapt to multiple, combined CCV and agricultural market pressures. Some of the reported adaptation measures are reactive, i.e., employed at the time, or after impacts have occurred, while others are anticipatory, i.e., employed before the pressure occurs. Table 5.8 below documents the current adaption practices employed by rice growers in response to CCV and other environmental pressures in the three study sites. In addition, adaptation practices are documented according to growers' sociodemographic characteristics (Table 5.9).

Table 5.8. Percentage of growers who adopted different adaptation practices in the three study sites

Type of adaptation	Source of pressure	Example of adaptation	Makurdi (N=11)	Gboko (N=9)	Adikpo (N=10)
Strategic anticipatory	Flooding	Avoid flood prone fields	4 (36.4%)	3 (33.3%)	
		Plant early	6 (54.5%)	6 (66.7%)	4 (40%)
		Weather communication	3 (27.3%)	1 (11.1%)	
		Dry season farming	3 (27.3%)		7 (70%)
		Double or triple cropping			5 (50%)
Tactical reactive		Water control techniques (e.g., digging of ridges or dykes, and construction of water channels)	6 (54.5%)		7 (70%)
		Claim crop insurance	3 (27.3%)		
	Rain water shortages	Water control techniques (e.g., redirection of stream channels to rice fields)	6 (54.5%)		7 (70%)
Strategic anticipatory		Selection of well-watered fields	1 (9.1%)	3 (33.3%)	3 (30%)
		Diversified cropping (e.g., double or triple cropping)			5 (50%)
		Plant early	6 (54.5%)	6 (67.7%)	4 (40%)
		Plant pressure withstanding variety	5 (45.5%)		6 (60%)
		Weather communication	3 (27.3%)		
		Access to knowledge through experts (IFAD, USAID, OLAM, etc.)	3 (27.3%)		
Tactical reactive	Broadleaf and grasses	Hand weeding	2 (18.2%)	4 (44.4%)	1 (10%)
		Application of herbicides	3 (27.3%)	5 (55.6%)	2 (20%)
	Termites and rice weevil	Insecticides	4 (36.4%)	4 (44.4%)	1 (10%)
Strategic anticipatory	Rice blast, brown leaf	Plant resistant varieties	4 (36.4%)	3 (33.3%)	3 (30%)
		Regular visits to rice field	2 (18.2%)	3 (33.3%)	1 (10%)
Tactical anticipatory	Iron toxicity and nitrogen loss	Mineral fertiliser application	6 (54.5%)	4 (44.4%)	4 (40%)
Strategic anticipatory		Access to knowledge through experts (IFAD, USAID, OLAM, etc.)	3 (27.3%)		
Tactical anticipatory		Regular visits to rice field	3 (27.3%)	3 (33.3%)	1 (10%)

N denotes the total number of growers and, in brackets, within group percentage.

Table 5.9. Adaptation practices by sociodemographic characteristics of growers

Type of adaptation	**Adaptation**	**Gender**		**Age**			**Education level**				**Income class**			**Farm size**			**Years engaged as rice grower**		
		M (n-28)	*F (n=2)*	*20-39 (n=4)*	*40-49 (n=15)*	*50-89 (n=11)*	*None (n=4)*	*Prim. (n=10)*	*Sec. (n-7)*	*High (n=9)*	*Low (n=21)*	*Mid (n=7)*	*High (n=2)*	*Small (n=18)*	*Med. (n=7)*	*Large (n=5)*	*1-10 (n=11)*	*11-20 (n=11)*	*>21 (n=8)*
Strategic anticipatory	Avoid flood prone fields	7(25)	-	2(50)	4(27)	1(9)	-	3(30)	3(43)	1(11)	5(24)	2(29)	-	4(22)	3(43)	-	5(45)	1(9)	1(13)
	Plant early	14(50)	2(100)	2(50)	8(53)	6(55)	4(100)	5(50)	4(57)	3(33)	11(52)	4(57)	1(50)	9(50)	3(43)	4(80)	6(55)	7(64)	3(38)
	Weather communication	4(14)	-	-	3(20)	1(9)	-	-	1(14)	3(33)	2(10)	2(29)	-	1(6)	3(43)	-	2(18)	1(9)	1(13)
	Dry season farming	9(32)	-	3(75)	2(13)	4(36)	-	5(50)	2(29)	2(22)	7(33)	2(29)	-	6(33)	3(43)	-	5(45)	2(18)	2(25)
	Double or triple cropping	5(18)	-	1(25)	1(7)	3(27)	-	3(30)	1(14)	1(11)	4(19)	1(14)	-	4(22)	1(14)	-	2(18)	1(9)	2(25)
Tactical reactive	Water control techniques (e.g., digging of ridges or dykes)	12(43)	1(50)	2(50)	4(27)	7(64)	1(25)	6(60)	3(43)	3(33)	8(38)	4(57)	1(50)	9(50)	2(29)	2(40)	5(45)	4(36)	4(50)
	Claim crop insurance	3(11)	-	1(25)	1(7)	1(9)	-	-	1(14)	2(22)	-	1(14)	2(100)	-	-	3(60)	1(9)	2(18)	-
	Redirection of stream channels to rice fields)	12(43)	1(50)	2(50)	4(27)	7(64)	1(25)	6(60)	3(43)	3(33)	8(38)	4(57)	1(50)	9(50)	2(29)	2(40)	5(45)	4(36)	4(50)
Strategic anticipatory	Selection of well-watered fields	7(25)	-	2(50)	4(27)	1(9)	-	4(40)	2(29)	1(11)	6(29)	1(14)	-	4(22)	3(43)	-	6(55)	-	1(13)
	Diversified cropping (e.g., double or triple cropping)	5(18)	-	1(25)	1(7)	3(27)	-	3(30)	1(14)	1(11)	4(19)	1(14)	-	4(22)	1(14)	-	2(18)	1(9)	2(25)
	Plant stress withstanding variety	11(39)	-	2(50)	4(27)	5(45)	-	3(30)	5(71)	3(33)	6(29)	4(57)	1(50)	6(33)	3(43)	2(40)	6(55)	2(18)	3(38)

Cells show (n) number of growers and, in brackets, within group percentage.

Table 5.9. Cont'd

Type of adaptation	Adaptation	Gender		Age			Education level				Income class			Farm size			Years engaged as e grower		
		M	*F*	*20-39*	*40-49*	*50-89*	*None*	*Prim*	*Sec.*	*High*	*Low*	*Mid*	*High*	*Small*	*Med.*	*Large*	*1-10*	*11-20*	*>21*
		(n-28)	*(n=2)*	*(n=4)*	*(n=15)*	*(n=11)*	*(n=4)*	*(n=10)*	*(n-7)*	*(n=9)*	*(n=21)*	*(n=7)*	*(n=2)*	*(n=18)*	*(7)*	*(n=5)*	*(n=11)*	*(n=11)*	*(n=8)*
	Access to knowledge through experts (IFAD, USAID, OLAM, etc.)	3(11)	-	1(25)	1(7)	1(9)	-	-	1(14)	2(22)	1(5)	1(14)	1(50)	1(6)	-	2(40)	2(18)	1(9)	-
Tactical reactive	Hand weeding	5(18)	2(100)	-	4(27)	3(27)	3(75)	2(20)	1(14)	1(11)	5(24)	2(29)	-	5(28)	-	2(40)	5(45)	-	2(25)
	Application of herbicides	9(32)	-	-	6(40)	3(27)	2(50)	3(30)	1(14)	3(33)	4(19)	4(57)	-	4(22)	4(57)	1(20)	4(36)	1(9)	3(38)
	Insecticides	8(29)	1(50)	-	5(33)	4(36)	1(25)	2(20)	2(29)	4(44)	5(24)	3(43)	-	4(22)	4(57)	1(20)	5(45)	2(18)	2(25)
Strategic anticipatory	Regular visits to rice field	5(18)	1(50)	1(25)	2(13)	3(27)	1(25)	2(20)	1(14)	2(22)	4(19)	2(29)	-	5(28)	1(14)	--	5(45)	-	1(13)
Tactical anticipatory	Mineral fertiliser application	14(50)	-	2(50)	8(53)	4(36)	2(50)	5(50)	3(43)	4(44)	6(29)	5(71)	2(100)	4(22)	6(86)	4(80)	8(73)	3(27)	3(38)

Cells show (n) number of growers and, in brackets, within group percentage.

For the purpose of presentation, the adaptation practices in Table 5.8 above are presented under seven headings. These include: rice field management and water control practices; best planting and diversified cropping practices; weed, pest and nutrient management practices; communication of weather information; access to expert knowledge; enrolment in a farming programme; and claiming crop insurance. In addition, these adaptation practices were analysed in relation to gender, age, educational level, income classes, farm size and years of engagement as rice growers (Table 9).

5.5.1 Rice field management and water control practices

In all the sites, rice growers identified avoidance of flood prone rice fields and/or selection of well-watered rice fields and water management techniques, such as channelling of floodwater in and out during rainwater shortages and flooding of lowland rice fields, as some of the most common practices employed in response to CCV pressures. In Table 5.10, growers' expressions of their adaptive practices are presented.

Table 5.10. Highlights of growers' rice field management and water control adaptive practices

Adaptive practice	Grower's experience	Reference
Selection of well-watered rice fields and water	…I do proper planning ahead of the planting season and carefully supervise my farm. Also, I try to have a good idea of the climate and this helps me to avoid farming rice in fields likely to dry out, or where I have foreseen rainwater shortages in a year	[Grower 12]
Avoiding flood prone rice fields	…for flooding, what I do is to avoid farming on fields/areas that are likely to be flooded..… This is a key experience that is necessary for me to manage flooding without paying a bigger price of incurring losses on my rice farm…	[Grower 14]
Water control during flooding and rainwater shortages	…I ridge round my rice farm in order to secure tender rice plants from being washed off by floods until when they are fully rooted and grown to overcome floods… and on other occasions…	[Grower 3]
Water control during flooding and rainwater shortages	…I create channels to take away excess water or flooded water out of the farm and open the same channels to bring in water during periods of low rainfall…	[Grower 24]
Regular visits to rice field	…the next thing to do after planting is to manage the rice farm. I usually visit my farm every day, so I notice the changes. This helps me to know if everything is going well or not…	[Grower 1]

For social demographic characteristics of growers, refer to appendix 5.1

The first two adaptive practices (see Table 5.10 above) are strategic and anticipatory in that they are taken far in advance of floods and rainwater shortages, hence they are generally easy and inexpensive to employ, but also a most effective response to CCV pressures in years of normal rainfall. However, in years with extreme rainfall events such practices may potentially increase exposure to floods or rainwater shortages. For example, in Makurdi, with its recurring flood incidences, well-watered rice fields are usually avoided, less-watered fields are preferred because during the peak months of rainfall, between August and September, well-watered rice fields are usually the first to be inundated as the river water rises. Nonetheless, in years or seasons of limited rainfall, especially during times of drought, those less well-watered rice fields tend to have an adequate supply, and thus become ideally suited to rice cultivation.

Meanwhile, the last two adaptive practices (see Table 5.10) are tactical and reactive as they are often employed during, or after, flooding or rainwater shortages have occurred. As such, they are often expensive and more demanding, while also often very ineffective, especially in years of extreme rainfall. For example, construction of cemented embankment walls and other forms of obstruction, and of flood drain channels, is expensive; only large landholders with sufficient financial capital engaged in this practice. Small landholders, with less capital, engaged in the redirection of stream water and channels of no firm structure. While these measures are helpful during peak rainy seasons when the flooding of rice fields is recurrent, in the off-peak rainfall seasons (usually towards the end of October onwards), and during prolonged dry spells, such water management measures are rather problematic. For example, during periods of water shortages, channel embankments and obstructions are found to create artificial water scarcity by starving surrounding rice fields of water. This further exacerbates water shortages as the available water flows only to fields with well-constructed water channels. Despite this, water management techniques, in general terms, have been less effective in the management of severe floods in the region. Nonetheless, in times of rainwater shortages, techniques such as the redirection of rainwater in order to flood the rice fields have been effective (see Table 5.10).

Regular visits to the rice fields were identified as one of the last rice field management practices. One grower described this as "*keeping an eye on the farm"* [Grower 1]. It is a practice carried out regularly by growers to monitor both positive and negative changes on their farms throughout the rice growing season, so any necessary action can be taken appropriately (see Table 5.10).

With respect to sociodemographic characteristics (Table 5.9), the study reveals that adoption of water management practices in Benue State appears to cut across age groups, educational levels, farm sizes and years engaged as rice grower. However, for specific practices, such as carrying out regular visits to rice fields and rice field management and water control practices (digging of ridges or dykes), growers in the middle income class and above seem to be engaged in these practices more than those in the low income class. This highlights the importance of income, especially for carrying out heavy operations, which may demand hired and skilled labour.

5.5.2 Best planting and diversified cropping practices

In addition, best planting practices, such as early or careful timing of planting and the use of stress resistant seeds\varieties, along with diversified cropping, such as dry season rice farming and double or triple cropping, have been employed by a number of growers in response to CCV and other pressures. Evidence of these practices are presented in Table 5.11 below.

Table 5.11. Highlights of growers' rice planting and diversified cropping practices

Adaptive practice	Growers' experiences	Reference
Planting early or careful timing of planting	…any variety planted early, from June to July, on any field, matures for harvest before cessation of the rains, producing high yields and good quality, while rice planted late, from August to September, experiences water shortages from irregular cessation. Therefore, when planting of rice is not carefully timed, I incur heavy losses owing to flooding and water rainwater shortages…	[Grower 1]
Planting stress resistant seeds\varieties	… In this particular field, which has so much water, I used to plant Tone 4, which enjoys deep-water conditions… but with the coming of FARO 44 (Sipi), Tone 4 no longer has a good market as before… so I decided to change to Sipi. However, last year my rice matured when the field still had too much water… So, harvesting and threshing was very challenging as the water continued to flow. The situation led to significant losses as the mature rice remained undried and easily rotted in the wet conditions… and, in turn, the overall quantity of rice I expected to harvest from this field was not achieved…	[Grower 24]
Diversified Cropping	…I do engage in dry season farming, under this system I have control over factors like when the water volume is either too much and it floods, or is too little and we have drought, this is beyond my control in rainy season farming…There is nothing like floods nor drought or water shortages… and if the need be… I use my small water pumping machines to supply water to my farm, to irrigate … Also, weeds, insects, and diseases are fewer during dry seasons…	[Grower 24]
	…here in this field I plant rice sometimes twice or thrice in a year. This has not only increased the quantity of rice I harvest yearly, but also my income too…	[Grower 28].
	…another thing I do now is instead of depending on rice farming, I do farm other crops such as yam, cassava, and soybeans for food and for selling to get additional income...	[Grower 1]

For social demographic characteristics of growers, refer to appendix 5.1

Planting or sowing early, or proper timing of rice cropping activities and processes, are generally crucial decisions made by growers across the sites to safeguard against flooding or rainwater shortages. Table 5.9 shows that older growers (≥50 years), and who are large landholders (large farm size), and who have been engaged as growers for more than 11 years, often plant their rice earlier than the middle age (40-49 years) and young growers (20-39 years), who are small landholders, and less experienced as growers (≤10 years). This is because, in the absence of viable weather projections and communication, age and long-term engagement as a grower tends to increase the growers' capacity to time rice planting more favourably. According to growers, early/careful timing of planting helps prevent losses during a false start to rainfall (i.e., a situation where the rains starts and retreats immediately the crops are planted), and early cessation of rainfall in a farming season. However, this depends on the nature of the rice field (e.g., well-watered) and the variety (e.g., 90 or 120 maturing days) (see Table 5.7).

While early planting of rice can be advantageous, there are certain farming seasons when it can be detrimental. For example, in situations where the rice matures for harvest in September and early October because it was planted early, and it happens that the intensity of rainfall is very high, the rice is likely to be washed away by flood water. Moreover, the rice that is not washed away may remain wet and decompose. Handling harvested rice (unmilled) at such times of rainfall and wet weather is very difficult as there is usually limited sun to properly dry the unmilled rice for storage, which compounds the problem of losses. Despite this, planted early, particularly by July, often helps growers manage flooding as the rice planted before, or by, this period usually grows to such heights that in the event of flooding it can survive the pressure, especially if the floodwater recedes after a few weeks (see Table 5.7 above).

Rice growers also highlighted the planting of stress resistant rice seeds and varieties as a means of response to pressures from water stress, such as flooding or rainwater shortages. Table 5.9 revealed that educational level, income class and the size of landholdings all appear to make a difference in planting of stress resistant rice seeds and varieties. Thus, highlighting rice growers with secondary education and above, and with large landholdings are more likely to embark on planting of stress resistant rice seeds and varieties, regardless of their ages and the number of years involved in rice growing. Thus education enlightens growers' about the importance new technologies in enhancing their adaptive capacity.

In the Adikpo site, where triple cropping is usually practised by growers, FARO 44 (Sipi) and 52 (WITA 4) were the major rice varieties adapted by the majority of growers. These varieties have different agronomic characteristics, such as height and maturing duration, and these are important for coping with water stress or excess (see table 5.7 above on sensitivity). However, the adoption of stress resistant varieties entails certain trade-offs. For example, a variety such as FARO 44 is early maturing and resistant to pressures such as rainwater shortages, and sometimes less expensive, while FARO 4 or 52 are late maturing and flood resistant, but may be preferred by buyers in the market, and are more expensive.

Another practice through which rice growers have adapted their response to pressures generally is diversified cropping (Table 5.11). Thus, growers practised three forms of diversified cropping were commonly practised among older growers (≥50 years), especially among those engaged for a relatively long time usually more than 11 years (Table 5.9). Growers in this category tend to depend on the experience of many years as rice growers to successfully practice various forms of diversified cropping than the younger growers. This practice holds promise for the achievement of intensification of rice cropping, both in the existing area of rice cultivation and in the face of growing uncertainties surrounding weather and CCV in the region. The advantage of this practice is that apart from increasing earnings from multiple rice farming, it has the potential to for buffer, or spread, risks which may result from crop failure due to flooding and rainwater shortages. The first is double or triple cropping, the practice of farming rice twice or thrice in a season

In Adikpo, for example, where this practice is commonly carried out by small landholders, growers always hope that in the event of crop failure rice planted in any of the remaining farming times (i.e., two, or at least one) may do well, and thus offset losses incurred from the previous farming time(s) (Table 5.11).

In close relation to spreading the planting of rice over a period of up to three times in a single year is the practice of dry season farming, popularly called ‘amahundu’ in the Tiv language, literally meaning ‘farming in the dust’. This practice aims to attain intensification on a single rice field, but in recent years it has become a very effective means of response to pressures, especially those related to flooding. In Adikpo, dry season farming is a long-standing rice cropping system widely practised, primarily to boost income. Irrigation is usually not required because it is practised in the rice fields (fadamas) which remain wet throughout the year, except in seasons where acute rainwater shortages mean there is inadequate water to recharge the fadama fields. This makes dry season farming very easy, it is less time consuming and less expensive to practice than irrigation. As a result, dry season farming is spreading to places such as Makurdi which frequently experience flooding.

The last aspect is crop diversification. This is a practice by which a rice grower plants other crops, such as groundnuts and yams, so that in the event of rice failure owing to CCV and related pressures these will buffer, or spread, the risks. Among the three sites, crop diversification is most commonly reported among small landholders in Makurdi.

5.5.3 Weed, pest, and nutrient management practices

By way of managing weeds, pests, and nutrients, rice growers employed a number of practices, including hand weeding and the application of herbicides, insecticides, and mineral fertilisers. Growers weed manually by physically removing weeds in the rice fields, usually pulling them out by hand or using implements like small hoes. According to one grower, "…this practice is mostly employed in case of herbicide failures…" [Grower 1], but it is common among the small landholders with little or no financial capital to access herbicides. The advantage of hand weeding is that it can be carried out anytime and is the most effective method, especially for the control of stubborn weeds, although it is time consuming and labour intensive.

The use of agrochemicals to control weeds is quick and saves time; it is widely used, especially among medium and large landholders. Pre-emergence and post-emergence are the two common techniques of herbicide application on rice farms. The pre-emergence technique means the herbicide is usually applied 24 hours after direct-seeding, while post-emergence herbicide is applied 25 days after direct-seeding and 2-3 weeks after transplanting (Nwilene et al., 2013). The former prevents weeds from germinating together with the rice plants, while the latter kills the weeds in the rice fields. Most growers favoured the post-emergence technique; one grower who used this noted, *"Once I have planted, 3 weeks after I apply chemicals to control the weeds …"* [Grower 15].

Furthermore, some of the medium/large landholders in Makurdi reported using insecticides to control insect vectors from destroying rice plants both on the farm and off the farm after harvest. Access to finance was the key reason for adoption of the practice. However, for chemical weed control to be effective, growers must have access to authentic chemicals, although this has remained a big issue across the study sites due to lack of regulation.

Additionally, application of mineral fertiliser is a practice widely adopted by growers in response to the pressures they face, especially to nitrogen loss in the soil. Across the three study sites, adoption of mineral fertilisers was higher among medium/large landholders in Makurdi than at the other sites; one Makurdi grower said: "*…one of the things I do to manage my rice farm is mineral fertiliser application*…" [Grower 1]. However, access to mineral fertiliser across the sites may be reliant on a grower's income as not all growers use it. Those growers without access to mineral fertilisers practised bush fallowing to enable the soil to regain its fertility when minerals are leached.

In general, among the weed, pest, and nutrient management practices reported above, Table 5.9 suggests that growers with middle income and farm size and above tend to engage in application of herbicides, insecticides and mineral fertilizers more than small landholders with limited income.

5.5.4 Communication of weather information

The communication of weather information was only practised by medium/large landholders in Makurdi. Weather information is a service offered by the Nigerian Meteorological Agency (NIMET) to sectors such as agriculture and transportation. The most commonly communicated weather information to rice growers is forecasts of rainfall, this clearly provides rice growers the opportunity to make informed decisions about the timing of crop planting and the choice of variety to plant (e.g., an early, medium, or late maturing variety or seed). Despite this, Table 5.9 reveals that growers with high level of education seem to be engaged in weather communication more than growers who are less educated regardless of how long they have been identified as growers. According to one grower "*...Sometimes, I don't have enough weather information about rainfall… and sometimes what we have is not… reliable to make correct decisions, and sometimes, the one I got was even incorrect. So, making decisions becomes much more difficult…"* [Grower 2]. However, unreliability of forecasts or projections often makes growers dependent on personal weather knowledge, and this too can be very unreliable in terms of the provision of information for accurate timing of planting and choice of variety.

5.5.5 Access to knowledge through experts and joining a farming programme

Access to knowledge through experts and by joining a farming programme are two related, strategic, long-term adaptation practices employed by growers in Makurdi to foster a relationship with different organisations and experts in the rice sector. By the first, farmers seek to maintain contact with experts from agricultural organisations and companies, such as IFAD, USAID, OLAM, Mikap, Olam, and Stallion, for the purpose of accessing new knowledge, skills, and best practices about rice production, such as information about integrated rice management which incorporates soil fertility, weed, pest, and water management, amongst other information.

Meanwhile, the latter, joining a farming programme/partnership, is more than simply helping growers acquire new knowledge, it is a full partnership, i.e., it is a formal arrangement between the outsourcing companies, those listed above, and individuals/groups of growers and the Benue State Government. The partnership aims to promote demand-driven production by developing a supply chain model which encourages the use of improved technologies, growth of grower capacity, commercial links with credible market outlets, such as the mill, and strategic public-private partnerships (Olam, 2013). Participation in farming programmes is expected to help growers overcome the challenge of inadequate government support, lack of market access (e.g., in the event of a price crash), and the influence of third-party prices.

Furthermore, opportunities to easily access critical inputs, such as mineral fertilisers, and modern rice farming technologies which are difficult to come by, are available. The lack of these opportunities has exacerbated instability in annual rice yields over the years. Thus, Table 5.9 shows that growers with high level of education, income, large farm size and many years of engagement in rice production are gradually adopting this practice more that growers with less of the above state characteristics. According to one grower, the most important incentive received by growers from such contacts is access to quality seeds, e.g., high yielding and stress resistant rice varieties. In the growers' words:

> …I have contact with USAID. Therefore, I can get good seed varieties that can resist pressures from drought and water shortages…. and my yield is far better than before. In addition, I now get to the market and I can sell at a good price… [Grower 7]

> …Presently, I have signed a memoranda of understanding (MOU) with the new agro dealer in town. This will also help me to escape from poor prices and the hands of intermediaries (Branda) in the periodic market system… [Grower 6]

While networking with experts, especially outsourcing companies, is beneficial to the growers, only a few middle and large landholders of rice fields in and around Makurdi, which is near the state capital where these organisations are located, have this opportunity. Thus, small landholders in Makurdi and growers in other parts of the state have little contact with experts and cannot engage in this adaptation practice, despite its merits.

5.5.6 Claiming crop insurance.

This is an emerging, tactical adaptation strategy which aims to help rice growers offset losses incurred as a result of flooding, rainwater shortages, or other pressures. As Table 5.9 shows, growers with higher level of education, income, large landholders and who have long years of engagement as rice producers (>11 years) tend more to buy and claim crop insurance than growers who are not in any of these categories. Medium/large landholders in Makurdi have adopted the practice. However, they have expressed concerns about the effectiveness of crop insurance when they are severely exposed to these pressures.

> What I do is I try to work with the insurance people to cover my rice farm, but they are not reliable. In one case, after I paid what I was supposed to pay [i.e., the premium], when flood destroyed 100 hectares of my rice farm, the insurance people came and assessed the level of damages, but paying the claim became a problem. They kept postponing it. There was a time when I took them [the insurance company) to court, but the court took an even longer time to hear the case and deliver a judgement… [Grower 8]

Lastly, Tables 5.2, 5.5 and 5.9 above showed that there is no clear overall pattern associated with the way growers of varying gender, ages, educational level, income class and with different years of engaging in rice growing are exposed, sensitive and adapting to CCV-related pressures in Benue State. This highlights that, there is no single factor that seems to be regularly associated with growers' exposure, sensitivity and adaptation in Benue State.

5.6 Exposure to agricultural market pressures (AMP)

In this section, rice growers' perceptions of exposure to agricultural markets in Benue State, in which the three research sites are located, are presented. Accordingly, on the left-hand side VSD (Figure 5. 8), the component of rice growers' exposure to agricultural market-induced pressures in the three study sites are highlighted while the differences and similarities presented in Table 5.12. While the types of market-related pressures by sociodemographic characteristics of growers are presented in Table 5.13.

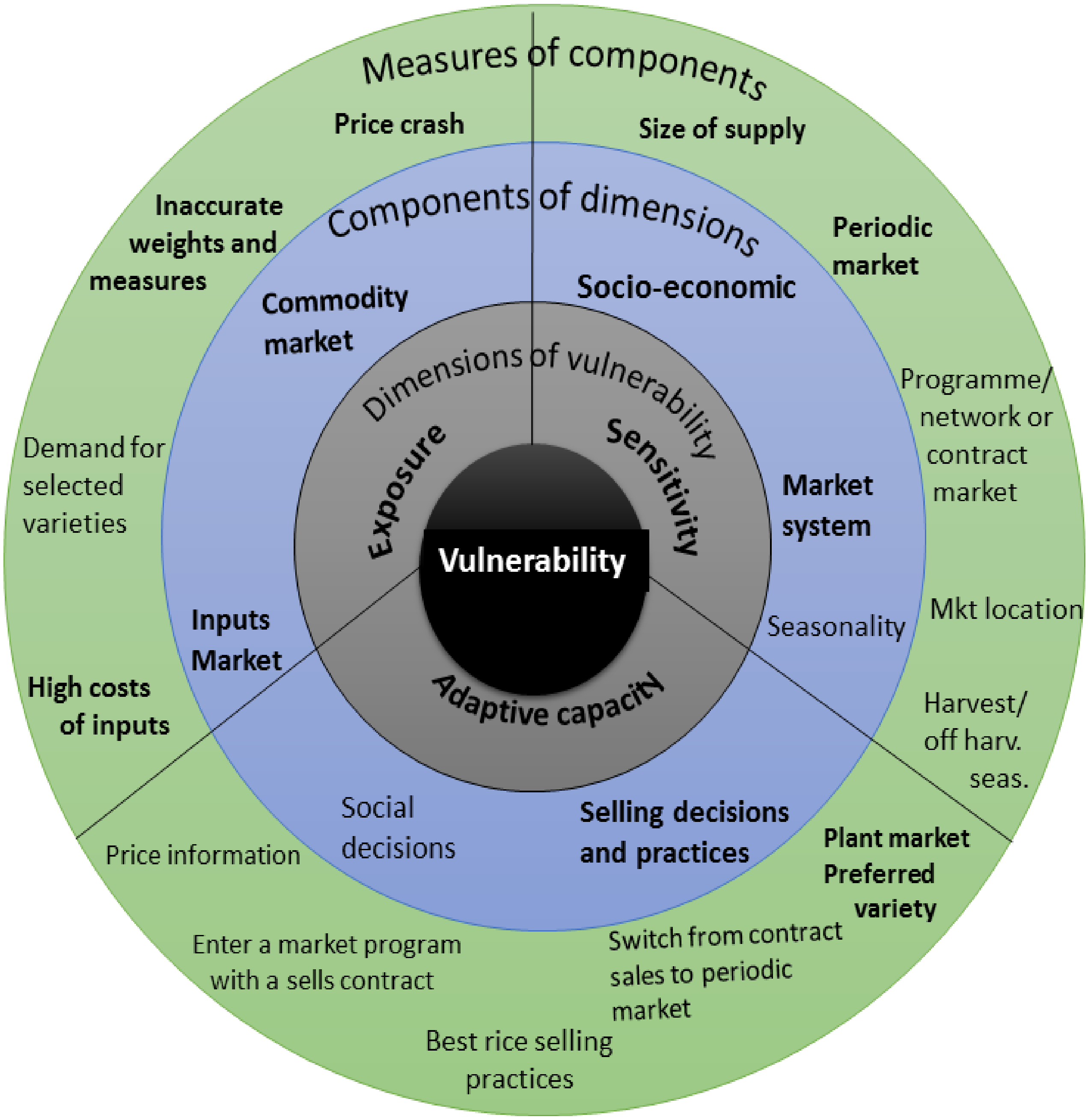


Figure 5.8. Vulnerability scoping diagram for Makurdi, Gboko and Adikpo, Benue State, Nigeria[14]

[14] Factors highlighted in bold were mentioned by at least 33% of rice growers

Table 5.12. Differences in exposure, sensitivity and adaption highlighted by the VSD across sites

Sites	Makurdi	Gboko	Adikpo
Exposure to MP	No difference	No difference	No difference
Sensitivity to MP	No difference	No difference	No difference
Adaptive responses to MP			
Enter a market programme with a sell agreement/contract	√	X	X
Switching from a contract sells to open (periodic) market	√	X	X

√=denotes the presence of adaptive practice in the site while x=denotes absence

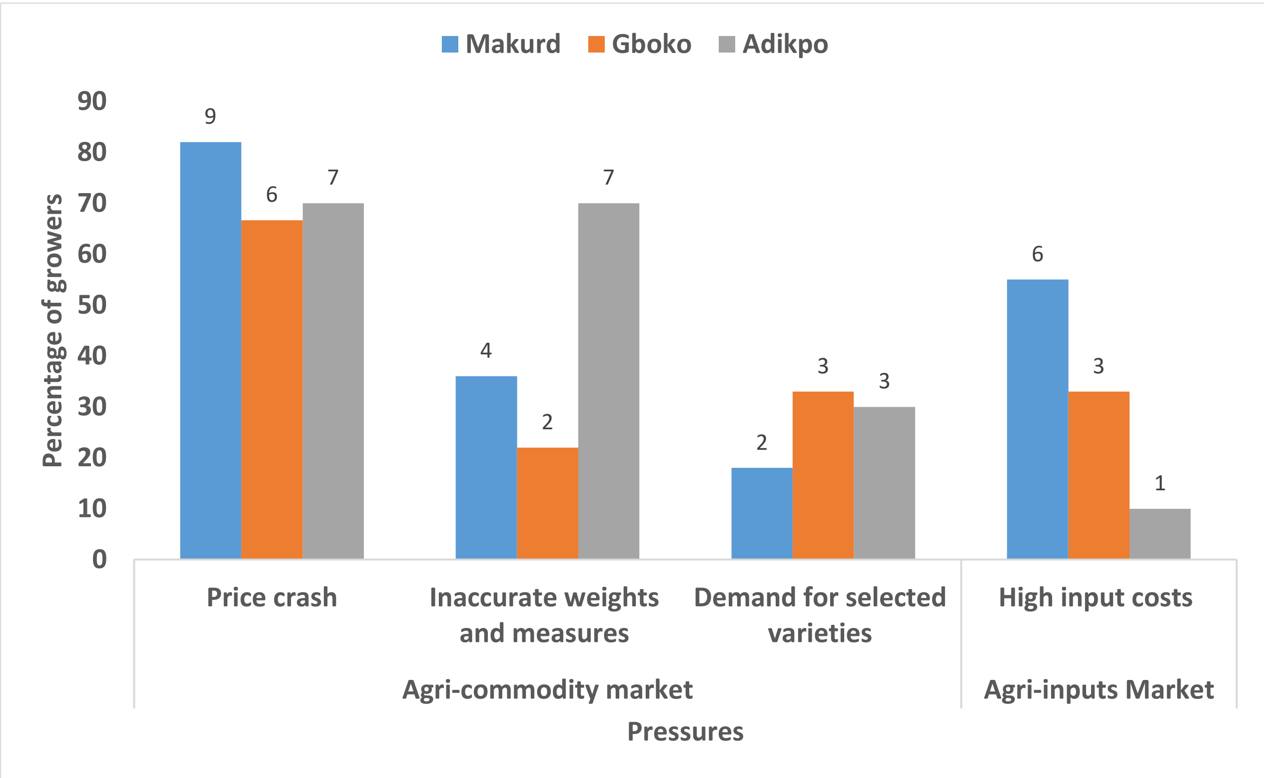


Figure 5.9. Percentage of growers who identified different types of pressures in the three study sites

Table 5.13. Types of market-related pressures by sociodemographic characteristics of growers

Factors	Gender		Age			Education level				Income class			Farm size			Years engaged as rice grower			Labour access		
	M (n-28)	F (n=2)	20-39 n=4)	40-49 (n=15)	50-89 (n=11)	None (n=4)	Prim. (n=10)	Sec. (n-7)	High (n=9)	Low (n=21)	Mid. (n=7)	High (n=2)	Small (n=18)	Med (n=7)	Large (n=5)	1-10 (n=11)	11-20 (n=11)	>21 (n=8)	Family (n=17)	Hired (n=4)	Hired/ Family (n=9)
Price crash	21(75)	1(50)	3(75)	12(80)	7(64)	2(50)	8(80)	6(86)	6(67)	16(76)	5(71)	1(50)	12(67)	6(86)	4(80)	8(73)	8(73)	6(75)	13(76)	3(75)	7(78)
Inaccurate weights and measures	14(50)	-	2(50)	8(53)	4(36)	-	6(60)	5(71)	3(33)	11(52)	2(29)	1(50)	9(50)	4(57)	1(20)	7(64)	4(36)	3(38)	9(53)	1(25)	4(44)
Demand for selected varieties	8(29)	-	1(25)	5(33)	2(18)	2(50)	2(20)	1(14)	3(33)	4(19)	4(57)	-	5(28)	2(29)	1(20)	3(27)	2(18)	3(38)	5(29)	1(25)	2(22)
High input costs	8(29)	2(100)	2(50)	6(40)	2(18)	2(50)	3(30)	3(43)	2(22)	7(33)	3(43)	-	7(39)	2(29)	1(20)	6(55)	2(18)	3(38)	7(41)	1(25)	3(33)

Cells show (n) number of growers and, in brackets, within group percentage.

Across the study sites, rice growers identified price crashes as one of the most important pressures to which they are exposed in the agricultural market (see Figure 5.9). Other pressures equally identified, and which growers experienced in many ways are: inaccurate weights and measures; demand for selected varieties; and the high cost of inputs. Table 5.13 reveals that older growers, and those with high level of education, large landholdings, and have access to hired or a mix of hired and family labour seems to be less exposed to market pressures than growers without these characteristics. The expressions of growers' different experiences with price crashes and other agricultural market pressures are presented in Table 5.14.

Table 5.14. Highlights of evidence of growers' exposure to market pressures across study sites

Pressures	Growers' experiences	Reference
Price crashes	….so, on market days, if a lot of us [growers] take unmilled rice to the market there would be plenty, in fact a surplus of unmilled rice on the market. Therefore, buyers and intermediaries will have a day of feasting as they manipulate growers and buy at give-away prices…	[Grower 22]
	… Buyers, through their agents [middlemen], do not give us good prices, but that is their nature. This is very much when they are desperate and need more cash…	[Grower 2]
Inaccurate weights and measures	…over the years, there has not been a uniform sales measurement across all agri-markets in the state. I have noticed all the times of selling my unmilled rice that the sizes of the sacks are very dissimilar. This gives intermediaries an opportunity to manipulate growers. It is expected that the ideal size for selling unmilled rice is in 28 inch sacks, however, buyers will bring over-sized sacks, 30 inches and above, due to lack of enforcement by leaders who benefit from it…	[Grower 22]
Demand for selected varieties	…when I take my rice to sell on the market buyers do have preferences, and therefore they pay higher prices for varieties such as FARO 52 (OC). However, we do not cultivate it here in Adikpo because we cultivate rice twice a year during the dry and the wet season and FARO 52 (OC) tends to take too long to mature…	[Grower 26]
High input costs	… the high cost of fertiliser sometimes makes it very difficult to get on time. Then, if you do not apply it on time when the rice plants need it most, then you do not get much yield…	[Grower 19]

For social demographic characteristics of growers, refer to appendix 5.1

Price crashes, or a sudden drop or fall in the price of unmilled rice, is the first, and perhaps the most important, market pressure that growers across the sites overwhelmingly identified as being exposed to in recent years (Figure 5. 9 above). According to the growers (see Table 5.14), most often a crash in the market price means the price goes far below the expectations which would allow them to break even, or to make a profit. One grower stated, "….*my biggest worry is usually high supply in the market, especially during harvesting time. This is the cause of price crashes…"* [Grower 7]. This indicates that price crashes are not associated with improvements in rice production per se, but rather in the interplay between demand and supply (e.g., peak and off-peak season supply). As can be seen during the off-peak harvesting season, for example, the prices gradually appreciate over the months until they peak at the time of the planting season, a period when unmilled rice becomes scarce and market supply is almost nil.

Meanwhile, in Gboko and Adikpo, in addition to seasonal over-supply of rice during the harvest season, the lack of buyers, price fixing, and increased activities of intermediaries were mentioned as major reasons for frequent price crashes across the markets (Table 5.14).

Figure 5.10. (A) Rice sold using accurate weights and measures (kgs/tons), and (B) Rice sold using inaccurate weights and measures (sacks of different sizes)

Aside from price crashes, growers cited inaccurate weights and measures as another pressure to which they are constantly exposed in the market (see Table 5.14). This is a situation whereby within a market rice growers encounter different weights and measures for a given price. Instead of buyers using uniform weights and measures, unapproved weights and measures aimed at cheating, such as the use of sacks of different sizes, are commonplace (see Figure 5.10). The intermediaries who act as agents for the buyers facilitate this practice. Growers who do not have a sales contract or agreement, and therefore must sell their rice in the periodic market, are the most exposed to this challenge. They are often left short-changed as they are offered so little for so much of their rice (see Table 5.14).

Furthermore, growers highlighted demand for selected varieties, also called preference, as yet another pressure with which they are faced. According to growers (Table 5.14), long grain rice varieties, such as FARO 52, are preferred in the rice markets, therefore they record high demand and higher prices. However, most of these varieties (e.g., FARO 52) require more water and take longer to produce than others, this leaves growers with difficult decisions to make. That is, they must choose between farming a high demand variety which is likely to experience water stress, and one in less demand (e.g., FARO 44) which may be more resistant to water stresses and other pressures.

The final pressure identified by growers in relation to their exposure to the market was the high cost of farm inputs (e.g., mineral fertilisers and agrochemicals). Across the study sites, growers reported that rises in the cost of inputs have led to a new challenge, i.e., the faking of inputs by input dealers to make more money, which has become commonplace (see Table 5.14). This situation has resulted in an increase in the number of cases of input failure and was widely reported by rice growers across the study sites. This challenge of substandard inputs has added to the growing list of uncertainties for growers, such that now they are uncertain not only about CCV and market prices, but also about the quality of inputs available.

5.7 Sensitivity to agricultural market pressures

Figure 5.11 presents the results which concern the sensitivity of rice growers to combined climate change and agricultural market pressures across the three study sites. The discussion that follows is centred around factors to do with market systems, i.e., the ways by which growers sell harvested rice, and seasonality of production which effects market supply size and selling location. It is these factors which make rice growers more (or less) prone to harm from agricultural market-related pressures. Moreover, factors of sensitivity to market-related pressures by sociodemographic characteristics of growers are presented in Table 5.15.

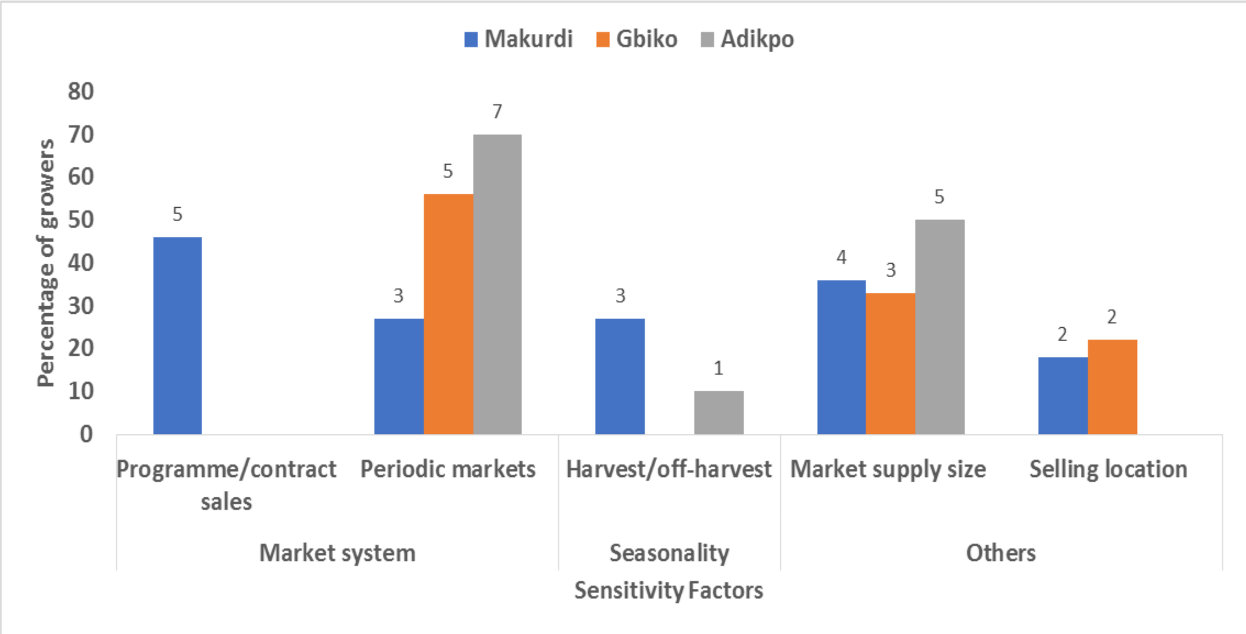


Figure 5.11. Percentage of growers who mentioned different factors related to their sensitivity to various pressures in the three study sites

These results (Table 5.15 below) reveal that growers with small farms and low income appear to be more sensitive to market pressures than growers with more income and large farms. While the longer growers have been engaged in rice production, the less sensitive they are to market pressures.

Thus, rice growers reported that rice harvested from farms (e.g., unmilled rice) is sold either through the traditional periodic market system, or via network/programme markets where a contract is usually made. Each of these markets explain why certain growers are more or less sensitive to different market pressures (see Figure 5.11). According to the growers, the common challenge of the periodic market is the uncertainty about buyers and the prices they will offer. In other words, there is no guarantee that growers will find buyers willing to pay good prices and which will allow them to break even. This is what one of the growers said:

…in the periodic market, the middlemen constantly change quantity [size of sacks] to maximize profit. While the company or direct market [contract sales] have standard prices and quantity per kg of rice sold, selling my rice directly to these companies and market networks [contract] gives me more money than selling in an open market… [Grower 2]

Table 5.15. Factors of sensitivity to market-related pressures by sociodemographic characteristics of growers

Factors	Gender		Age			Education level				Income class			Farm size			Years engaged as grower		
	M (n-28)	F (n=2)	20-39 n=4)	40-49 (n=15)	50-89 (n=11)	None (n=4)	Prim. (n=10)	Sec. (n-7)	High (n=9)	Low (n=21)	Mid. (n=7)	High (n=2)	Small (n=18)	Med (n=7)	Large (n=5)	1-10 (n=11)	11-20 (n=11)	>21 (n=8)
Programme/ contract sales	5(18)	-	-	2(13)	3(27)	-	1(10)	1(14)	3(33)	1(5)	3(10)	1(50)	1(6)	2(29)	2(40)	1(9)	2(18)	2(25)
Periodic markets	14(50)	1(50)	2(50)	8(53)	5(45)	2(50)	6(60)	5(71)	2(22)	12(57)	3(10)	-	11(61)	4(57)	-	7(64)	5(45)	3(38)
Harvest/ off-harvest	4(14)	-	1(25)	2(13)	1(9)	-	-	3(43)	1(11)	2(10)	1(3)	1(50)	2(11)	1(14)	1(20)	3(27)	1(9)	-
Market supply	12(43)	-	2(50)	8(53)	2(18)	1(25)	4(40)	4(57)	3(33)	6(29)	5(17)	1(50)	7(39)	2(29)	3(60)	7(64)	5(45)	-
Selling location	13(46)	2(100)	1(25)	8(53)	6(55)	3(75)	3(30)	4(57)	5(56)	8(38)	6(86)	1(50)	8(44)	4(57)	3(60)	6(55)	7(64)	2(25)

Cells show (n) number of growers and, in brackets, within group percentage.

In contrast to periodic markets, network/programme markets often buy back produce and therefore provide a credible market outlet with stable prices and accurate weights and measures of quantity, thereby guaranteeing returns on investment. Despite their benefits, network/programme markets have yet to be localised or known in and around Makurdi, the Benue State capital (see Figure 5.11). As a result, growers participating in network/programme sales of unmilled rice are generally less sensitive when exposed to seasonal price crashes and the lack of unified standard weights and measures, both exacerbated by third party activities (Branda).

Apart from the market system, seasonality plays a key role in the sensitivity of growers; prices of unmilled rice on the market often reflect strong seasonality. This is a trend in which prices are very low during the peak harvesting season, when unmilled rice is in abundance, and therefore it is over-supplied in the markets in most instances

Furthermore, the location of periodic markets where growers take unmilled rice to sell is also a factor in growers' sensitivity to market pressures, e.g., price crashes. In most selling locations, the interplay between supply and demand creates a price difference, locations with less supply and a high number of buyers experience higher prices per unit of unmilled rice sold. According to one grower:

…Selling locations [e.g., periodic markets] with good road networks, such as Adikpo, Ihugh, Ugbema, and Gboko, usually attract more buyers because of the ease of transporting unmilled rice, while those around Makurdi, such as Aondona and Anwegh, do have fewer buyers because of poor accessibility… [Grower 1]

Therefore, small landholders selling in locations with less unmilled supply and high patronage of buyers often realise high prices per unit of unmilled rice, hence they are less sensitive to agricultural market pressure, including seasonal prices crashes, than are those selling in other locations. High patronage increases demand, which in its turn stabilises prices even when the supply is high.

Moreover, when more buyers are present to buy unmilled rice, other pressures faced by growers, such as buyers using unapproved weights and measures and demand for certain varieties, (e.g., FARO 52, 44) are reduced. Moreover, the intermediaries (Branda) and speculators, whose activities often contribute to these pressures, find it difficult to operate in such market environments. Ultimately, this make growers who sell in locations with more buyers less sensitive to market pressures, such as price crashes and the use of inaccurate weights and measures.

In addition, growers identified supply size (i.e., the volume or quantity of unmilled rice supplied to market) as important in determining how buyers relate to them, which is relevant to understanding their sensitivity to market pressures. In the study sites, medium and large landholders supplying large volumes of unmilled rice to market have a high bargaining power to negotiate better prices than do the small landholders supplying small quantities, as one of the medium/large landholders said: *"…due to… I usually sell to processing companies… the size of my produce gives me bargaining power…"* [Grower 7]. This is a direct result of the large amount of produce they have to sell. Buyers offer higher prices and use correct weights and measures when buying in large quantities from a single source. The reason for this is that unmilled rice supplied by a single source provides a uniform grain quality, which is more desirable to processors and consumers than when the produce is supplied by different sources. This makes medium and large landholders less sensitive to most of the agricultural market pressures.

5.8 Adaptation to unmilled rice market pressures

This section presents the tactical and anticipatory adaptation practices employed by growers in the short- and long-term in response to agricultural market dynamics (see Table 5.16 below) while adaptation practices by sociodemographic characteristics of growers are presented in Table 5.17.

Table 5.16. Percentage of growers who adopted different adaptation practices in the three study sites

Type of adaptation	Challenging situation	Example of adaptation	Makurdi (N=11)	Gboko (n=9)	Adikpo (n=10)
Strategic anticipatory	Price crash	Enter into a programme/network to sign an agreement to sell rice	4 (36.4%)		
		Plant market preferred variety	5 (45.5%)	3 (33.3%)	3 (30%)
		Time the sale	3 (27.3%)	5 (55.6%)	1 (10%)
Strategic reactive		Mill and sell		3 (33.3%)	4 (40%)
		Sell during scarcity	3 (27.3%)	4 (44.4%)	2 (20%)
Tactical anticipatory		Get price information	2 (18.2%)		1 (10%)
Tactical reactive		Sell in small amounts	1 (9.1%)		3 (30%)
		Sell in bulk	3 (27.3%)	1 (11.1%)	3 (30%)
		Change selling location	1 (9.1%)	1 (11.1%)	
Strategic anticipatory	Inaccurate weights and measures	Enter into a programme/network to sign an agreement to sell rice	4 (36.4%)		
Tactical reactive		Change selling locations	2 (18.2%)	1 (11.1%)	
		Switch to periodic market	3 (27.3%)		
Strategic reactive		Mill and sell	2 (18.2%)	3 (33.3%)	4 (40%)
Strategic anticipatory	Demand for selected variety	Plant market preferred variety	5 (45.5%)	3 (33.3%)	3 (30%)
Strategic reactive		Store and sell during scarcity	3 (27.3%)	4 (44.4%)	2 (20%)
Tactical reactive		Switch to periodic market	3 (27.3%)		
		Change selling locations	2 (18.2%)		
Tactical reactive	High cost of inputs	Cooperative loan	1 (9.1%)	1 (11.1%)	3 (30%)
		Government loans	2 (18.2%)		
		Borrow from family members	2 (18.2%)	1 (11.1%)	
Strategic anticipatory		Enter rice trading agreements	4 (36.4%)		

N denotes the total number of growers and, in brackets, within group percentage.

Table 5.17. Adaptation practices by sociodemographic characteristics of growers

Type of adaptation	Adaptation	Gender		Age			Education level				Income class			Farm size			Years engaged as rice grower		
		M (n-28)	*F (n=2)*	*20-39 (n=4)*	*40-49 (n=15)*	*50-89 (n=11)*	*None (n=4)*	*Prim (n=10)*	*Sec. (n-7)*	*High (n=9)*	*Low (n=21)*	*Mid (n=7)*	*High (n=2)*	*Small (n=18)*	*Med. (7)*	*Large (n=5)*	*1-10 (n=11)*	*11-20 (n=11)*	*>21 (n=8)*
Strategic anticipatory	Enter into a programme/network to sign an agreement to sell rice	4(14)	-	1(25)	2(13)	1(9)	-	--	2(29)	2(22)	1(5)	2(29)	1(50)	-	2(29)	2(40)	2(18)	2(18)	-
	Plant market preferred variety	10(36)	1(50)	1(25)	4(27)	6(55)	3(75)	1(10)	1(14)	4(44)	6 (29)	4(57)	1(50)	6(33)	2(29)	3(60)	6(55)	4(36)	1(13)
	Time the sale	9(32)	-	2(50)	4(27)	3(27)	2(50)	2(20)	2(29)	3(33)	5(24)	3(43)	1(50)	3(17)	4(57)	2(40)	5(45)	4(36)	-
Strategic reactive	Mill and sell	8(29)	1(50)	-	5(33)	4(36)	1(25)	5(50)	2(29)	1(11)	8(38)	1(14)	-	7(39)	2(29)	-	4(36)	3(27)	2(25)
	Sell during scarcity	10(36)	-	1(25)	5(33)	4(36)	2(50)	2(20)	2(29)	4(44)	6(29)	3(43)	1(50)	4(22)	3(43)	3(60)	6(55)	4(36)	-
Tactical anticipatory	Get price information	7(25)	-	1(25)	5(33)	1(9)	-	2(20)	2(29)	3(33)	3(14)	3(43)	1(50)	1(6)	4(57)	2(40)	5(45)	2(18)	-
Tactical reactive	Sell in small amounts	4(14)	-	1(25)	1(7)	2(18)	-	1(10)	2(29)	1(11)	2(10)	2(29)		2(11)	2(29)	-	1(9)	3(27)	1(13)
	Sell in bulk	8(29)	-	2(50)	2(13)	3(27)	1(25)	1(10)	1(14)	4(44)	1(5)	5(71)	1(50)	1(6)	3(43)	3(60)	4(36)	3(27)	-
	Change selling location	4(14)	-	-	1(7)	3(27)	1(25)	1(10)		2(22)	1(5)	2(29)	1(50)	1(6)	1(14)	2(40)	1(9)	2(18)	1(13)
Tact. reactive	Switch to periodic market	3(11)	1(50)	1(25)	2(13)	-	1(25)	-	2(29)	1(11)	2(10)	2(29)	1(50)	1(6)	2(29)	1(20)	3(27)	-	-
	Cooperative loan	4(14)	-	1(25)		3(27)	1(25)	3(30)	1(14)	-	3(14)	1(14)	-	3(17)	-	1(20)	2(18)	1(9)	1(13)
	Government loans	2(7)	-	1(25)	-	1(9)	-	-	-	2(22)	-	1(14)	1(50)	-	-	2(40)	1(9)	-	1(13)
	Borrow from family members	3(11)	-	-	2(13)	1(9)	1(25)	-	1(14)	1(11)	1(5)	2(29)	-	1(6)	1(14)	1(20)	2(18)	1(9)	-

Cells show (n) number of growers and, in brackets, within group percentage

One of the first set of adaptive practices reported by some medium and large-scale growers in Makurdi involved entering into a market programme, or network, with a sales contract or a buyback agreement, to facilitate easy access to good buyers and improved prices. This also allows growers to switch from programme or network markets to a periodic market at any time any of these arrangements become unprofitable (Table 5.16 above). In addition, the adaptive practices are examined following the sociodemographic characteristics of growers such as gender, age, educational level, income class, farm size and years engaged as growers (Table 5.17). Thus, with respect to sociodemographic characteristics, age of growers and the number of years engaged as rice growers appeared to be important factors for adaptation to market pressures (Table 5.17). This implies that older growers are likely to adapt more effectively to market pressures than younger growers. Moreover, the results show that growers who have been involved in the production and marketing of rice produce for a longer period are more like to adapt to market pressure than those involved for a shorter period. Due to the many years of engagement in rice market, this class of growers seems to have acquired the necessary marketing/trading skills that enable them to manage unexpected market pressures that confront them. Growers' expressions of adaptive practices are presented in Table 5.18 below.

Table 5.18. Highlights of rice trading techniques employed by growers

Adaptive practice	Growers' experiences	Reference
Entering into a programme or network to help with selling	…it is not all the time that I sell to programme buyers. During the off-harvesting season when the unmilled rice is fully dried and the moisture content is almost zero, selling to programme buyers in kgs/tons gives us less gain because metric measurement scales weigh a huge quantity of unmilled rice at a smaller amount… So, I prefer selling on the periodic markets where the measurement is not in kgs/tons. Second, when issues of variety preference arise at the point of selling…	[Grower 1]
Switching from programme or network markets to a periodic market	…when the variety I have is less preferred by a programme buyer and as a result I'm offered a low price regardless of the prevailing high price on the periodic market, or vice versa. At such time, selling, either on the periodic market or through the market programme, becomes a better option for me to reduce income losses resulting from variety preferences…	[Grower 1]

For social demographic characteristics of growers, refer to appendix 5.1

Growers in Makurdi considered market programmes or networks with a sales contract or buyback agreement to have great potential to help them respond effectively to all market pressures (Table 5.18). This is because market networks and/or buyback programmes ensure that growers sell at a profit by setting up committees who monitor compliance with approved weights and measures, and who adjust prices whenever they increase in order to deflect the changes which could result in growers being short-changed. Although belonging to a rice trading network or programme can be beneficial, there can be seasons when selling unmilled rice via such market arrangements exposes growers to lower prices (Table 5.18). At such times, growers in these market networks usually employ another strategy, i.e., to switch from programme or network markets to periodic markets.

Switching from a programme market to a periodic market, and vice versa, is often employed by medium or larger-scale growers in Makurdi during two periods. Firstly, during periods of high market supply (e.g., harvesting seasons), and secondly, during the off-harvesting season (see Table 5.18). During any of these periods, a per unit quantity or volume of unmilled rice sold is perceived to be underpriced, either as a result of supply overwhelming demand, or due to weight losses as a result of long periods of storage. While market switching has the potential to reduce the effect of agricultural market pressures (e.g., seasonal price crashes, inaccurate weights and measures, and preferences for one variety) on growers' incomes, in most cases it can also be a source of exposure to the same pressures it seeks to reduce. For example, if growers switch en masse from programme sales to a periodic market, even in the off-harvesting season (i.e., during low supply), this will result in high supply and may cause prices to crash. Therefore, growers must remain flexible at all times, not only to be able to easily switch markets when it becomes unprofitable, but also to employ other best selling practices to cope with pressures.

5.8.1 Best rice selling practices

Some of the best selling practices growers have commonly employed to respond to market pressures are: milling harvested rice themselves before selling; waiting for an appropriate time to sell; withholding supply by subjecting rice to storage until prices appreciate on the market; selling in bulk or in small amounts; changing the selling location; accessing price information; planting the market preferred variety.

The practice whereby small landholders mill their own harvested rice before selling is an emerging one. According to growers, selling milled rice during the months of November and December is more profitable because the period corresponds with the Christmas season and at times with the moveable festival of Salah celebrations, the demand for rice is high due to its use as a festive food in the majority households in the study sites. As milling adds value, it increases the price and, subsequently, income. This in turn abates the impact of poor prices and other market pressures, especially on small landholders. In the words of one small landholder: *"… usually, I mill my rice and sell to retailers to get additional profit…"* [Grower 27]. Among the sites, the practice of 'mill and sell' is well accepted by all growers in Adikpo where no farming programme exists and unmilled rice is supplied all year round due to multiple cropping times. In Makurdi, however, where farming programmes with contract sales and buyback arrangements exist, the practice is less popular and only a handful of small landholders are involved.

On the other hand, seasonal price movements of unmilled rice is the major reason that most growers wait for an appropriate time to sell in order to make profit. They often do so by withholding supply, a practice where harvested rice is subjected to storage until such a time as prices improve on the periodic markets, it is then taken to the market for sale. Seasonal price movement is a situation wherein prices are typically lowest immediately after the harvesting season, and then they increase throughout the off-harvesting season to fall again in the next. In the area of the study sites, price movement occurs for the dominant rain-fed rice cropping system from November to December, the peak of the harvesting season. During this period, prices are very low and market supply is usually high because most growers, especially the small landholders with no diversified sources of income, sell their rice to offset farm loans and meet pressing family needs, such as children school fees. However, prices progressively rise in the off-harvest season and become very high just before the start of the next planting season. A number of growers attested to this:

> …there are certain seasons when the prices are higher. For example, from March to June prices usually go up. Selling now gives me more profit… [Famer 7, Makurdi]. … I normally reserve [store] part of my harvest, which I then sell especially during the planting period when market prices are at their peak … [Grower 12].

The practices of timing entry to the market by withholding unmilled rice in storage helps growers adapt to agricultural market pressures in two ways: firstly, by curbing the excess supply which contributes to price slumps in major markets; and secondly, by creating flexibility in supply. Clearly, growers supply the market when there is most demand, and especially during off-harvesting seasons.

Furthermore, growers who could not time market entry or withhold their produce for a more favourable price, reported adopting either of the two opposing practices, i.e., to sell in bulk or in small amounts. Selling in bulk is a situation where all the unmilled rice harvested in a season is sold at once, mostly to a single buyer, while the latter means the unmilled harvest is sold piecemeal, often to different buyers. Most likely to adapt these practices are the small landholders who lack access to storage facilities and who do not want to mill their own unmilled rice before it goes to market. Each practice is important in its own right. For example, generally, unmilled rice buyers prefer large quantities, thus selling in bulk gives small landholders some level of bargaining power to negotiate for better prices, a power they often lack because of their limited size and the subsequent, relatively small quantity of rice they have to sell. One grower commented*: "…selling in bulk to processing companies….this gives me bargaining power due to the size of my produce, so I don't face the problem of a lack of buyers…"* [Grower 7]. Therefore, selling in bulk, even during the peak supply season when there is an excess of unmilled rice on the market, helps growers negotiate better prices. On the other hand, staggering unmilled rice sales in small amounts helps growers sell at different prices over time, thus they avoid a situation where all their produce is sold in the peak supply seasons when prices are at their lowest. In the study sites, the practice of selling in bulk was found to be common among the medium and larger landholders in Makurdi, while that of selling in small amounts was common among small landholders in Gboko and Adikpo.

Another common adaptive practice highlighted by growers is changing selling locations to alternative ones offering higher prices. In Makurdi, where low prices are commonplace in those markets which are poorly accessible, such as Aondona and Anwegh, small landholders who seek appreciable prices usually explore alternative selling locations which have a history of gaining higher prices, such as Adikpo, Ugbema, and Ihugh. The selling locations offering better prices are characterised by high demand, created by high patronage of buyers and limited supply, which in some seasons is less than the supply in interior markets (i.e. markets situated in villages distanced from urban centres). According to one grower:

> ...choice of selling point is also helpful. In a periodic market system, there are markets where the prices are better. In such markets buyers come from the Eastern and South-western parts of Nigeria. So, there are instances where we take our unmilled rice to sell there, and sometimes they come here and sell their unmilled rice… [Grower 1]

Therefore, during off-harvest seasons, when supply is relatively stable, small landholders in selling locations with poor accessibility and high supply move their unmilled rice to selling locations which offer higher prices. In this way, growers can reduce the impact of poor prices and variety preferences.

Also identified by growers was the practice of planting a market preferred rice variety. One grower claimed:

> ...because buyers preferred varieties that have long grains and the whiteness comes out very well after processing. Therefore, I farm a variety called OC (FARO 52). This helps me to

reduce the challenge of poor prices which have been perpetuated by intermediaries… [Grower 15].

Planting of a variety preferred by buyers is a strategic practice adopted at the time of planning to grow rice. The practice helps growers respond to price crashes which are a result of demand for selected rice varieties, such 52 (OC) and 44 (sipi) which have a distinctive grain quality (i.e., long and slender), and also their good cooking quality means these varieties are highly preferred by consumers. As these varieties enjoy better prices from consumers, millers pay more for them. However, there is often a trade-off between market preferred varieties and pressure resistant or tolerant varieties, depending on the rice fields. For example, FARO 44 is preferred in the market, but planting this variety in heavily flooded or water-logged rice fields may result in significant losses as it is less tolerant to floodwater than other varieties.

The receipt of market price information is the penultimate adaptive practice reported to be employed by growers. Price information is essential for making key decisions regarding when, where, and how to sell unmilled rice at a profitable price. The Nigeria Agricultural Market Information Service (NAMIS) office in Makurdi is expected to provide information on the market prices for rice to growers, however, this service is not regularly provided. In fact, most growers outside of the Makurdi area are not aware of the existence of such information, let alone able to make use of it. Therefore, they often rely on fellow growers and middlemen to obtain price information; however, in most cases the information conflicts and is too unreliable for appropriate decisions to be made on whether to sell, when, and where. The use of mobile phones is especially helpful, one grower said: "…*I use my mobile phone to call brander [agents or middlemen) to get price information before I decide to sell my unmilled rice..."* [Grower 7].

The last practice adopted by growers in response to rising costs of inputs, such as mineral fertilisers, and agro-chemical herbicides and pesticides, is to take out a loan from a local co-operative or from the government, or to borrow from a family member. However, not all growers had access to all types of loans as access was dependent on the grower's characteristics (e.g., small or large landholder) and their location. For example, access to government loans were only cited by medium and large landholders in Makurdi, while small landholders were completely unaware of the existence of government loans. The same was the case with growers from Gboko and Adikpo. In Adikpo, with a predominance of small landholders, loans from local co-operatives, such as Bam and Adashi (local translation), was very common. The reason being that the village of Adikpo has no bank and only a few government establishments, this absence of facilities provides incentive for these local co-operatives. One of the small landholders noted: *"…the only way I can get money to buy fertiliser is from our weekly contribution (Adashi)… as for the government, I have never got anything from them…"* [Grower 25]. Lastly, borrowing from a family member was the least adopted, however, in Makurdi and Gboko sites where small landholders did not embrace traditional co-operatives like Bam and Adashi, a few small landholders often source input money from family members.

In summary, Table 5.17 shows no clear pattern of adaption to market pressures in relation to growers' level of education, income classes, and farm size except in regard to age and the years growers have been engaged in rice production as highlighted above. Thus, indicating vulnerability and adoption of adaptive practices cuts across growers' social distinctions such as level of education, income classes, and farm sizes.

5.9 Validation of results

To build confidence in this study, two separate participatory workshop meetings were held with different sets of rice growers in two of the three study locations, namely Makurdi and Adikpo. The aim was to validate the results on the vulnerability of rice growers to the multiple, combined pressures presented in this chapter.

Table 5.19. Weak spots and possible action identified by growers at two study sites

Site	Weak spots	Main reasons	Other reasons
Makurdi	Rice trading	-Poor market prices	-Lack of access to loans
			-Substandard inputs
			-High cost of labour
	Production	-Lack of inputs	-Flooding
	Production	-Lack of mechanisation	-Weather changes
			-Seeds
	Rice trading	-Price crashes	-Limited market access
	Production	-Poor quality of seeds	-Weed infestation
			-Flooding
	Production	-We have no control over weather	- We lack price control
			-Substandard inputs
			-Limited access to land
	Storage	-Counterfeit seed and treatment	-Inadequate and poor storage facilities
Adikpo	Production	-Weather (rainfall fluctuation)	-Lack of modern processing capacity
			-Lack of price information
	Production	-Difficulty accessing land	-Poor storage and processing facilities
	Production	-Weather (floods and rainwater shortages)	-Lack of good seeds
			-Inaccurate weights and measures
	Production	-Lack of inputs	-Poor road infrastructure
	Production	-Water shortages	-Price crashes
	Rice trading	-Price crashes	-Limited access to inputs
	Production	-Changing weather	-Water challenges

Comparing these results (see Table 5.19) with those on vulnerability of rice growing to multiple, combined pressures already presented above (see section 5.2 and 6), it is found that each method, i.e., semi-structured interviews and participatory workshop meetings, provided almost the same results in most locations. Only in a few instances did the results overlap or diverge from each other. Firstly, in both Makurdi and Adikpo, growers perceived rice production and trading as the weakest spot of the rice value chains (RVC), which justifies the need for this study to assess vulnerability, not only of rice farming, but also of rice trading.

In terms of exposure and sensitivity to pressures, changing climate and weather, such as flooding and rainwater shortages, and other pressures, such as limited access to inputs, lack of mechanisation, poor seed quality, and difficulty of access to land, were identified by growers in the workshops in Makurdi and Adikpo as the reasons why rice production was considered weak in the area (see Table 5.19 above). On the other hand, growers in both these sites highlighted price crashes as the major reason for the weak trade in rice (see Table 5.19). Most of the challenges cited in the workshops correspond with those to which the growers at the study sites are exposed, and to which they are subsequently sensitive. This also justifies the focus on a variety of pressures.

However, there were some overlaps and divergences of results in some locations. For example, during the workshops, growers in Makurdi identified counterfeit seeds as an issue, while those in Adikpo, claimed difficult access to land as a new pressure in relation to exposure and sensitivity to rice growing (Table 5.19). Meanwhile, the results about growers' vulnerability showed weed infestations on their rice farms to be a key pressure identified by growers in Makurdi, Gboko and Adikpo, but this was rarely mentioned in the participatory workshops in Makurdi and Adikpo.

Perhaps the most significance divergence of results is witnessed in growers' perceptions of the rice market. During the workshops in both Makurdi and Adikpo, frequent price crashes were highlighted as the major challenge confronting rice trading. Meanwhile, the results from the growers about their vulnerability highlighted others factors, such as demand for selected rice varieties, the use of inaccurate weights and measures by intermediaries other than those approved by the government, the high cost of inputs, and price crashes, were all mentioned as the pressures to which rice production is exposed in the area.

In summary, both sets of results on vulnerability of rice growing to multiple pressures using two different methods (VSD-interviews and participatory workshops) show agreement on most of the factors highlighted by growers. This indicates that the findings of this study are somewhat solid. The differences in growers' perceptions highlighted in both sets of results revealed distinctive experiences of growers in relation to their vulnerability across the study sites.

5.10 Discussion

This study has analysed rice growers' vulnerability to CCV and agricultural market dynamics at three sites in Benue State, Nigeria. In this section, key weaknesses and strengths of the current adaption practices employed by rice growers across the three study sites are highlighted, and possible entry points for initiation of vulnerability reduction or resilience building interventions are discussed. These comprise: (i) information to facilitate the adoption of promising adaptive practices; (ii) encouragement of anticipatory and long-term adaptation responses; (iii) more planned adaptive responses; (iv) collective adaptive responses and coordination; (v) assessment of trade-offs and the costs of adaptation; and (vi) addressing uncertainties.

5.10.1 *Information*

Existing vulnerability theories have stressed that successful adaptation increases with the dissemination and diffusion of information, including weather and price information (Amelia, et al., 2014; Seck, et al., 2010; Totin, et al., 2012). The adoption of many promising adaptive practices are grounded in knowledge, both in the short- and the long-term. Such knowledge is acquired through effective learning, both from successes and failures, from which growers benefit by comparing different information and by discussing new ideas with other growers from different social groups and in different locations (Darnhofer, et al., 2009; Darnhofer, 2014; Vermeulen et al., 2012).

However, in the study sites, while adaptive practices, such as accessing weather communication, claiming crop insurance, entering a farming programme or sales contract, changing market point or selling location, and accessing knowledge through experts from organisations, are all promising, these practices were localised among medium and large landholders in Makurdi. Consequently, most small landholders in Makurdi were generally unaware of the existence of these practices, let alone having used any of them at any time. This suggests that access to short or long-term information that could facilitate the adoption of such practices was unevenly spread across the different sites, particularly between Makurdi and the others, Gboko and Adikpo, and among types of growers (e.g., small and medium or large landholders).

Given the promise held by some of the adaptation practices highlighted for the reduction of the vulnerability of the rice growers, it is imperative that these practices spread beyond their current effective areas. Thus, peer learning (i.e., grower-to-grower) is suggested as one important tool for the conveyance of information required to facilitate the uptake of adaptive practices more easily and widely to different parts of the state in order to build growers response capacity to pressures (Zossou, et al, 2009, Demont et al., 2012; Totin et al., 2012).

In a similar case in Benin for example, Zossou et al. (2009) showed that grower-to-grower diffusion of improved rice parboiling practices among local women processors by using different information dissemination sources (e.g., video), were more effective than the conventional community training workshops. This underscores the importance of peer learning in improving growers' practices and attitudes to the dissemination of new agricultural technology. Apart from this, other studies have highlighted the role played by social institutions and networks (families, cooperatives, and unions) in the dissemination of information about adaptive farming practices (Chhetri, et al., 2012; Darnhofer, et al., 2016; Feola, et al., 2015).

However, it is important to acknowledge that, while information is important for making adaptive decisions (on- and off-farm), information alone is usually not sufficient for growers to adopt different adaptive practices. Other factors, such human and capital resources, infrastructures and capacities (e.g., machinery, technical and operational skills, are needed to enable growers to adopt adaptive practices and technologies (Feola, et al., 2015). At the same time, growers need to ensure that adaptive practices are planned and implemented in a timely manner to avoid maladaptation (Jain, et al., (2015). A situation in which a well-intended practice, such as building flood control channels, may moderate the impact of flooding in seasons with high rainfall must also be recognised as a means to moderate the impact of rainwater shortages, whereby in seasons with low rainfall the same channels become a source of water.

5.10.2 Anticipatory and long-term adaptation practices

Adaptation responses employed in anticipation of pressures, and on a long-term basis, often yield better results (Gitz & Meybeck, 2012; Smit & Pilifosova, 2001; Tendall et al., 2015). Anticipatory adaptive practices are typically employed well in advance of the occurrence of long-term pressures, thereby providing more 'room for manoeuvre' (Darnhofer, et al., 2008, p. 343). In addition, anticipatory and long-term adaptive actions are flexible, and therefore easier to implement, and when structural adaptive interventions are not required they tend to be less costly than reactive practices (Belliveau, Smit, & Bradshaw, 2006).

This study found that although a number of anticipatory adaptation practices (e.g., planting stress resistant varieties, practicing double or triple cropping, and planting early) existed in the study sites, the tendency to adopt reactive and short-term adaption practices (e.g., controlling flood water instead of avoiding flood prone rice fields) was strong. This unwillingness to invest in long-term preventive measures is not uncommon to rice growers in the region. Elsewhere, in California, Nicholas and Durham (2012) reported that farmers were unwilling to adopt preventive practices, but may often tolerate a specific pressure (e.g., pests) until it reaches a certain impact threshold, at which time failure to address the problem could result in total crop losses.

Some anticipatory adaptation has been observed in the study sites. For example, some growers plant early, or plant a variety that tolerates rainwater shortages (FARO 44-SIPI). While it is true that all adaptation practices are not employed without certain investment or costs, those practices employed in the long-term create a sufficient amount of time which the growers need to harness the resources they require to invest in a reduction of their vulnerability.

5.10.3 Planned adaptation

Insufficient planned adaptation practices are an apparent weakness that may have degraded the capacity of rice growers to respond adequately to recurring pressures in the study sites. While a host of studies on vulnerability have underscored the success of planned adaption practices for reducing vulnerability, especially in SSA regions (Füssel, 2007; Smith & Pilifosova, 2001; Vermeulen et al., 2012), this study revealed that most of the adaptation practices employed by growers, with the exception of those granted government rice cultivation loans, were largely autonomous.

Such autonomous practices, e.g., constructing a flood water drainage channel to take floodwaters out of a rice field, or changing the sales location to attract higher prices, may be insufficient to offset damages linked to CCV and market pressures. This calls for prioritisation of the adoption of more planned adaptive practices, especially by small landholders at the centre of agriculture and rural development policies in Benue State (Eakin & Luers, 2006; Füssel, 2007; Gallopín, 2006).

To this end, planned adaptive responses may be formulated as public policies or private sector initiatives which aim to provide adequate support to the rice growers, e.g., in the form of credit, infrastructure, and improved technical capacity. This would enable them to effectively respond to multiple, combined pressures. Planned adaptation should include all rice producers regardless of status (i.e., small and medium and large landholders), so that growers can access formal credit schemes and structural projects, and also claim subsidies on farming inputs and machines, which would include public land development and irrigation schemes, and thereby enhance their adaptive response capacity. In Ghana for example, Mumuni & Oladele (2012) found that a growers' support programme run by donor agencies significantly enhanced the capacity of small rain-fed lowland rice growers to increase their yield in the face of poor weather conditions and other production challenges, such as lack of capital among others. Meanwhile in Madagascar, Harvey et al., (2014) showed that non-participation in the formal credit system is one of the reasons that small landholders are extremely vulnerable to agricultural risks and climate change.

Ensuring that growers in Benue State participate in planned adaptive practices and intervention may entail addressing the issues of exclusion and non-participation that concern small landholders especially (Coady, et al., 2009). This may involve relaxing, or making outright changes to, some of the stringent conditions and set criteria, which the majority of small landholders often fail to meet, for access to credit facilities and participation in farming support or unmilled rice trading programmes. Examples of these conditions include large farm size, collateral, and part funding. Even so, it is important to acknowledge that while government interventions are needed, generally those implemented in agriculture and other sectors across SSA have been inefficient and ineffective due to corruption and inadequate public engagement in planning, implementation, and monitoring of them (Aniekwe, 2010; Colen, et al, 2013; Enete & Amusa, 2010). This underlines the importance of building stronger institutions, carrying out public sector reforms, and setting up proper monitoring and enforcement mechanisms to ensure that government initiatives and interventions deliver desired outcomes.

5.10.4 Collective and coordinated adaptation responses

Strongly connected to planned adaptation, the inability of rice growers to respond to pressures collectively and in a coordinated manner have been identified as another weakness that is characteristic of the current adaptation practices in this region. As the name implies, these are not special practices, but rather they are responses undertaken by growers collaboratively. While vulnerability studies have shown that collective and coordinated adaptive practices enable growers with limited resources to respond effectively to pressures (Feola et al., 2015, Nicholas and Durham, 2012; Smith & Olga, 2001), in the context of this study it has been revealed that collective and coordinated adaptive practices were infrequently carried out by growers. Across the three study sites, for example, only at the time of sourcing capital did small landholders pool funds for co-ordination by local co-operatives (e.g., Adashi or Bam).

The particular tendency of growers to adopt individual actions beyond collective and co-ordinated actions in response to pressures was also reported in Madagascar among small landholders (Harvey et al., 2014), and in in Northern California among wine growers (Nicholas & Durham, 2012). In spite of this, other studies have shown the added advantage of actions embarked upon collectively and coordinated by local institutions, such as cooperatives, to the enhancement of response capacities of local producers to rapid and unforeseen pressures or risks, even in the absence of public (government) support. For example, Becker and Yoboue (2009) showed that in Cote d'Ivoire during the removal of state support for rice producers (i.e., subsidies, liberalised prices, and imports), as a result of the implementation of the Structural Adjustment Policy (SAP), regional producer/processor networks, coordinated by millers, pooled their resources to maintain production and milling. This became the sole source of domestic commercial rice supply for many low income households. Similarly, in Southeast Kazakhstan, Barrett et al., (2017) showed that when state support for agriculture was terminated following the dissolution of the Soviet Union, water supply rotation in periods of drought and the voluntary maintenance of unmanned canals before the start of irrigation were collectively managed and coordinated by Water Use Associations (WUAs) to enable growers to keep producing, even in the face of climate change.

Given the strategic role that collective and coordinated actions could play in adapting agriculture to dynamic pressures across the region of the study sites, this calls for future research to investigate constraints to the adoption of collective and coordinated actions, especially among growers in Benue State.

5.10.5 Trade-offs and cost of adaptation practices

Vulnerability and resilience studies have emphasised that successful adaptation involves trade-offs between one adaptive practice and another (Leichenko & O'Brien, 2008; Nelson, et al, 2007; O'Brien et al., 2004). In this specific case which involves Benue State, this study showed that some of the adaptation practices widely employed by the rice growers required trade-offs between one practice and another. For example, growers using well-watered rice fields may have to make the decision to plant a variety which accommodates a flooded ecosystem, but which may have low market demand due to its inferior grain quality (short grains); or growers using a less-watered rice field may have to make the decision to plant a variety that tolerates water stress, but which provides a lower yield.

Furthermore, this study reveals that trade-offs are not limited to farming decisions alone, but extend to market decisions, such as: changing the selling location (marketplace) to attract more income, but incurring additional expenses which include higher transportation costs; or, selling on the periodic market where third party influences (middlemen) exist; or, selling to a programme, or to networked buyers, using a sales contract or buy back programme where growers feel prices do not reflect the higher prices on the periodic market during the off season (O'Brien et al., 2004). The existence of trade-offs between certain adaptation practices clearly shows that some, such as those discussed above, reduce vulnerability in the short-term, but in the long-term they increase it, a situation which results in maladaptation (Jain et al., 2015). This is a view shared by those who have conducted similar studies, e.g., Belliveau et al. (2006) and Jain et al. (2015). Therefore, it could be considered urgent for future vulnerability research in the region to be undertaken to evaluate the costs and trade-off between growers adopting certain practices over others, and whether trade-offs and costs form the bedrock for the choice of adaption practices amongst growers in the study region.

5.10.6 Uncertainties

Successful adaptation depends on how best uncertainties surrounding a system are addressed, or what plans are put forward to address the impacts which arise from them (Darnhofer et al., 2009; Darnhofer, 2014; Gitz & Meybeck, 2012;). In the specific case reported here, it is shown that rice growers were uncertain not only about future effects of climate change and its variability on agricultural markets, but also about how changes in rice production policies (e.g., public support for inputs and subsidies), and trade policies (e.g., liberalisation or protectionism) might shape the rice sector in the future (Daramola, 2005; Enete & Amusa, 2010; Obi-egbedi, et al., 2013). In other words, rice growers operate in a dynamic environment not only because of CCV and markets, but also politically and institutionally, which is challenging for farmers.

Therefore, addressing uncertainties calls for diversification to enable growers to spread the risks and create buffers (Darnhofer et al., 2009). The two common ways of diversification are off-farm (moving to non-farm income) and on-farm activities (Darnhofer et al., 2016). Of these, on-farm activities common among the rice growers included diversification of: i) crops, e.g., switching from rice to other crops, or to rice with other crops, such as cassava and groundnuts; ii) rice varieties, e.g., short, medium, or long duration maturing varieties, such as FARO 44, 52, and 4); and, iii) cropping systems, i.e., upland or lowland techniques.

Flexibility is key to diversification, hence rice growers must remain flexible at all times, they must be willing to easily adopt new practices and technologies and to either change or moderate some of their current practices (Darnhofer et al., 2009; Darnhofer, 2014; Gitz & Meybeck, 2012; Benzie & John, 2015; Tendall et al., 2015). For example, they may undertake practices such as: double or triple rice cropping, i.e., planting rice two or three times within a farming season; changing rice trading market channels, i.e., from open to buyback agreements or contracts; growing crops other than rice, e.g., soya beans, cassava, or yams); or undertaking entirely different income earning activities, e.g., carpentry, block making, or labouring on a road construction site. These practices do not only moderate or spread risks, but also give growers room to manoeuvre so they can pursue desired economic goals.

5.11 Summary and Conclusions

This chapter has assessed the vulnerability of rice growers to multiple, combined pressure from CCV and agricultural market dynamics in Benue State, Nigeria, with the aim of answering four research questions (see section 5.1).

Thus, regarding question (I):

What pressures are rice growers in Benue State exposed to at present, and how sensitive are rice growers to such pressures?

This chapter showed that rice growers in Benue State are presently exposed, on the one hand, to recurring flooding and rainwater shortages in addition to weed infestations, disease, pests, and soil infertility. On the other hand, they are exposed to market pressures from a number of sources, including: price crashes, high cost of inputs, use of inaccurate weights and measures, and market demand for selected varieties. However, drivers of the sensitivity of growers to CCV, market, and other related pressures include the socioeconomic characteristics of growers, such as: experience and the size of farm; access to technology, such as mechanisation and modern rice seeds/varieties; cropping systems, such as rainfed upland or lowland rice techniques; market systems, such as periodic markets and network/contract markets, and location; and seasonality of prices.

Secondly, with regards to question (II):

What practices do growers employ to respond to climatic and agricultural market pressures?

This chapter has shown that rice growers in Benue State employed both reactive and tactical practices, in the long- and the short-term, in response to the pressures of CCV and agricultural markets. Practices employed in the face of CCV and other related pressures include: rice field management and water control, e.g., avoiding flood prone fields and/or selecting well-watered rice fields; channelling water in and out of rice fields; visiting the farm regularly; employing best planting and diversified cropping practices, e.g., embarking on dry season farming, planting rice twice or thrice in a year, planting early, and planting stress resistant rice varieties; claiming crop insurance; controlling for weeds and pest; applying mineral fertilisers; accessing knowledge through experts; entering a farming support programme; and accessing weather information. While practices employed in connection with market pressures include: entering a market network/contract sales agreement; switching market, e.g., from programme to periodic market and vice versa; adopting best selling practices, e.g., milling harvested rice before selling it, keeping rice in storage for a length of time and selling when it becomes scarce on the market, selling in bulk and in small amounts, and changing selling location; planting a market preferred variety; and taking out a loan.

Thirdly, research question (III):

How do rice growers' exposure, sensitivity and adaptive capacity vary across the study sites?

The study revealed that all the farmers in the study sites were exposed and sensitive to similar pressures (CCV, markets, and others). However, the degree of their exposure, sensitivity, and adaptability was largely informed by: their location, in either Makurdi, Gboko, or Adikpo; their choice of cropping system, rainfed upland or lowland, or mixed and double or triple cropping; and their identification as a grower, i.e., a small, medium, or large landholder. For example, growers in Makurdi were more exposed to flooding due to the location of their rice fields in a low lying topography and within the floodplains of the Benue River. While in Adikpo, growers were more exposed to rainwater shortages due to the practices of mixed cropping systems employed, e.g., rainfed upland or lowland, or double or triple cropping.

Furthermore, among the types of growers, this study showed that growers who are medium/large landholders in Makurdi are less sensitive, more adaptable and, by extension, less vulnerable to pressures due to their ability to access promising adaptive practices, such as entering a farming support programme or rice selling network/partnership which provides buyback agreements or contracts, weather information, expert knowledge, and farming safety nets which include crop insurance and a formal credit system. Conversely, small landholder growers in each of the study sites lacked access to the above-mentioned farming safety nets, and thus are more sensitive, less adaptable, and ultimately more vulnerable to the combination of pressure from CCV, markets, and others.

Lastly, in relation to question (IV):

What are possible entry points for the reduction of vulnerability in the study sites?

This study finds that some of the adaptive practices employed by growers were promising, but that they were either localised, e.g., in Makurdi, the Benue State capital, or mostly unplanned and uncoordinated. Furthermore, some were employed for a short-term and often not collaboratively. Some required trade-offs for their adoption, hence there were uncertainties surrounding these particular practices. Consequently, this study identified six entry points for a reduction in the vulnerability of rice growers to multiple, combined pressures. These include the need for: (i) information, both short- and long-term, to help with publicity and the diffusion of promising adaptive practices more widely across all parts of the state; (ii) adoption of anticipatory, or preventive and long-term adaptive practices; (iii) more planned adaptive practices; (iv) scaling up the adoption of collective adaptive practices and coordination. More than these, there is a need for: (v) assessing trade-offs between different adaptation practices and the cost implications; and (vi) addressing uncertainties regarding the pressures themselves, policy options, and certain adaptation practices in the study region.

Based on these points, this study suggests that further research on vulnerability investigate the constraints to adoption of collective adaption practices by growers in the study region; collective actions may be important in helping growers to build synergy and pool resources together in response to pressures and in the absence of government support. Further, this study suggests that future vulnerability research evaluate the trade-offs between the adoption of certain adaptation practices over others, including costs of employing those practices by different growers, e.g., small, medium or large landholders. Finally, future research may assess whether trade-offs and costs really do form the bedrock of adaption practices employed by rice growers in response to CCV and the agricultural markets in the study region.

Chapter 6
Vulnerability and adaptation of rice millers and traders to combined climate change and variability, and market pressures in Benue State, Nigeria

6.1 Introduction

The rice value chains (RVCs) in Sub-Saharan Africa (SSA) is vulnerable to multiple, combined climate change and agricultural market dynamics (Terdoo & Feola, 2016). Yet existing research has focused almost exclusively on rice production, while other parts of the value chain have been overlooked. This chapter fills this gap by examining the vulnerability and adaptation of rice millers and traders to multiple, combined pressures of climate change and variability (CCV) and market dynamics in three study sites in Benue State in North-Central Nigeria.

The chapter outlines the current pressures and adaptive practices experienced by rice millers and traders in their responses to CCV and market pressures. By applying the Vulnerability Scoping Diagram (VSD) the chapter examines the exposure, sensitivity, and adaptive capacity (practices) components of millers and traders in detail, thereby highlighting the present differences between the three study sites.

The chapter answers four research questions:

I. What pressures are rice millers and traders currently exposed to in Benue State, and how sensitive are they to such pressures?

II. What current practices are employed by rice millers and traders in response to combined climate change and agri-market pressures in Benue State?

III. How do rice millers' and traders' current exposure, sensitivity, and adaptive practices vary across Benue State?

IV. What are the leverage points (weaknesses and strengths) from which policies which aim to reduce vulnerability and build resilience can stem?

The chapter is divided into three major sections as follows. First, the vulnerability of rice millers is assessed within three sub-sections: exposure, sensitivity, and adaptive practices or responses. Then, the vulnerability of traders of domestic milled rice is explored within the same three sub-sections. Lastly, the findings are validated and discussed in light of current adaptation theories and research findings from SSA and other regions.

6.2 Vulnerability of rice millers in Benue State, Nigeria

This section presents the components and measures of vulnerability of rice millers to combined CCV and to market pressures in the study sites (see Figure 6.1). It also highlights the differences in rice millers' exposure, sensitivity, and adaptation practices across the study sites (see Table 6.1 after the VSD).

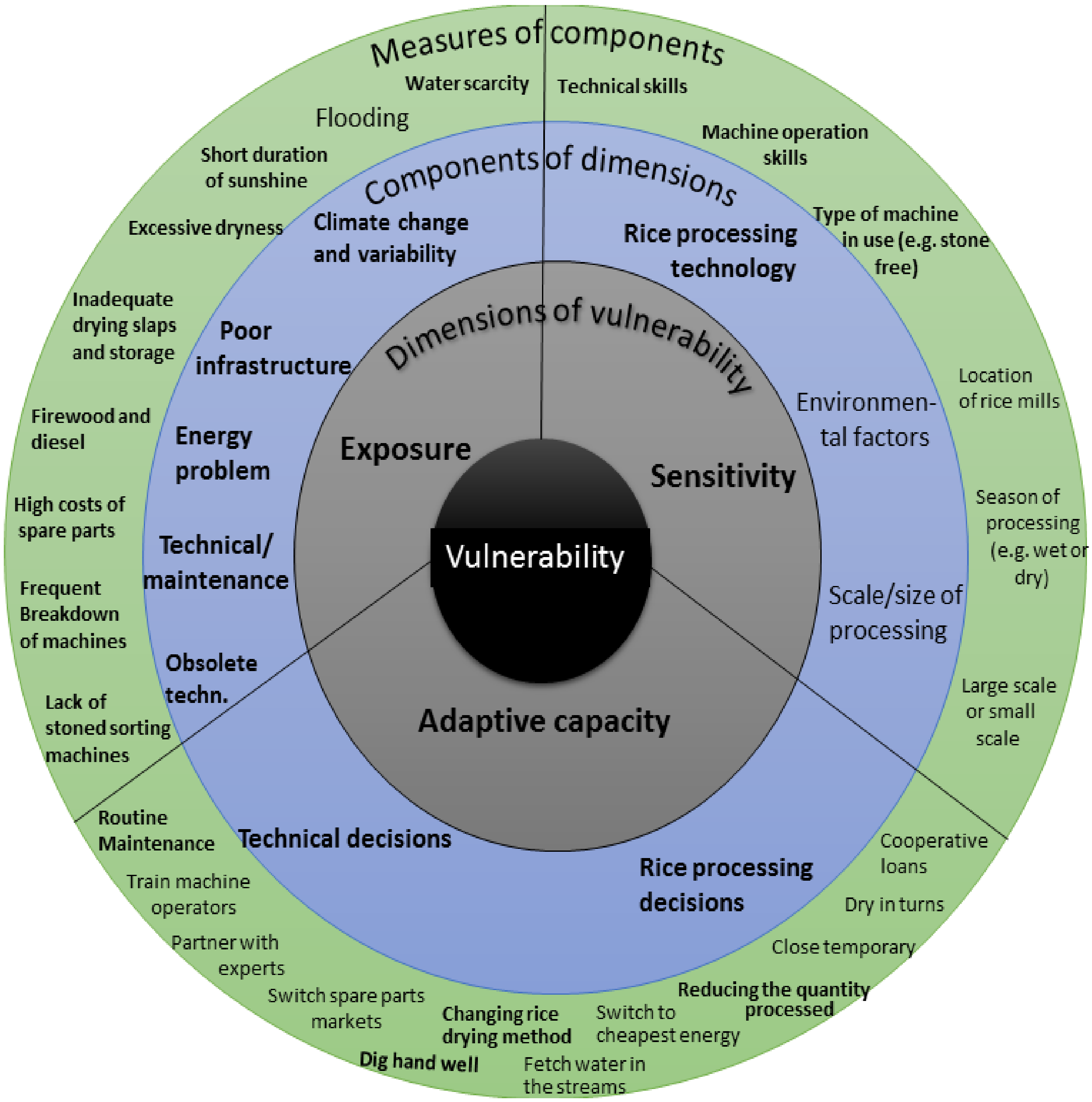


Figure 6.1. Vulnerability scoping diagram for Makurdi, Gboko, and Adikpo, Benue State, Nigeria[15]

[15] Factors highlighted in bold were cited by at least 33% of the rice millers

Table 6.1. Differences in exposure, sensitivity, and adaptation of millers across the study sites

	Study sites	Makurdi	Gboko	Adikpo
Exposure to pressures	Water scarcity	x	√	√
	Flooding	√	X	x
Sensitivity		No difference	No difference	No difference
Adaptive practices	Temporary relocation during flooding	√	X	x
	Partner experts	√	X	x
	Fetching water in streams	√	√	√
	Dig hand well	x	√	√

√ denotes the presence of pressures or adaptive practices in the site, while x denotes their absence

6.3 Exposure of rice millers in Benue State

6.3.1 Exposure to climate change and variability

Figure 6.2 presents the climate related pressures experienced in the three study sites while on Table 6.2, types of CCV-related pressures by sociodemographic characteristics of millers are presented.

.

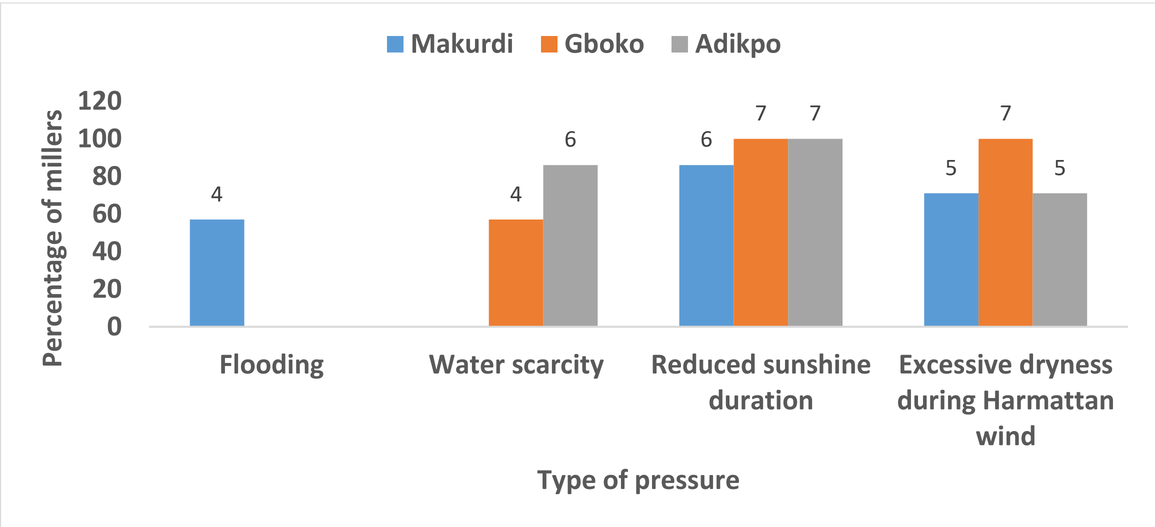


Figure 6.2 Percentage of rice millers who identified different types of pressures in the study sites

Table 6.2. Types of CCV-related pressures by sociodemographic characteristics of millers

Source of pressure	Gender		Age			Education level				Income class			Identification as millers			Years engaged as miller		
	M *(n-15)*	F *(n=6)*	20-39 *(n=2)*	40-49 *(n=12)*	50-89 *(n=7)*	No *(n=0)*	Prim *(n=9)*	Sec. *(n-11)*	High *(n=1)*	Low *(n=18)*	Middle *(n=2)*	High *(n=1)*	Small *(n=18)*	Med *(n=2)*	Large *(n=1)*	1-10 *(n=8)*	11-20 *(n=8)*	>21 *(n=5)*
Flooding	2(31)	2(33)	-	3(25)	1(14)	-	2(22)	2(18)	-	4(22)	-	-	4(22)	-	-	-	3(38)	1(20)
Water scarcity	9(60)	1(17)	2(100)	7(58)	3(43)	-	4(44)	5(45)	1 (100)	9(50)	1 (50)	-	9(50)	1 (50)	-	5(63)	5(63)	-
Reduced sunshine duration	13(87)	6(100)	2(100)	11(92)	7(100)	-	9(100)	9(82)	1(100)	16(89)	2(100)	1 (100)	16(89)	2(100)	1 (100)	8(100)	8(100)	3(60)
Excessive dryness during by Harmattan wind	12(80)	5(83)	2(100)	9(75)	7(100)	-	8(89)	7(64)	1 (100)	15(83)	2(100)	-	15(83)	2(100)	-	6(75)	7(88)	4(80)

Cells show (n) number of millers and, in brackets, within group percentage.

Rice millers identified the CCV pressures confronting them as: recurrent flooding of rice mills; water scarcity; reduced sunshine hours during peak rainy seasons; and, excessive dryness owing to the harmattan winds experienced in the dry season (see Figure 6.2). Table 6.2 suggests that female millers were more exposed than male millers in Benue State. With respect to the age of millers, educational level, income class, and their identification as millers (e.g. small, medium and large size) and the number of years they have been engaged in rice milling the "N" from various classes is small (e.g. N=2 or N=1). Therefore, nothing can be deduced from exposure to CCV between the younger millers of ages 20-39 and older millers from ages 40 and above, uneducated and educated millers, middle and high income millers, and medium and large size millers (Table 6.2). While for the number of years the respondents have been engaged as millers, the N is not too small, but the within group classes are very similar, thus indicating a lack of substantial difference in exposure to CCV pressures between growers engaged for ≤10 years and ≥11 years. The rest of the section relies on millers' experiences drawn from field interviews to account for differences in their exposures to CCV pressures.

Table 6.3. Highlights of millers' exposure to CCV and seasonal changes

Pressures	Experiences	reference
Flooding	… I and others experience floods in this area which cover our drying slabs completely, this disrupts the milling activities such as soaking, parboiling, and drying…	[Miller 2]
	… When we are facing flood problems, the drying time increases from 3 days to even 7 days or more. When this happens, the quality of milled rice becomes poor as the unmilled rice that is not well dried usually shatters or splits during milling…	[Miller 2]
Water scarcity	…I usually experience water shortages toward the peak of the dry season, which is between March and April, as all our hand dug wells dry up during this period…	[Miller 20]
	… Causing millers to buy water at high costs when all the hand dug wells dried up…	[Miller 8]
Seasonal changes in sunshine duration	… Getting dried firewood to use for parboiling rice becomes very difficult during cloudy and wet weather as the sunshine is not enough for firewood to be easily dried	[Miller 1]
	…drying in the rainy season sometimes takes a whole week instead of 2 to 3 days, and in situations where the cloud or rainfall continues, the rice ends up rotting…	[Miller 1]
Excessive dryness during harmattan wind	…over dryness as a result of inability to correctly determine the optimum drying time during the harmattan when the wind is fiercest and the intensity of the sun is high, it results in shattering and splitting of the rice grains during milling	[Miller 10]
	… During the harmattan season, the fire set to parboil rice is usually blown away by the harmattan wind. As a result, the rice does not get heated to the desired temperature and the quality is, in turn, affected. This is the cause of the white spots [Gba Kpatema; local name in Tiv], which occasionally appear on rice milled locally…	[Miller 15]

For social demographic characteristics of millers, refer to appendix 6.1

Thus, a number of the millers shared their experiences on these pressures, which are highlighted in Table 6.3 above. Flooding was a major challenge in Makurdi. In this area, the two rice mills in Wurukum and Wadata are both situated on the bank of River Benue, so they can meet the water demand during parboiling and milling of rice. However, this exposes the two mills to recurrent flooding, which often disrupts milling activities (e.g., soaking, parboiling, and drying), sometimes for days, weeks, and even months, particularly during the peak rainfall months between August and September (see millers' comments in Table 6.3, above).

In contrast to Makurdi, millers in both Gboko and Adikpo identified water scarcity as one of challenges they often experienced in the mills. In these sites the rice mills are also located near water sources to cater for easy access during milling processes, however, according to millers (see Table 6.3), these water sources dry off at the peak of the dry season (i.e., March and April), thus rice milling activities during this period become more challenging and costly.

Another recurring pressure with which rice millers are currently faced across the three study sites is seasonal changes in sunshine duration, which is a result of prolonged changes and variability in weather and climate. Firewood is the main source of energy used during milling processes and during the peak period of the rainy season (i.e., between August and September), drying it becomes challenging due to frequently cloudy weather and limited sunshine hours. Not only this, drying the parboiled rice to the desired moisture content is also challenging due to inadequate sunshine, this results in high rates of shattering or splitting of the whole grains during the de-husking process (i.e., the removal of the chaff on the rice grains by the milling engines).

Contrary to the effects of wetness as a result of limited sunshine hours, millers in each of the study sites identified excessive dryness during the harmattan period (i.e., between December and January) as problematic to milling. According to the millers, during this period the wind and the sunshine are at their peak, hence drying is quicker. As a result, firewood is usually too dry and burns faster than it should. In addition, during steaming and parboiling, the wind tends to blow the fire away, leaving the rice improperly parboiled. Moreover, rice dried during this period becomes over dry and results in shattering or splitting of the grains during de-husking (see Table 6.3).

6.3.2 Exposure to non-CCV pressures

In addition to pressures of CCV and seasonal change presented above, rice millers highlighted a number of non-CCV pressures on rice milling (see Figure 6.3).

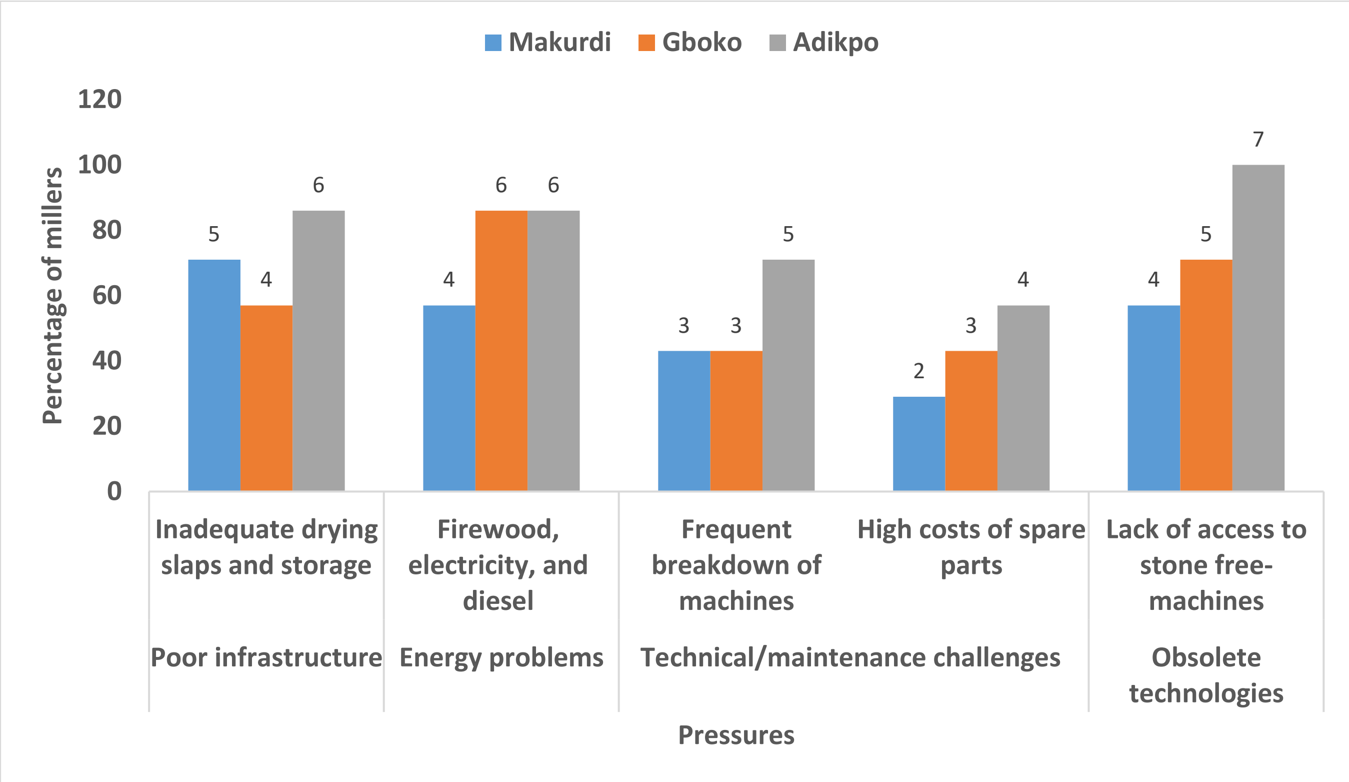


Figure 6.3. Percentage of rice millers who identified different types of pressures in the study sites

The non-CCV pressures include: poor infrastructure, e.g., for rice drying slabs and for storage facilities; energy problems, e.g., rising costs of fire wood, diesel, and lubricants, the challenge of using firewood in certain rainy seasons, and instability of the electricity supply; technical/maintenance challenges, e.g., machine breakdowns and the high cost of spare parts; and obsolete technology, e.g., the use of old machines that cannot separate stones and other impurities in the rice during milling (see Figure 6.4).

Figure 6.4. Cemented slabs/pavements used for drying parboiled rice in small-sized rice mills.

Table 6.4 below presents results of exposure to various types of non-CCV pressures by sociodemographic characteristics of millers. The results revealed that female millers appear less exposed to non-CCV pressures than male millers. However, with respect to educational level, millers with primary education seem more exposed than millers with secondary education and above. However the age of millers, income, and identification as miller (i.e., their size of milling), the number of respondent (N=2 or 1) is small. Consequently, nothing can be said about the differences in exposure to Non-CCV between the group classes of above variables. However, for the number of years engaged as miller, the class size of the less experienced millers (ages 1-10) and experienced millers (ages 11-20) is somewhat similar. Thus, indicating a lack of substantial difference in exposure to non-CCV pressures between the less experienced and experienced millers in Benue State.

Table 6.4. Types of non-CCV pressures by sociodemographic characteristics of millers

Source of pressure	Gender		Age			Education level				Income class			Identification as millers			Years engaged as miller		
	Male *(n-15)*	Fem. *(n=6)*	20-39 *(n=2)*	40-49 *(n=12)*	50-89 *(n=7)*	None *(n=0)*	Prim *(n=9)*	Sec. *(n-11)*	High *(n=1)*	Low *(n=18)*	Middle *(n=2)*	High *(n=1)*	Small *(n=18)*	Medium *(n=2)*	Large *(n=1)*	1-10 *(n=8)*	11-20 *(n=8)*	>21 *(n=5)*
Inadequate drying slabs and storage	11(73)	4(67)	2(100)	7(58)	6(86)	-	8(89)	6(55)	1(100)	14(78)	1(50)	-	15(83)	-	-	5(63)	7(88)	3(60)
High costs of firewood, electricity, and diesel	11(73)	4(67)	2(100)	9(75)	4(57)	-	9(100)	5(45)	1(100)	14(78)	1(50)	-	14(78)	1 (50)	-	4(50)	6(75)	3(60)
Frequent breakdown of machines	9(60)	2(33)	2(100)	7(58)	2(29)	-	7(78)	2(18)	1(100)	10(56)	-	1 (100)	10(56)	-	1 (100)	5(63)	5(63)	1(20)
High costs of spare parts	7(47)	2(33)	1 (50)	5(42)	3(43)	-	6(67)	2(18)	1(100)	7(39)	1(50)	1 (100)	7(39)	1 (50)	1 (100)	4(50)	4(50)	1(20)
Lack of access to stone free machines	11(73)	4(67)	2(100)	8(67)	5(71)	-	8(89)	6(55)	1 (100)	14(78)	1(50)	-	14(78)	1(100)	-	5(63)	6(75)	4(80)

Cells show (n) number of millers and, in brackets, within group percentage

Table 6.5. Highlights of millers' exposure to non-CCV pressures

Pressures	Experiences	reference
Poor milling infrastructure	…parboiled rice is open dried on tarred road surfaces, as a result small pieces of stone are mixed with the rice, contributing to poor quality after milling. In addition, the expected drying time, which under normal conditions is two or three days, is extended to seven days or more …	[Miller 3]
Energy problems	… the costs of diesel and engine oil have increased now from before… a litre of engine oil is 700 Naira now [about $US2, $US1=N360 at the time of interview] and that of diesel is 220 Naira per litre [about $US0.61, $1=N360 at the time of data collection] …	[Miller 12]
	…a litre sells for 230 Naira [about $US0.64 USD, $1=N360] …	[Miller 17]
	…firewood is so costly that a piece like the one there goes for 130 Naira [$US0.36, $1=N360], and consider the quantity of this firewood that is needed to make fire like the one you are seeing there, it is actually costly… The implication of using less firewood is that the rice will carry spots…	[Miller 20]
Obsolete technology	…we do not have the drier that gives the desired moisture content for long-term storage of paddy before parboiling, therefore sometimes our paddy is either decomposing or undergoing decolouration while in storage, so even when we have milled with the best milling practices, the quality is yet affected in some way…	[Miller 6]
	…I used a Blackstone machine to mill rice and it often comes out with small pieces of stones and other impurities as these technologies are not designed to either remove stones or polish rice …	[Miller 10]
High costs of spare parts	… For us to process quality rice here in this mill we often need spare parts, such as grinders [Anshwam-Tiv language], sifters [lalia-Tiv language], blazers, and spring holders; all these are costly and their prices have doubled now. In the past, 3000 Naira [about $US8.33 USD, $1=N360] was the cost, but now it costs 7000 Naira [about $US19.44 USD, $1=N360]. While a sifter was 500 Naira [about $US1.38], but now we are buying it for 1500 Naira [about $US4.16]. A blazer was 400 Naira [about $US1.11], but now it is 1000 Naira [$US2.77] and a spring holder was 400 Naira [about $US1.11], now it is being sold at 1500 Naira [about $US4.16]. These are the difficulties we are having now…	[Miller 10]

For social demographic characteristics of millers, refer to appendix 6.1

According to the millers (see Table 6.5), the poor state of rice milling infrastructure, including insufficient drying slabs (see Figure 6.4 above) and storage facilities (see Figure 6.5 below), constitute a major pressure, not just for the ease of drying and keeping rice safe during the rainy season, but also for enhancing the milling quality generally. Across the three sites, the problem of drying slabs or pavements becomes acute during the peak of the rainy season when the duration of sunshine is limited. Moreover, also during this period, most small-sized mills experience decaying or rotting of parboiled rice owing to insufficient drying slabs. While among large mills the challenge of inadequate drying equipment remains, it is not as acute as it is with the smaller mills.

Figure 6.5. Storage conditions: rice stored in the open at a large mill (A), and rice stored inside a room at a small mill

In terms of energy problems, electricity supply is a major challenge in Benue State. As a result, most rice millers depend on firewood and diesel as sources of energy for steaming, boiling, and milling (Figure 6.6 below). Among the three sites, Adikpo and Gboko rice mills are not well connected to the national grid and do not have well-functioning electricity transformers, however, in Makurdi, the Wurukum and Wadata rice mills have good electricity connections. In addition, the electric power that is available is not sufficient for the needs of the mills, and therefore it is usually rationed, this then creates uncertainties about when millers will have electricity to power their milling machines.

On the other hand, over reliance on firewood and diesel over time exacerbates energy pressures on millers as these energy sources are also subject to external and internal pressures, such as: import deficits; Nigerian currency devaluation and a falling exchange rate; poor transport infrastructure; strike actions by members of transport unions; and seasonal changes in the weather. Such pressures often result in an energy supply deficit, which in turn, creates artificial energy scarcity and high energy costs at certain times of the year (see Table 6.5).

Figure 6.6. Firewood used as energy (A), and metal drums (B) used for steaming and parboiling rice at small mills

Apart from poor infrastructure and energy problems, millers identified frequent breakdowns of milling machines and high costs of spare parts as current threats to rice milling in Benue State (see Table 6.5). Across the study sites, millers attributed these challenges to the use of very old technologies (e.g., Blackstone and Ruston milling engines), for which spare parts are no longer available in large numbers (see Figure 6.7, below). Thus, accessing new spare parts is challenging and rice millers tend to rely on fabricated spare parts, which often breakdown. The import of spare parts is the only option rice millers have to resolve the pressure created by frequent breakdowns of their milling machines, but this also has its challenges, especially the high costs and currency issues which have been highlighted as challenges to the import of energy above. Nevertheless, the use of obsolete technologies, especially rice milling machines like Blackstone and Ruston which cannot automatically perform tasks such as sorting out stones from the rice (de-stoning), or of polishing or whitening the grains during milling, has remained the cause of poor quality domestic rice milling across the study sites (see Figure 6.7, below).

Figure 6.7. Some of the old and obsolete technologies in use in small rice mills across the study sites

6.4. Sensitivity to pressures

In this section, structural pressures which make rice millers more or less sensitive to CCV and other market pressures (non-CCV) are discussed (see Figures 6.1 and 6.8). Furthermore, the sensitivity of rice millers to structural pressures in relation to their sociodemographic characteristics is presented on Table 6.6.

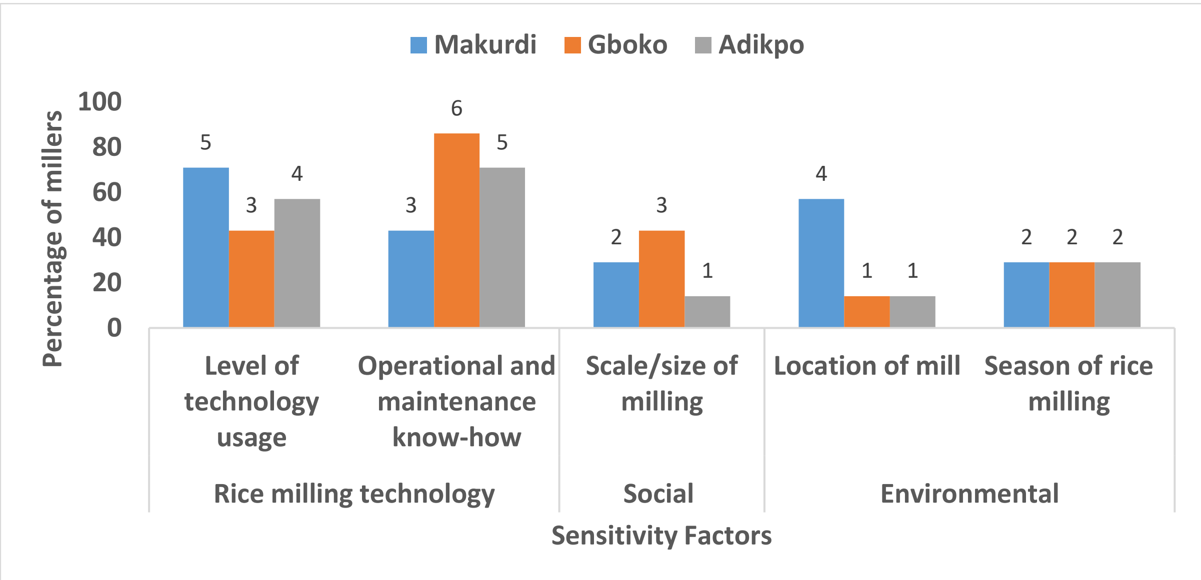


Figure 6.8. Percentage of millers who mentioned different structural factors related to their sensitivity to various climatic and non-climatic pressures in the study sites

Table 6.6. Factors of sensitivity to pressures by sociodemographic characteristics of rice millers

Source of pressure	Gender		Age			Education level				Income class			Identification as millers			Years engaged as miller		
	Male *(n-15)*	Fem. *(n=6)*	20-39 *(n=2)*	40-49 *(n=12)*	50-89 *(n=7)*	No *(n=0)*	Prim *(n=9)*	Sec. *(n-11)*	High *(n=1)*	Low *(n=18)*	Medium *(n=2)*	High *(n=1)*	Small *(n=18)*	Med. *(n=2)*	Large *(n=1)*	1-10 *(n=8)*	11-20 *(n=8)*	>21 *(n=5)*
Level of technology usage	9(60)	3(50)	-	8(67)	4(57)	-	6(67)	4(36)	1(100)	11(61)	-	1(100)	11(61)	-	1(100)	5(63)	6(75)	1(20)
Operation and maintenance know-how	11(73)	3(50)	2(100)	9(75)	3(43)	-	8(89)	4(36)	1(100)	12(67)	2(100)	-	12(67)	2(100)	-	5(63)	5(63)	22(40)
Scale/size of milling	4(27)	2(33)	1(50)	3(25)	2(29)	-	1(11)	5(45)	-	6(33)	-	-	6(33)	-	-	3(38)	2(25)	1(20)
Location of mill	3(20)	2(33)	1(50)	3(25)	1(14)	-	3(33)	2(18)	-	55(28)	-	-	55(28)	-	-	2(25)	2(25)	1(20)
Season of milling	4(27)	2(33)	-	4(33)	1(14)	-	1(11)	5(45)	-	6(33)	-	-	6(33)	-	-	1(13)	4(50)	1(20)

Cells show (n) number of millers and, in brackets, within group percentage

The level of technology used for rice milling (i.e., whether it is modern or old technology, and how it is maintained), including the scale/size of milling (i.e., small, medium, or large mills), and environmental factors, such as location of the mills and the season of milling (i.e., rainy/wet or dry/harmattan), were identified by millers as important factors in relation to their sensitivity to pressures (Figure 6.8). These factors were then examined on the basis of the sociodemographic characteristics of millers. Table 6.6 shows that sensitivity of millers to pressures in Benue State is not regularly patterned specifically to their gender, age, educational level, income class and size of milling (i.e. identification as miller). This suggests that their sensitivity to pressures generally cuts across these factors. However, the only factor that seems to make a difference is the years engaged as a miller, implying that the longer millers have been engaged in rice milling, the less sensitive they are to pressures. This explains the place of milling experience acquired over time in reducing sensitivity. Many of them related their experiences with regard to these factors, as can be seen in Table 6.7.

Table 6.7. Highlights of millers' sensitivity to various pressures, climatic and non-climatic

Pressures	Experiences	Reference
Level of rice milling technology used	…our reliance on weather [i.e., sunshine] to dry parboiled rice is the reason I and others here always experienced either high moisture content in rice in the rainy season, or very low moisture content in the dry, Harmattan seasons, which causes splitting of rice during milling, and decomposition after milling. Therefore, now that the weather is becoming very unpredictable, sometimes the quality of milled rice is highly affected by moisture content, so that selling it becomes very difficult…	[Miller 10]
Maintenance and operational know-how of millers	… the machine itself along with its parts must be in good shape, properly serviced… …the operator must be well experienced…	[Miller 19]
	…the rice must be properly parboiled at the right temperature and dried to have the right moisture content…	[Miller 3] [Miller 10]
Location of mills	…rice milling infrastructures and equipment, such as drying slabs and pavements, storage facilities and warehouses, and parboiling drums among others, are often the first to meet floodwaters when the current is highest…	[Miller 2]
Season of rice milling	…in the rainy season, from July to September, milling activities are at their lowest because parboiling is usually difficult due to the wetness of firewood needed in the parboiling process, and this is due to frequent rainfall and limited sunshine hours to make firewood dry…	[Miller 1]
	…in the dry Harmattan period, there is always a challenge of rice drying beyond the desired moisture content for yielding good quality and whole grains during the milling processes…	[Miller 8]

For social demographic characteristics of millers, refer to appendix 6.1

Firstly, millers have highlighted that the level of technological development not only exposes them to pressures, but also makes different millers (e.g., small or large) more or less sensitive to various climatic and non-climatic pressures, such as poor prices and quality preferences (see Table 6.7). According to the millers, the inability to use modern rice milling technologies, such as rice de-stoning machines and mechanical boilers and driers, by the majority of small millers across the study sites undermines the end quality of domestic milled rice, sometimes resulting in splitting or shattering of grains, decomposition, and dis-colouration and, subsequently, the miller's ability to compete on the market (Figure 6.9). This often happens when the moisture content of parboiled, dried, and milled rice is high. Moreover, when the quality of the milled rice is poor, the result is poor prices as purchasers (consumers) prefer high quality rice, which includes certain attributes such as grains which are long, white, and clean. However, the situation is different for large millers, such as MIVA rice, who have been able to purchase new equipment, such as mechanical driers which allow the desired moisture content to be achieved and guarantee quality milling, i.e., much less splitting of grains and decomposition after milling.

Figure 6.9. Level of milling technology used: engines without (A. small mills) and with (B. large mills) capability to remove all impurities in rice, and to sort and polish the grains

Across the sites, millers have also highlighted the need for technical knowledge to maintain and operate milling machines in relation to sensitivity to pressures (see Table 6.7). The majority of small millers depend on old milling machines, such as Blackstone and Ruston, among others, which have been in use for over 30 years without replacement. Moreover, these engines are manually operated and operators tend to experiment through trial and error to set or calibrate them for optimal operation. This makes necessary the ability to effectively operate, service, and to replace worn out machines parts to enhance the quality of the milled rice. Thus, millers who lack technical abilities are more prone to pressures, such as the preference for high quality milled rice, and this is what drives the domestic rice market in Benue State.

Furthermore, the location of the rice mills was highlighted in relation to sensitivity to pressures. Across the sites, small rice mills are located very near water sources, while large mills are located farther away. Moreover, in the small mills the facilities and infrastructure, e.g., storage buildings, drying pavements and slabs used in milling the rice, are not well constructed. Therefore, when floods occur, these small mills are usually the most affected. Therefore, because of their inherent limited capital for reinvestment in new infrastructure and equipment, exacerbated by their exclusion from the formal credit systems, the small millers find it harder to recover from pressures than do the large millers, like MIVA Rice. As a result, some of the worst affected millers abandon the business for alternative ones. This may be another reason why investment in milling in the area has remained stagnant over the years.

Lastly, in relation to sensitivity, millers identified seasonality as another factor (see Table 6.7). According to them, while rice is usually milled throughout the year across the state, there are certain seasons when milling activities are very sensitive, particularly to weather owing to CCV. For example, as already highlighted in the section on exposure, in the rainy season not only is parboiling difficult, but drying the unmilled rice at this time is equally challenging due to limited sunshine hours. The opposite is the case during dry (harmattan) seasons. Thus, during these two challenging seasons, small millers, who depend on artisan rice milling equipment and natural methods for drying rice, are more sensitive to weather and CCV-related pressures than are the large millers, like MIVA Rice, who use modern mechanical equipment. Certainly, getting rice parboiled and dried to the desired moisture content level for the yield of high quality milled rice is very difficult without the use of mechanical equipment in these seasons.

6.5. Adaptation to CCV and other pressures

This section presents the adaptive capacity component of rice millers' vulnerability (Figure 6.1 above). It highlights a list of current adaptive practices employed by millers across the three sites in response to pressures, for some the main driver is CCV, while for others it is not. These are tactical (i.e., short-term), reactive (e.g., employed after the pressure occurs), and strategic (i.e., long-term), anticipatory or preventive (e.g., employed well before the pressure occurs) (see Table 6.8) (Smith &

Pilifosova, 2001). In the sub-sections that follow, these practices are discussed following the sociodemographic characteristics of millers (Table 6.9).

Table 6.8. Percentage of millers who adopted different adaptation practices in the three study sites

Type of adaptation	Source of pressure	Example of adaptation	Makurdi (n=7)	Gboko (n=7)	Adikpo (n=7)
Tactical reactive	Flooding	Temporary closure and relocation	4 (57.1%)		
	Limited sunshine in the rainy season	Changing rice drying technique (e.g., from thickly to thinly)	4 (57.1%)	4 (57.1%)	2 (28.6%)
		Reducing the usual quantity processed	3 (42.9%)	4 (57.1%)	4 (57.1%)
		Taking turns to dry	2 (28.6%)	1	1
	Excessive dryness in the harmattan	Changing rice drying technique (e.g., from thinly to thickly)	4 (57.1%)	4 (57.1%)	2 (28.6%)
		Reducing the usual quantity processed	3 (42.9%)	4 (57.1%)	4 (57.1%)
	Water Scarcity	Going to nearby streams and rivers		3 (42.9%)	2 (28.6%)
Strategic anticipatory		Digging a hand well		4 (57.1%)	4 (57.1%)
Tactical reactive	Seasonal shortfall in unmilled rice supply	Temporary closure of mills	1 (14.3%)	1 (14.3%)	1 (14.3%)
	Inadequate drying slabs and storage	Taking turns to dry	2 (28.6%)	1 (14.3%)	1 (14.3%)
Strategic anticipatory	High costs of firewood, electricity, and diesel	Taking a loan from cooperative (bam and adashi)	1 (14.3%)	2 (28.6%)	3 (42.9%)
Strategic anticipatory	Frequent breakdown of machines	Routine maintenance	1 (14.3%)	3 (42.9%)	5 (71.4%)
		Train machine operators Partner with experts	1 (14.3%)	2 (28.6%)	3(42.9%)
Tactical reactive		Temporary closure of mills	1 (14.3%)	2 (28.6%)	2 (28.6%)
	Unavailability and/or high costs of spare parts	Explore alternative spare parts markets	1 (14.3%)	1 (14.3%)	1 (14.3%)
		Temporary closure of mills	1 (14.3%)	2 (28.6%)	2 (28.6%)
		Take loan from cooperative (bam and adashi)	1 (14.3%)	2 (28.6%)	3 (42.9%)
	Lack of access to stone-free machines	Changing drying platforms	2 (28.6%)	1 (14.3%)	1 (14.3%)
		Hand picking of stones	1 (14.3%)	2 (28.6%)	1(14.3%)
Strategic anticipatory		Ensuring paddy with less stones is milled	1 (14.3%)	2 (28.6%)	1 (14.3%)

N denotes the total number of millers interviewed at each site and, in brackets, within group percentage.

Table 6.9. Adaptation practices by sociodemographic characteristics of millers

Type of adaptation	Adaptation	Gender		Age			Education level				Income class			Identification as miller (size)			Years employed as rice miller		
		M (n-15)	*F (n=6)*	*20-39 (n=2)*	*40-49 (n=12)*	*50-89 (n=7)*	*None (n=0)*	*Prim (n=9)*	*Sec. (n-11)*	*High (n=1)*	*Low (n=18)*	*Mid (n=2)*	*High (n=1)*	*Small (n=18)*	*Med. (n=2)*	*Large (n=1)*	*1-10 (n=8)*	*11-20 (n=8)*	*>21 (n=5)*
Tactical reactive	Temporary closure and relocation	2(13)	2(33)	-	3(25)	1(14)	-	2(22)	2(18)	-	4(22)	-	-	4(22)	-	-	-	4(50)	-
	Changing rice drying technique (e.g., from thickly to thinly)	6(40)	4(67)	1(50)	5(42)	4(57)	-	7(78)	3(27)	-	10(56)	-	-	10(56)	-	-	3(38)	6(75)	1(20)
	Reducing the usual quantity processed	7(47)	4(67)	-	4(33)	7(100)	-	8(89)	3(27)	-	10(56)	1(50)		11(61)			3(38)	4(50)	4(80)
	Taking turns to dry	3(20)	1(17)	-	2(17)	2(29)	-	3(33)	1(9)	-	4(22)	-	-	4(22)	-	-	2(25)	2(25)	1(20)
	Going to nearby streams and rivers	5(33)	1(17)	-	3(25)	3(43)	-	4(44)	2(18)	-	5(28)	1(50)	-	6(33)	-	-	3(38)	2(25)	1(20)
	Changing drying platforms	3(20)	2(33)	-	3(25)	2(29)	-	2(22)	3(14)	-	5(28)	-	-	5(28)	-	-	3(38)	2(25)	-
	Hand picking of stones	3(20)	1(17)	1(50)	3(25)	-	-	3(33)	1(9)	-	4(22)	-	-	4(22)	-	-	1(13)	3(38)	-
Strategic anticipatory	Digging a hand well	7(47)	-	1(50)	3(25)	3(43)	-	4(44)	3(27)	-	6(33)	1(50)		6(33)	1(50)		3(38)	2(25)	2(40)
	Routine maintenance	8(53)	1(17)	1(50)	6(50)	2(29)		5(56)	3(27)	1(100)	7(39)	1(50)	1(100)	7(39)	1(50)	1(100)	5(63)	2(25)	2(40)

Cells show (n) number of millers and, in brackets, within group percentage

Table 6.9. Cont'd

Type of adaptation	Adaptation	Gender		Age			Education level				Income class			Identification as miller (size)			Years employed as rice miller		
		M *(n-15)*	*F* *(n=6)*	*20-39* *(n=2)*	*40-49* *(n=12)*	*50-89* *(n=7)*	*None* *(n=0)*	*Prim* *(n=9)*	*Sec.* *(n-11)*	*High* *(n=1)*	*Low* *(n=18)*	*Mid* *(n=2)*	*High* *(n=1)*	*Small* *(n=18)*	*Med.* *(n=2)*	*Large* *(n=1)*	*1-10* *(n=8)*	*11-20* *(n=8)*	*>21* *(n=5)*
Strategic anticipatory	Taking a loan from cooperative (bam and adashi)	6(40)	-	1(50)	4(33)	1(14)	-	3(33)	3(27)	-	6(33)	-	-	6(33)	-	-	3(38)	2(25)	1(20)
	Train machine operators	5(33)	-	-	4(33)	1(14)	-	3(33)	1(9)	1(100)	4(22)	-	1(100)	4(22)	-	1(100)	3(38)	1(13)	1(20)
	Partner with experts	1(7)	-	-	1(8)	-	-	-	-	1(100)	-	-	1(100)	-	-	1(100)	1(13)	-	-
	Explore alternative spare parts markets	3(20)	1(17)	1(50)	2(17)	1(14)	-	3(33)	-	1(100)	2(11)	1(50)	1(100)	2(11)	1(50)	1(100)	2(25)	1(13)	1(20)
	Ensuring paddy with less stones is milled	3(20)	1(17)	-	4(33)	-	-	2(22)	2(18)	-	4(22)	-	-	4(22)	-	-	1(13)	3(38)	-

Cells show (n) number of millers and, in brackets, within group percentage

6.5.1 *Current adaptation practices of rice millers to CCV*

Across the study sites, rice millers employed a combination of mixed practices before (anticipatory or preventive) and after (reactive) the occurrence of pressures when they responded to pressures owing to CCV, such as recurrent flooding, limited hours of sunshine in the peak rainy season months, excessive harmattan winds, and water scarcity (see Table 6.8 above). Regarding the millers' sociodemographic characteristics, Table 6.9 suggests that male millers are adapting to pressures generally better than their female counterparts, and that the older millers (≥40 years) seems to be adapting to pressures better than younger millers between ages 20-29. As the section on the political economy of rice in Nigeria has shown, in a patriarchal and gerontocratic society like Benue State, women and young people generally tend to lack equality of access, resources and opportunities compared with the male and older members of the society. Moreover, Table 6.9 shows that millers who have been engaged in milling business for a long time (≥11) appear to be adapting to pressures more effectively than the less experienced ones who have been engaged for ≤10 years. While income is key to investment to transform rice milling quality, the size of N between middle and high income millers is very small (N=1 or 2), hence no conclusions can be drawn on the relation between adaptation to pressures and income classes or the size of milling (e.g. small, medium and large millers), however this data is complemented by qualitative on millers' experiences gathered during interviews and workshops, all of which are described in the sub-sections that follow.

Table 6.10. Highlights of adaptation practices employed by rice millers in response to CCV

Pressures	Experiences	Reference
Temporary closure and relocation	… during the peak of flooding in the months of August and September, to avoid being severely affected by floodwater, I usually stop milling and relocate to a safer place for a while and return to the mill once the floodwater subsides...	[Miller 4]
	…sometimes we do stop milling completely because of lack of machine parts to replace the bad part(s). When we send for spare parts in this manner…. the machine is completely inoperative… our business is equally tied down within the period and there is nothing we can do about this…	[Millers 19]
Reducing the usual quantity of rice milled	…sometimes I reduce to half or even to a quarter, depending on the weather situation. This helps me to reduce the quantity of rice that would decay or rot owing to lack of sunshine…	[Millers 9]
Changing of rice drying techniques and platforms	At this time of the year [i.e, August-September], I no longer dry rice thickly but thinly…	[Miller 5]
	…. rice dried thinly easily becomes over-dried…	[Miller 9]
Taking turns to dry parboiled rice	…the usual drying time increases from 3 days to 7 days, so we usually take turns to dry…	[Miller 2]
Dig hand wells or fetch water from nearby streams and rivers	…during this period of acute water scarcity, I and other millers travel to nearby streams and rivers to fetch water…	[Miller 13]

For social demographic characteristics of millers, refer to appendix 6.1

Table 6.10 above presents the highlights of the millers' adaptive practices across the sites. In Makurdi, for example, whenever rice millers experienced regular flooding, one of the practices they commonly employed to respond to the situation was temporary closure of the rice mills and relocation to safer sites. According to the millers, while the practice of temporarily relocating saves them from incurring total damages from flooding, at the same time the practice puts pressure on their income during the entire duration of the flooding event, when everything comes to a standstill. In addition, the millers highlighted that in other situations, such as a prolonged shortfall in the supply of unmilled rice and a serious breakdown of a milling machine, including the difficulty of accessing the needed spare part(s), are often best handled by temporary closure of milling activities (see also Table 6.10, above).

Moreover, when millers experienced seasonal changes in sunshine duration due to cloudy weather or excessive dryness from the harmattan wind, they commonly respond by changing the way they dry the rice. Changing the usual way of drying during the peak rainfall period, from August to September, is the only way most millers manage the situation. As reported by the millers (see Table 6.10), by drying the rice in thin layers the air can circulate easily and the heat generated by the limited hours of sunshine can penetrate easily. In this way, the high moisture content in the rice becomes dried to levels sufficient for milling. This also prevents the rice from decay and discolouration. Conversely, during the harmattan period, usually from December to January, the wind becomes very dry as the intensity of the sun strengthens, as a result the moisture content in the rice is reduced to below the levels required to yield high quality grains during milling. Therefore, millers dry the rice in thick layers, or in clusters, as this prevents the easy circulation of air and deep penetration of sunshine, and thus reduces the rate of shattering during the milling process.

Apart from changing the way rice is dried, during periods of heavy rainfall, when the hours of sunshine are limited, most millers reduce the quantity of rice milled to a manageable level. As highlighted in Table 6.10, with small quantities of rice being parboiled they are able to reduce losses from improper handling, while at the same time maintaining the quality of milled rice. Although reducing the volume of rice milled during periods of heavy rainfall creates a supply shock, which in turn sends market prices up, this is short-lived.

Furthermore, millers often practiced taking turns to dry parboiled rice. This is because during wet weather the average time required to dry rice which will allow a quality milling rate usually increases (see Table 6.10). As this happens, the drying slabs or pavements become inadequate to support mass drying activities, therefore millers panic dry parboiled rice, even using unhealthy places such as the road side, to avoid decomposition. However, such drying on road sides and other undesignated surfaces affects the quality of the yield as broken pieces of stone are often found in the milled rice. Therefore, by taking collective action, whereby one or only a few millers are permitted to dry parboiled rice at one time, these challenges are abated and others must wait their turn to dry their rice.

In response to water scarcity, millers in Gboko and Adikpo, where rice mills are not situated beside big rivers, often resort to the use of well water. As stated by the millers, this practice takes place from January to May when the water scarcity becomes acute. However, during prolonged dry seasons, especially when early onset of rainfall is delayed, most of the hand wells dry up, worsening the situation. At such times, some of these millers claim they travelled long distances to large streams and rivers to source water (see Table 6.10).

6.5.2 Current adaptation practices of rice millers to non-CCV

Table 6.11. Highlights of adaptation practices employed by rice millers in response to non-CCV

Pressures	**Experiences**	**Reference**
Take a loan from a cooperative (bam and adashi*)*	…Bam and Adashi are the major financial sources easily accessible by rice millers to respond to challenging situations during rice milling when there is need. By running these, Bam and Adashi are able to finance our needs so we can remain in business despite enormous challenges…	[Miller 17]
Routine maintenance of machines	...running the old machines to maximum capacity causes some of the machine parts to wear out quickly and also increases the diesel consumption, hence creating a need for regular replacement of worn out spare parts and general servicing…	[Miller 17]
Train milling machine operators	…the boy you see outside there is understudying the older one and until perfection he cannot be left to parboil unmilled rice or operate a milling machine on his own...	[Miller 9]
Partnership with international organisations	…training on acquisition of the state of the art skills and techniques of milling quality rice, such as grading and separation of rice grains based on their size [e.g., broken or long and short grain] and colour [e.g., white, brown and milk], using image classification techniques, which were hitherto lacking in Nigeria… …the benefits of this partnership is that our milled rice is now of high quality and its demand has been rising steadily in the past two years since we have adopted these technologies	[Millers 6]

For social demographic characteristics of millers, refer to appendix 6.1

Across the study sites, rice milling was increasingly burdened by the rising costs of spare parts, energy, and routine maintenance of milling machines, at the same time substantial capital is required to effectively address these challenges. However, the dominant small millers were structurally excluded from access to formal credit facilities which could be used to address such pressures. Consequently, they rely on local cooperatives, such as Bam and Adashi. These are a collective effort formed by a rice milling union or association with resemblance to a formal banking system. Members of a cooperative save a designated amount and are then able to borrow on terms generally endorsed by participating members. This practice was common in places like Adikpo, where a formal banking system is yet to be operational (see Table 6.11).

Once they have sourced capital, millers can undertake routine maintenance and servicing of their milling machines to avoid interruption from frequent breakdowns during the milling process. While regular servicing of the rice machines may be costly, millers say the benefit goes beyond having a quality end rice product, there are also cost savings where, as the millers themselves say, "*machines that are routinely maintained consume less diesel*…" [Miller 17], and, "…*the rate at which spare parts get worn out is also slower…"* [Miller 16].

Another practice commonly embarked on, although this is a long-term practice, is the training of operators of the milling machines. In addition to ensuring that the end quality of milled rice is not compromised, trained operators handle and maintain machines properly, and this extends the years they are in service. According to the millers, the type of training given to operators depends on the type of miller and the milling machines in use. In Makurdi, MIVA Rice Company was the only large miller in operation at the time of data collection, one miller said of the company, "*because their milling machines are modern, they usually send their operators to formal training abroad, including workshops and courses on specialised milling operations, such as paddy cleaning and grading* …" [Miller 6]. For small millers, training of their operators is informal, mostly through apprenticeships (see Table 6.11).

In addition to training, going into partnership with an international organization, such as the United States Agency for International Development (USAID) or the Japanese International Cooperation Agency (JICA), was practiced by large rice millers as a long-term solution to improve the quality of milled rice in line with international food safety standards and regulations (see Table 6.11).

Table 6.12. Highlights of adaptation practices employed by rice millers in response to non-CCV

Pressures	Experiences	Reference
Ensuring unmilled rice with little or no stone is milled	…One thing we do to solve this problem is that I try to avoid buying unmilled rice that has stones, or that is not properly threshed. This means that buying quality unmilled rice from growers is key to enhancing the quality of milled rice. If you do not get it at the outset, forget it. No matter what you do during milling, the quality will be bad.	[Miller 1].
Use local stone removal techniques (e.g., hand picking)	…because I do not use stone free milling machines most times after milling the rice I discover the rice has broken pieces of stones in it, therefore what I do in such situation is to contract the local people who help with picking out the pieces of broken stones in the rice….	[Miller 2]
Exploring alternative spare parts markets	…I often have to send someone to buy the machine parts for me at distant markets like Onitsha. Whenever I send for parts in this manner, at times when the machine is completely down, our business is equally tied down within the period and there is nothing we can do about this…	[Miller 19].
	…when the colour sorting lenses [i.e., optical sorting] on our rice miller machine became weak, instead of buying from the manufacturer in India, we bought a South Korean make because it was less costly…	[Millers 6]

For social demographic characteristics of millers, refer to appendix 6.1

Moreover, one simple and cost-free practice easily employed by the small rice millers to improve the poor quality of the milled rice is to ensure that rice with little or no stone is milled in the first place. However, it is generally difficult for millers to get unmilled rice without stones because the majority of rice growers do not use combine harvesters. Thus, millers who seek to ensure quality commonly avoid buying and milling rice with impurities and broken pieces of stone (see Table 6.12).

Also practiced by the small size millers, to address quality and food safety issues, was hand picking or manual removal of stones from milled rice. With the exception of very few milling machines, most are non-stone free milling machines, so they are unable to process rice without stones in it. This, coupled with open sun drying of parboiled rice on cemented pavements or slabs, leaves broken pieces of stone or rock in the milled rice, and thus undermines its quality which results, in turn, in poor prices being offered. Thus, millers resort to manual sorting of stones to help improve the quality of the milled rice, although it is a very tedious and time consuming process Table 6.12).

Lastly, millers adopted the practice of exploring alternative spare parts markets to respond to the challenges of high costs and unavailability of quality spare parts for their rice milling machines. Quite often during the process of de-husking, some of the machine parts get worn out due to long term usage or lack of durability. At such times, most millers look for spare parts available in nearby towns and cities, but in a situation where such machine parts are costly and of lower quality millers often explore alternative spare part markets. The nature of the market (i.e., markets within or outside Nigeria) depends on the type of miller (i.e., small or large) (See Table 6.12 for millers' comments on this practice).

6.6. Vulnerability of milled rice trading in Benue State, Nigeria

Figure 6.10 illustrates components and measures of the vulnerability of rice traders in Makurdi, Gboko, and Adkipo to combined CCV and agricultural market pressures and highlights the differences across the three sites (see Table 6.13). In addition, types of pressure by sociodemographic characteristics of traders are presented in Table 6.14 below.

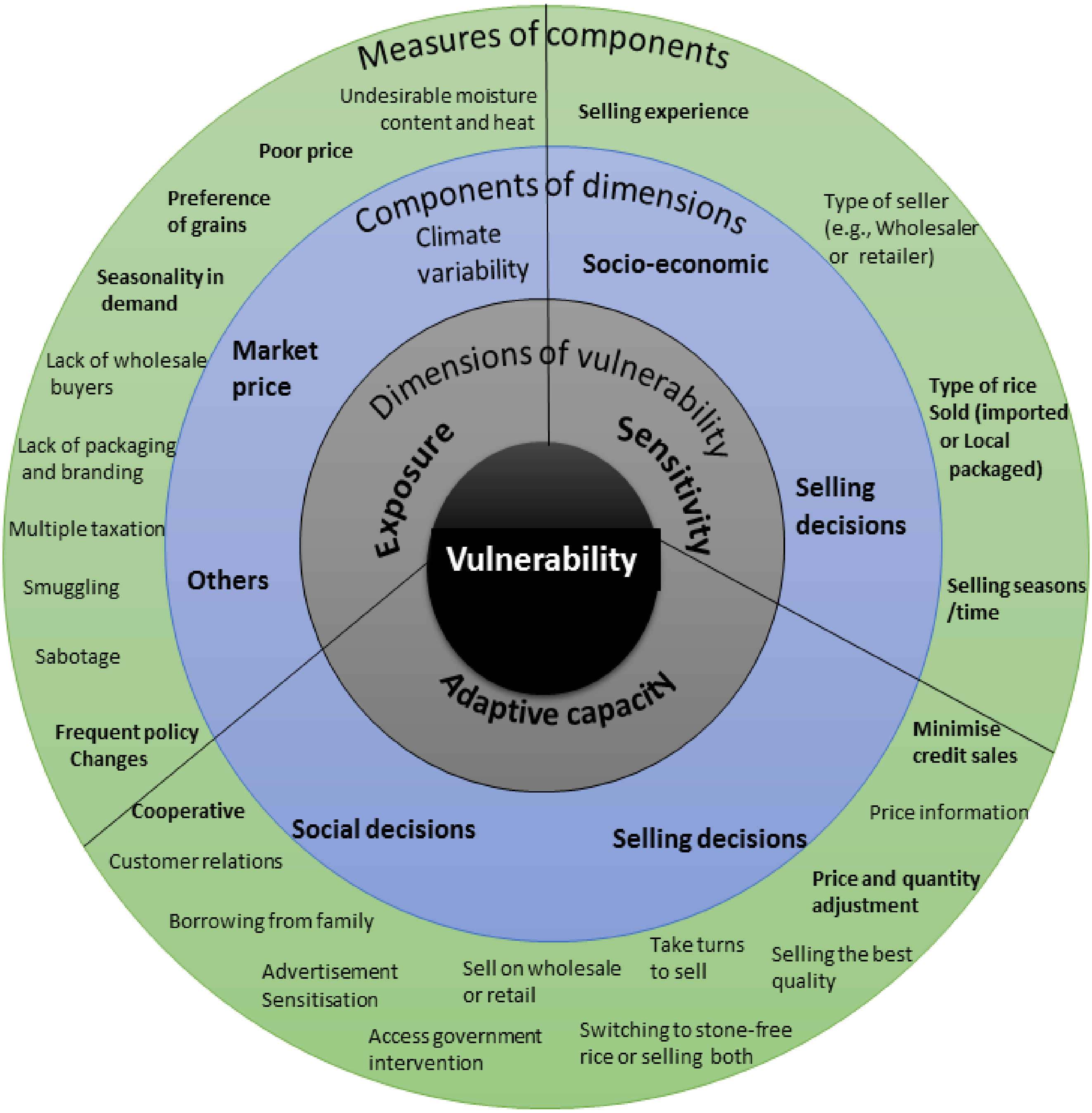


Figure 6.10. Vulnerability scoping diagram for Makurdi, Gboko, and Adikpo, Benue State, Nigeria [16]

[16] Factors highlighted in bold were cited by at least 33% of the milled rice traders.

Table 6.13. Differences in exposure, sensitivity, and adaptation of milled rice traders across the study sites

Dimensions of vulnerability	Factors	Makurdi	Gboko	Adikpo
Exposure		No difference	No difference	No difference
Sensitivity		No difference	No difference	No difference
Adaptive practices	Switching to stone-free milling	x	√	x
	Access government interventions	√	x	x
	Promotion, advertisement and sensitisation	√	x	x

√ denotes the presence of adaptive practice in the site, while x denotes its absence

6.7 Exposure to combined CCV and to market pressures

In this section the exposure component of rice traders' vulnerability is presented (Figure 6.11). Then, beginning with pressures whose main driver is CCV, pressures driven either directly or indirectly by the market are discussed.

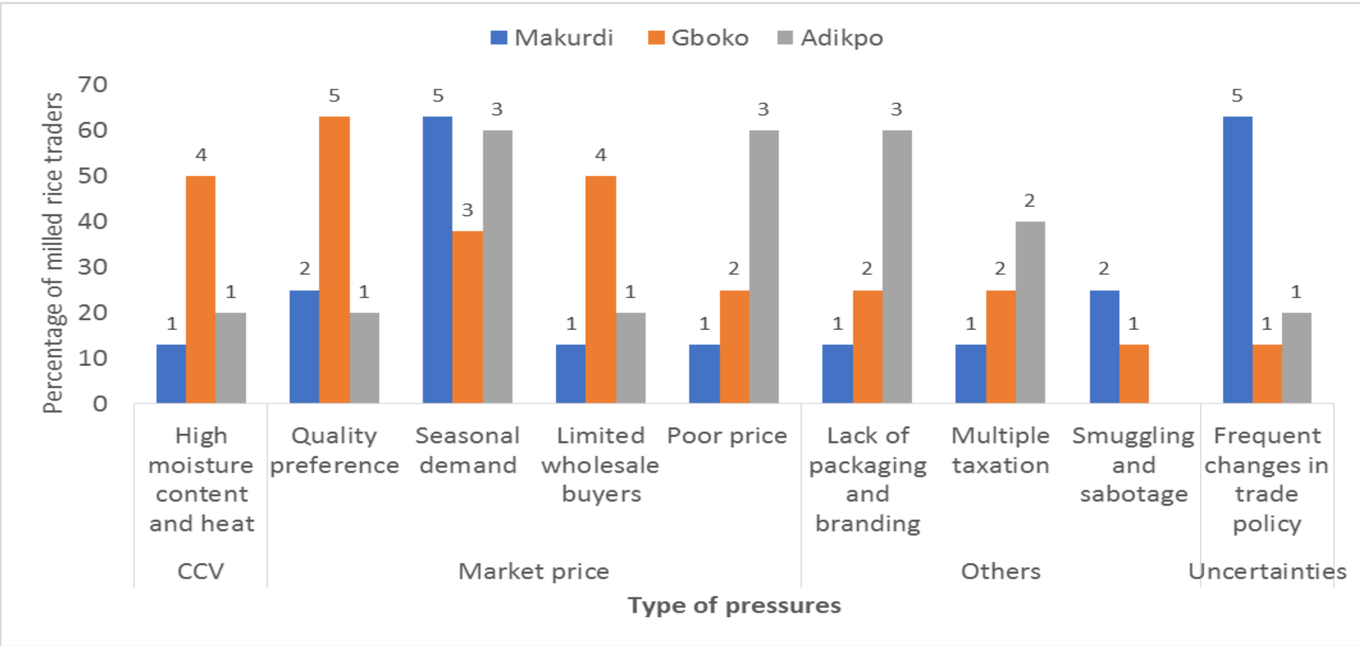


Figure 6. 11. Percentage of milled rice traders who identified different types of pressures in the study sites

Table 6.14. Types of pressures by sociodemographic characteristics of milled rice traders

Pressures	Gender		Age			Education level				Income class			Self-identification of trading scale			Years of trading rice			Rice type sold		
	Male *(n-13)*	F *(n=8)*	20-39 *(n=1)*	40-49 *(n=14)*	50-89 *(n=6)*	No *(n=2)*	Prim. *(n=7)*	Sec *(n-10)*	Higher *(n=2)*	Low *(n=14)*	Mid *(n=6)*	High *(n=1)*	Small *(n=17)*	Med. *(n=3)*	Large *(n=1)*	1-10 *(n=9)*	11-20 *(n=11)*	>21 *(n=1)*	Local *(n=12)*	Stone-free *(n=6)*	Foreign *(n=3)*
High moisture content	4(31)	2(25)	-	4(29)	2(33)	-	2(29)	3(30)	1(50)	3(21)	2(33)	1(100)	3(18)	2(67)	1(100)	3(33)	2(18)	1(100)	5(42)	1(17)	-
Lack of price regulation	4(31)	2(25)	1(100)	4(29)	1(17)		4(57)	2(20)	-	4(29)	2(33)		4(24)	2(67)		3(33)	2(18)	1(100)	6(50)	1(17)	-
Quality preference	5(38)	2(25)	-	5(36)	2(33)	-	2(29)	4(40)	1(50)	6(43)	-	1(100)	6(35)	-	1(100)	4(44)	3(27)	-	6(50)	2(33)	-
Seasonal demand	9(69)	2(25)	1(100)	6(43)	4(67)	2(100)	4(57)	5(50)	1(50)	6(43)	4(67)	1(100)	7(41)	3(100)	1(100)	5(56)	5(45)	1(100)	6(50)	2(33)	-
Limited wholesale buyers	3(23)	3(38)	-	5(36)	1(17)	-	3(43)	3(30)	-	5(36)	1(17)	-	5(29)	1(33)	-	3(33)	2(18)	1(100)	5(42)	1(17)	-
Poor prices	4(31)	1(13)	-	3(21)	2(33)	1(50)	4(57)	-	-	3(21)	2(33)	-	3(18)	-	-	2(22)	2(18)	1(100)	4(33)	2(33)	-
Lack of packaging and branding	4(31)	2(25)	-	2(14)	4(67)	-	3(43)	3(30)	-	4(29)	2(33)	-	4(24)	2(67)	-	5(56)	-	1(100)	5(42)	1(17)	-
Multiple taxation	2(15)	2(25)	-	3(21)	1(17)	-	3(43)	1(10)	1(50)	3(21)	-	1(100)	3(18)	-	1(100)	2(22)	2(18)	-	3(25)	1(17)	1(33)
Smuggling	3(23)	1(13)		2(14)	2(33)		1(14)	2(20)	1(50)	2(14)	1(17)	1(100)	2(12)	1(33)	1(100)	2(22)	1(9)	1(100)	2(17)	1(17)	1(33)
Sabotage	1(8)	-	-	1(7)	-	-	-	-	1(50)	-	-	1(100)	-	-	1(100)	1(11)	-	-	-	1(17)	1(33)
Frequent changes in policies	6(46)	1(13)	1(100)	3(21)	3(50)	2(100)	2(29)	1(10)	-	2(14)	4(67)	1(100)	3(18)	3(100)	1(100)	2(22)	3(27)	1(100)	2(17)	2(33)	3(100)

Cells show (n) number of traders and, in brackets, within group percentage

In general, Table 6.14 above suggests that milled rice traders who have been involved in the business recently (e.g., from 1-10 years) and who are less educated (e.g., primary level) appear more exposed to pressures than milled rice traders engaged in the business for a long time (usually between 11 years and more) and have at least a secondary level education. Moreover, milled rice traders who are dealers of local rice (i.e. rice milled without sorting impurity and broken pieces of stones) are more exposed to pressures than traders selling stone-free rice (e.g., locally milled rice with impurity sorted out). This is because poorer milled rice traders tend to sell local rice, which is often adjudged by consumers as inferior due to its poor processed quality, hence they are outcompeted on the rice market by high quality rice (e.g., stone-free and foreign rice).

On the contrary to the general belief that female actors in Africa are differentially exposed to pressures, this result suggests that male traders of milled rice seem to be more exposed to pressure than their female counterparts. In addition, Table 6.14 reveals that older, middle income and middle size milled rice traders were more exposed to pressures then the younger, small income and middle size milled rice traders. Milled rice traders' experiences of pressures are presented in the discussion that follows.

6.7.1 Moisture and heat

High moisture content in rice and heat are highlighted as recurring pressures that currently affect the trade in milled rice across Benue State (Figure 6.11). According to the traders, high moisture content and heat (e.g., hot weather) affect the quality of the rice, making it less preferred, and thus in less demand, on the market; subsequently, its market price is affected. In Makurdi, for example, one of the rice traders related the effects of high moisture content and other climate-related variables as follows:

> …If there is a lot of moisture in the rice, its quality is affected. In addition, if there is too much heat, the rice is affected too. Due to this type of weather change, even if you have good quality rice to sell, it begins to change colour. The quality it had when it was milled changes because of too much heat or too much humidity. This reduces demand for the rice because when consumers cook the rice that has too much moisture on it they will discover that it begins to foam. So when someone looks at it they will think the quality was not good right from when it was milled, whereas it is because of the climate that the quality became bad… [Trader 6].

6.7.2 Exposure to market price pressures

Rice traders also identified pressing challenges to include the preference for certain types/varieties of rice (e.g., long grains) and attributes associated with milling quality (e.g., cleanliness). As a result, the rice market is driven by quality and because small millers lack the technology and facilities to produce high quality rice to match imported rice, domestic rice is often considered inferior, and thus is less preferred. The situation is worse in urban centres, such as Makurdi, where most medium- and high-income earners in Benue State live (see traders' comments in Table 6.15, below).

Another market pressure identified by traders as impactful to rice trading across the state is poor market access related to insufficient numbers of wholesale buyers (e.g., people buying in large quantities). According to the traders (see Table 6.15), the lack of people buying wholesale in large quantities not only affects turnover, but also makes the quality of the rice, already fragile due to the use of obsolete milling equipment and infrastructure, further deteriorate, subsequently affecting rice prices negatively.

Table 6.15. Highlights of milled rice traders' exposure to market price pressures

Pressures	Experiences	Reference
Inadequate numbers of wholesale buyers	…lack of quick turnover due to over reliance on retailers	[Trader 3]
Poor prices	…we do experience an influx of traders who are not members of our association trooping in here to mill and sell. This affects the price of rice as most of these traders are eager to sell their rice even below the price stipulated by the association…	[Trader 17]
	…in the absence of a price control committee, whenever traders are under pressure from their creditors, they sell at any price they can. This is because our marketers' association is very weak in enforcing price control…	[Trader 18]
Preference	...I can say the demand for domestic milled rice is high mostly among low-income earners in villages and semi-urban centres of the state who do not have the money to go for high quality imported rice…	[Trader 11]
	…generally, in cities like Makurdi, imported rice is usually viewed by rice consumers as higher in quality, therefore it's considered cheaper by buyers when compared to the quality and price of the domestic milled rice…	[Trader 6]
Lack of packaging and branding	…they do not know how to go about it in the first place, not talking about the resources involved. Our desire is that if anyone wants to help us he/she should help us with packaging, branding, and advertising this business as this will help us do away with complaints our customers always give about the bushels (weights and measures) …	[Trader 17]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

Rice traders reported that the prices of domestic milled rice have been persistently poor over the years (see Table 6.15). Generally, rice prices in Nigeria are shaped by the interplay of demand and supply, while demand for rice consumption, on the other hand, is driven by the quality of milled rice. Although demand has remained high, the supply is usually much higher, a situation which has arisen from diverse sources, including legitimate ones, such as imports and domestic production, and illegitimate ones, such as smuggling and tax evasion (see Table 6.15). The situation makes the prices vary significantly, depending on the supply source, i.e., local or imported through legitimate or illegitimate means, and quality, i.e., packaged and branded, unpackaged and unbranded, with or without stones. Moreover, there is a general lack of price regulation across the sites, especially on how rice should be sold across markets (see comments in Table 6.15, above). As a result of this loophole, buyers manipulate the market by constantly crashing prices whenever the supply is high.

Figure 6.12. Domestic milled rice packaged and branded by one of the large mills (A), and unpackaged and unbranded rice from most small mills (B)

Also highlighted by rice traders as constituting a pressure on trading domestic milled rice in the three study sites is a lack of packaging and branding (see Figure 6.12). Unpackaged and unbranded rice is not distributed to viable marketing outlets, such as supermarkets, grocery shops, and stores that could guarantee better prices and a quick turnover and, subsequently, higher returns on investment. This, perhaps, is one reason why even high quality domestic milled rice, i.e., rice milled using stone free technologies, has less marketability than imported rice.

In all three sites, only MIVA Rice in Makurdi was found to carry out modern packaging and branding of its milled rice, and therefore it is the only domestic milled rice found in local supermarkets, grocery shops, and stores at the time of data collection. In contrast, in Gboko and Adikpo the dominant small traders admitted being very much aware of the adverse effects of a lack of packaging and branding on rice trading (see Table 6.15 above for their comments).

6.7.3 Other pressures affecting rice market prices

Table 6.16. Highlights of milled rice traders' exposure to other pressures affecting market price

Pressures	Experiences	References
Frequent changes in rice trade policy	…the policy of the government can change everything. One policy can make it good for you and another can make it worse for you. You look at it now, the ban placed by the government on the importation of rice over land borders has really boosted our market. This is because if you are going to bring rice in through the right channel [e.g., through the ports], there are some expenses [i.e., duties and tariffs] you have to pay. Therefore, by the time you pay these expenses and take the rice to the market, you will discover that the costs will be very high as compared to the Nigerian produced rice and many people may not go for it. Next year, I learnt there is going to be a total ban in 2017, which will increase our marketing activities. So, government policies do affect positively or negatively…	[Trader 5]
Smuggling	…the prices of smuggled rice are lower than that of internally milled rice… if you look at it critically, most of the foreign rice comes into the country through illegitimate means, such as smuggling, to evade tax, and politically motivated import duty waivers. If these issues are taken care of, the price will be higher than domestic processed rice.…	[Trader 5]
Multiple taxation	…in this market, on the same goods, we pay taxes or dues to state government officials, after that local authorities will come with their own different levies. That is not all, buyers, especially those buying in large quantities, will be asked by these same people to pay a produce levy and others charges too. When you add up these charges, they ultimately affect our profit. Also, multiple charges on the markets and roads discourage wholesale buyers from coming to buy from our market place. To worsen the situation, where these people meet your resistance in the process of collecting/extorting these monies, you are in most instances beaten up…	[Trader 19]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

Rice traders across the study sites have reported exposure to frequent changes in rice trade policies by the Nigerian government, a situation that makes investment in the rice business uncertain. According to the traders, changes have been from an open trade policy (i.e. an unbanned, liberalised rice market), to a protectionist policy (i.e., imposition of bans and tariffs), and vice versa (see Table 6.16 above for comments). According to one rice trader (see Table 6.16), each of these policy goals has its advantages and disadvantages, either in the long or short-term. For example, an open, liberalised rice trade policy has the short-term advantage of bringing down the price of rice on the market in the country due to increased annual rice imports. However, in the long-term, the locally produced rice is consistently outcompeted due to low milling quality, and hence investment in the sector is further reduced over time and more rice growers, millers, and traders are forced out of the rice business. On the other hand, a protectionist rice trade policy pushes prices up in the short-term, but in the long-term serves as incentive for investment in the sector that will stabilise prices.

Furthermore, smuggling of foreign rice into Nigeria is cited as a serious problem to the rice value chains (RVCs) in Nigeria, generally for a very long time. According to the rice traders (see Table 6.16) the most worrying aspect is that trade is being undermined by the rice trade policies (e.g., bans and tariffs), such that their impact is often not felt by the traders, and this results to a no-win situation. As the government continues to lose income which could be generated from tariffs on smuggled rice, at the same time the rice sector it seeks to protect remains unable to compete with that smuggled foreign rice and, as a result, growers, millers, and traders are increasingly being forced out of business. Therefore, the country continues to depend on massive rice importation to meet growing consumption demand for rice.

Lastly, domestic rice traders have identified multiple taxation as another pressure confronting domestic rice trading in recent years. Across the study sites, traders reported that locally produced rice is taxed multiple times at different parts of the value chain, e.g., when it is sold as unmilled rice on the market by growers, and both during and after milling as the final product. These various forms of taxation add to production costs, and when they are high they undercut profits (see Table 6.16).

6.8 Sensitivity to market pressures

In this section, the sensitivity components of traders of milled rice in the face of market pressures are discussed (see Figures 6.10 and 6.13).

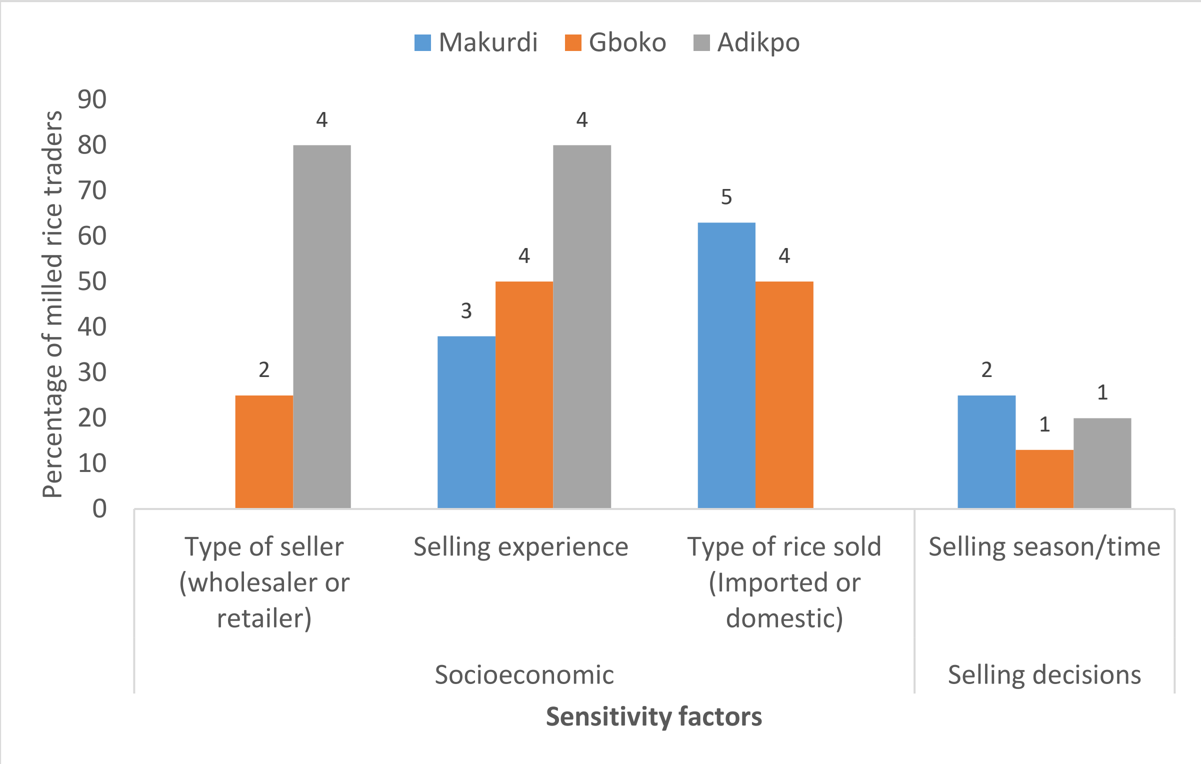


Figure 6.13. Percentage of traders of milled rice who mentioned different factors related to their sensitivity to pressures in the study sites

Table 5.17 below reports the sensitivity of milled rice traders to market pressures by sociodemographic characteristics while Table 6.18 is based on experiences of milled rice traders. These include: their selling experiences; the type of rice they sell, i.e., imported or packaged; unpackaged;, stone-free; or with stones); type of rice trader, i.e., wholesaler or retailer; and selling season, i.e., harvesting or off-harvesting, festive or off-festive. Thus, with regards to the sensitivity of milled rice traders in relation to the sociodemographic characteristics, gender seems to make no striking difference, suggesting that both the female and male milled rice traders are similarly sensitive to market pressures (Table 6.17). Furthermore, Table 6.17 shows that the low income and less educated (e.g. primary education) milled rice traders, including those who depend on selling local rice and those engaged for ≥10 years, seem more sensitive to market pressures than those with middle income, secondary education, who sell either of stone-free local milled or foreign rice and who have been engaged in the business for ≥11 years.

Table 5.17. Factors of sensitivity to market pressures by sociodemographic characteristics of rice milled rice traders

Pressures	Gender		Age			Education level				Income class			Self-identification of trading scale			Years of trading rice			Rice type sold		
	M (n-13)	*F (n=8)*	*20-39 (n=1)*	*40-49 (n=14)*	*50-89 (n=6)*	*None (n=2)*	*Prim (n=7)*	*Sec. (n-10)*	*High (n=2)*	*Low (n=14)*	*Mid (n=6)*	*High (n=1)*	*Small (n=17)*	*Med. (n=3)*	*Large (n=1)*	*1-10 (n=9)*	*11-20 (n=11)*	*>21 (n=1)*	Local *(n=12)*	Stone-free *(n=6)*	Foreign *(n=3)*
Type of seller (wholesaler or retailer)	3(23)	3(38)	-	4(29)	2(33)	1(50)	3(43)	2(20)	1(50)	5(36)	1(17)	-	5(29)	1(33)	-	3(33)	3(27)	-	6(50)	-	-
Selling experience	7(54)	4(50)	-	8(57)	3(50)	2(100)	5(71)	3(30)	1(50)	8(57)	2(33)	1(100)	8(47)	2(67)	1(100)	5(56)	5(45)	1(100)	8(67)	2(33)	1(33)
Type of rice sold (imported or domestic)	7(54)	2(25)	1(100)	3(21)	5(83)	2(100)	3(43)	3(30)	2(100)	4(29)	4(67)	1(100)	4(24)	3(100)	1(100)	4(44)	4(36)	1(100)	5(42)	1(17)	3(100)
Selling season/time	3(23)	2(25)	-	3(21)	2(33)	1(50)	-	2(20)	-	3(21)	1(17)	1(100)	3(18)	1(33)	1(100)	1(11)	3(27)	1(100)	2(17)	2(33)	1(33)

Cells show (n) number of rice traders and, in brackets, within group percentage

Table 6.18. Highlights of factors of sensitivity reported by the rice traders

Pressures	Experiences	Reference
Selling experience	…As a trader with several years of trading in rice, I am quick to perceive the future pressures and the plausible course of action to abate such pressure. For example, I know when to put in more rice for sale on the market and when not to, or when to demand increased or decreased prices…	[Trader 11]
Type of rice sold	…the quality is also very low, mostly with small pieces of broken stones and impurities [e.g., tiny pieces of rice shale and seeds], although not all rice milled in the small rice mills are in this condition. In fact some are of good quality [e.g., stone and impurity free]…	[Trader 9]
Type of trader or seller	…during festive periods, and when schools are in session, the demand is very high and the households frequently purchase in small measures [e.g., by the bushel]. Therefore, the turnover is very quick and this translates into higher profits, sometimes far above the one generated through selling wholesale…	[Trader 20].
Selling season	…throughout the year we normally have wholesale buyers in the dry season, that is from November ending in December. Also, during Easter, between March and April. However, when the rate of production is high, the demand tends to drop. On the other hand, when schools are resuming, we usually have high demand from the students. We also have high demand during the rainy season because most people are unable to mill rice, so those who mill within that period are able to sell easily and at very high prices. When the salaries are paid at the end of the month, we make good sales as well…	[Trader 12]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

6.8.1 Selling experience

More experienced traders are less sensitive to market pressures. As a result of domestic milled rice being overly pressurised on the market by many challenges, such as persisting low prices, competition from high quality imported rice, inefficient local markets, and hostile trading environments, some traders of domestic milled rice count on their selling knowledge and skills to reduce the extent to which they are affected by these pressures. For example, during seasons of low demand for domestic rice, traders are often expected to make certain decisions to manage the situation in order to minimise losses (see Table 6.18).

Furthermore, in many instances, experienced rice traders decide to sell at a very reduced price, provided that the capital invested in the business is recovered. They do this instead of keeping milled rice in storage to allow prices to appreciate, a situation which could result in discoloration and further damage to the quality of the rice. While at other times, retailing may be a better option for higher returns on investment than offsetting the entire stock of rice in storage on a wholesale basis, and vice versa. While in some challenging market situations when the stock of rice available for sale is low, often due to poor quality, "…*experienced traders often offset such rice through credit sales*…" [Trader 10]. By applying knowledge of these types of selling experiences, the degree of sensitivity to market pressures is reduced.

6.8.2 Type of rice sold

Figure 6.14. Various types of rice on the market: (A) Low quality rice milled from small mills, and (B) high quality imported and domestic packaged rice from large mills.

The type of rice sold, imported or domestic milled rice, is sensitive to market pressures. Of the two, imported rice is usually of higher quality, it is well packaged and branded, as is the domestic milled rice (e.g., MIVA Rice) from modern rice mills in Makurdi (Figure 6.14). The remainder of the rice milled at small commercial mills is unpackaged and unbranded. Moreover, because of the variation in quality, demand for the different rice types exists, particularly with reference to location (i.e., villages, semi urban, and urban centres) (see Table 6.18). Therefore, packaged and branded, high-quality rice (i.e., stone and impurity free), either imported or domestically produced, is in high demand in urban centres where household incomes are relatively high. Thus, urban traders tend to be less sensitive to poor prices and preferences for rice types than village traders who sell low quality unpackaged and unbranded rice to low income households.

6.8.3 Type of trader or seller

Generally, two types of traders engaged in the rice business exist across the study sites, retailers and wholesalers. Retailing remains the dominant type of rice trading because during certain seasons of the year, particularly after festive periods (e.g., Christmas) when the demand is low, even wholesalers engage in retailing to remain in business. However, generally, traders who sell wholesale are less sensitive to pressures from poor prices and consumer preferences (see Table 6.18). The quantity or volume of rice involved often serves as an incentive which gives traders the power to negotiate higher prices. Although there are certain seasons when retailing appears to offer more returns, traders selling on a large scale tend to be more resilient to pressures.

6.8.4 Selling season

As highlighted by the traders, the demand for rice consumption also defers to seasonality across the sites (see Table 6.18), as the price of rice often appreciates during festive seasons. Therefore, selling rice at these times or seasons is very profitable, e.g., during the peak of the rainy season between July and September, during the Christmas season in December, and the Easter season between March and April. This helps to reduce the degree of trader’s sensitivity to market pressures, such as: poor prices; preferences for quality and acceptable attributes; and, competition from imported rice due to high consumption demand.

6.9 Adaptation to market pressures

This section discusses the adaptive capacity components of rice traders’ vulnerability, highlighting key similarities and differences across the sites (see Figure 6.10 and Table 6.13, above). While in Table 6.20, the adaptation practices by sociodemographic characteristics of traders is presented.

6.9.1 Current adaptation practice

The current adaptation practice employed by rice traders is discussed here as either: tactical, i.e., short-term; reactive, e.g., employed after the pressure occurs; strategic, i.e., long-term; or, anticipatory or preventive, e.g., employed well before the pressure occurs (see Table 6.19, below). These adaptive practices are complementary and are often employed in combination, usually in relation to managing or coping with market demand and supply as they affect prices (highlighted mostly in Tables 6.21 and 6.22 below) and market prices (highlighted in Table 6.23 below).

Table 6.19. Percentage of milled rice traders who adopted different adaptation practices in the three study sites

Type of adaptation	Source of pressure	Example of adaptation	Makurdi (n=8)	Gboko (n=8)	Adikpo (n=5)
Tactical reactive	Price crashes	Adjusting prices and weights and measures	4 (50%)	3 (37.5%)	2 (40%)
		Making or minimise credit sales	4 (50%)	3 (37.5%)	1 (20%)
		Engaging in customer relations	2 (25%)	2 (25%)	1 (20%)
	Poor prices, lack of price regulation	Having dialogues with customers		3 (37.5%)	1 (20%)
Strategic anticipatory		Diversifying to other crops and income sources		1 (12.5%)	1 (20%)
	Poor prices, multiple taxation	Joining cooperatives	2 (25%)	4 (50%)	2 (40%)
	Preference	Sensitising to the pressure	1 (12.5%)		
	Competition between imported and domestic milled rice	Promoting and advertising	1 (12.5%)		
	Multiple taxation, smuggling, and sabotage	Seeking government intervention	1 (12.5%)		
Tactical reactive		Selling the highest quality	1 (12.5%)	2 (25%)	2 (40%)
		Switching to stone free		1 (12.5%)	
	Poor price, lack of wholesale buyers	Taking turns to sell	1 (12.5%)	1 (12.5%)	1 (20%)
		Selling either to retailers or wholesaler, or both	1 (12.5%)	2 (25%)	3 (60%)

N denotes the total number of rice traders interviewed at each site and, in brackets, within group percentage

Table 6.20. Adaptation practices by sociodemographic characteristics of traders

Type of adaptation	Adaptation	Gender (n=30)		Age			Education level				Income class			Self-identification of trading scale			Years engaged as rice trader		
		M (n-13)	*F (n=8)*	*20-39 (n=1)*	*40-49 (n=14)*	*50-89 (n=6)*	*None (n=2)*	*Prim (n=7)*	*Sec. (n-10)*	*High (n=2)*	*Low (n=14)*	*Mid (n=6)*	*High (n=1)*	*Small (n=17)*	*Med. (n=3)*	*Large (n=1)*	*1-10 (n=9)*	*11-20 (n=11)*	*>21 (n=1)*
Tactical reactive	Adjusting prices and weights and measures	6(46)	3(38)	1(100)	8(57)	-	-	4(57)	4(40)	1(50)	8(57)	-	1(100)	8(47)	-	1(00)	6(67)	3(27)	-
	Making or minimise credit sales	6(46)	2(25)	-	5(36)	3(50)	2(100)	1(14)	5(50)	-	4(29)	4(67)	-	4(24)	3(100)	-	4(44)	3(27)	1(100)
	Engaging in customer relations	3(23)	2(25)	1(100)	4(29)	-	-	4(57)	1(10)	-	5(36)	-	-	5(29)	-	-	4(44)	1(9)	1(100)
	Having dialogues with customers	2(15)	2(25)	-	3(21)	-	-	2(29)	2(20)	-	2(14)	1(17)	-	3(18)	1(33)	-	1(11)	2(18)	1(100)
Strategic anticipatory	Diversifying to other crops and income sources	1(8)	2(25)	-	3(21)	-	-	1(14)	1(10)	1(50)	2(14)	1(17)	-	2(12)	1(33)	-	2(22)	1(9)	-
	Joining cooperatives	6(46)	3(38)	1(100)	6(43)	1(17)	-	4(57)	4(40)	1(50)	7(50)	2(33)	-	7(41)	2(67)	-	3(33)	6(55)	-
	Sensitising to the pressure	1(8)	1(13)	-	1(7)	-	-	-	-	1(50)	-	-	1(100)	-	-	1(00)	1(11)	-	1(100)
	Promoting and advertising	1(8)	1(13)	-	1(7)	-	-	-	-	1(50)	-	-	1(100)	-	-	1(00)	1(11)	-	1(100)
	Seeking government intervention	1(8)	1(13)	-	1(7)	-	-	-	-	1(50)	-	-	1(100)	-	-	1(00)	1(11)	-	1(100)
Tactical reactive	Selling the highest quality	3(23)	2(25)		4(29)	1(17)	1(50)	2(29)	2(20)	-	4(29)	1(17)	-	4(24)	1(33)	-	2(22)	3(27)	-
	Switching to stone free	1(8)	1(13)	-	1(7)	-	-	-	-	1(50)	-	-	1(100)	-	-	1(00)	1(11)	-	-
	Taking turns to sell	3(23)	1(13)	-	3(21)	-	-	1(14)	1(10)	1(50)	1(7)	1(17)	1(100)	1(6)	1(33)	1(00)	3(33)	-	-
	Selling either to retailers or wholesaler, or both	8(62)	2(25)	-	9(64)	1(17)	-	3(43)	6(60)	1(50)	7(50)	2(33)	1(100)	7(41)	2(67)	1(00)	6(67)	2(18)	1(100)

Cells show (n) number of rice traders and, in brackets, within group percentage.

Table 6.20 reveals that among sociodemographic factors, self-identification of trading scale is importance for adapting to market pressures, as medium size milled rice traders seem to be adapting to pressures more than the small ones. This is because of their size, they are able to absorb and neutralised the effects of pressures. In addition, the table suggests that female milled rice traders are adapting to pressures better than their male colleagues. This is probably explained by the fact that female traders seems to have better customer relations skills than their male counterparts, and are able to make good sales using their relational skills (Table 6.20). Aside from these, adaptation of milled rice traders to pressures seems to cut across age groups, educational attainment, income classes and years engaged as rice trader.

Table 6.21. Highlights of adaptive practices employed by rice traders

Pressures	Experiences	Reference
Adjustment of price, and weights and measures	… Adjust weights and measures of rice down [i.e., resize the measurement] during off-harvesting season when the supply is low and prices are higher...	[Trader 20]
	… There are seasons that you know that existing prices cannot attract many buyers because it is an off-peak season when the market is usually very slow [e.g., low demand]. What I do in such situations is that I try to maintain the lowest price that will enable me to break even without minding whether profit is made or not, while at the same time ensuring that I incur no losses…	[Trader 5]
Credit sales	…I do supply rice to boarding schools within Gboko on credit, but for the schools to pay back the money they owe me has always been a challenge. Sometimes, it takes several months before I get my money back, so the credit situation here is not good for business…	[Trader 14]
Customer relations	…. in order to sustain our customers, I treat our customers well by ensuring they buy the best quality available in the right measure of quantity…	[Trader 9]
	…giving discount and signing credit sales agreements enable me to keep the confidence and trust of my customers…	[Trader 5]
Dialogue with customers	…when prices are poor or high to the point that either of the parties [traders or buyer], especially those buyers who move from wholesale to retail, are unable to breakeven, we invite them to a round table where we resolve our differences and they can come back to buy…	[Miller 9]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

Rice traders have reported that the prices of rice are lowest during the peak supply months (i.e., the harvesting season from November to the beginning of December), and gradually appreciate from mid-December to August (see Table 6.21). This is because rice is not just a staple food eaten at normal mealtimes, but is also one eaten during festive seasons and ceremonies, such as at Christmas and at weddings and conferences. Therefore, at such periods, prices, weights and measures are usually adjusted or reviewed, either up or down, to correspond with the changes in demand and supply to avoid incurring losses. However, adjustment of weights and measures is only possible with unpackaged and unbranded rice, and therefore only practiced by traders of this type. Moreover, according to the traders there is usually a trade-off between the adjustment of prices, weights and measures and the volume of sales because traders who lower their prices during some periods may record a high volume of sales, but no profit.

Moreover, during the seasons of low demand described above, traders carry out credit sales to offset very low-quality rice that is liable to decompose and/or discolour if left in storage for a long time. They provide credit sales to regular customers who take a certain quantity of rice, either without any payment, or after a deposit is paid, at which point an agreement is signed that payment will be made in the future, or periodically. While credit sales go some way to help rice traders to reduce income losses owing to poor milling quality and prices, there are certain seasons and conditions when this becomes a source of income loss, and thus becomes a further pressure to which rice traders are exposed (see Table 6.21). For example, during the off-harvesting season when the peak supply season is over and prices have gone up, this is often when buyers default on a credit sales agreement, and do so repeatedly.

Good customer relations is another practice employed by rice traders across the sites to maintain their customer base. As prices and weights and measures of rice are deregulated, good customer relations are key to boosting confidence and building trust among customers. Thus, rice traders, especially retailers, ensure that their customers are fairly treated and that they receive value for their money. One way they do this is to give discounts (see Table 6.21 above).

In addition to good customer relations, rice traders engage in a sort of dialogue as a collective way of resolving pressures relating to the fixing of prices, weights, and measures during certain seasons (see traders' comments on Table 6.21). One key strength of this practice is that it ensures no parties involved in trading of milled rice, traders or buyers, benefit at the expense of the other. By employing this practice of meaningful dialogue between the parties, and in the absence of regulation of prices and weights and measures, certain exploitive tendencies, especially among intermediaries, can often be reduced.

Table 6.22. Highlights of adaptive practices employed by rice traders

Pressures	Experiences	Reference
Diversification	… in order to augment our capital, we sell our farm produce, such as groundnuts, and reinvest into this market…	[Trader 19]
Cooperative/ union/association	…Yes, we have our association here that seeks to regulate prices. When they notice that there is a price difference in the market what is usually done is to identify the traders involved and sanction them with fines. Not only this, we settle differences too. If someone fights over a customer here, you are suspended… the association has made it mandatory that no individual member is allowed to take another member to the police… the association handles all cases internally and, if need be, they are the ones who involve the police …	[Trader 2]
Sensitisation, Promotion and advertisement	…in the cause of marketing our product, the marketing department travels to most of these areas and identifies the key marketers of rice. We approach them and give them our proforma invoice of how much we are selling, but before then we sample the market and see the prevailing prices of brands. At other times, we do some promotional activities and adverts, such as giving out our fliers to people to look at and then contact us. Then, we attend some exhibitions and display our products there for everybody to see. Because we are beginning to sensitise the Nigerian populace, so most of them are beginning to know the importance of eating the fresh rice produced locally, rather than imported rice, which mostly does not add any nutritional value to their lives…	[Trader 5]
Seek government intervention	…whenever smuggling of foreign rice and/or sabotage, like in a situation where importers of rice buy huge quantities in the markets to create artificial scarcity and force the government to change regulations on imports, it puts pressure on our business. We approach the government through the leadership of our union or association, the Nigerian Rice Millers Association (NRMA), so that the government is able to strengthen security in those areas we believe rice is smuggled through. We approach some of these agencies that are responsible for smuggling, like the Nigerian Customs and Immigrations that man some of these borders… Although, this has not been very effective, but at least it is helping our business to some extent...	[Trader 5]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

A number of rice traders also reported diversifying to other grains, so that in the event of market failure due to poor prices the income generated from multiple sources can act as a buffer. Although most rice traders are usually reluctant to diversify to other grains, such as maize, guinea corn, and soybeans, a few who have adapted this practice found it very promising, especially as a measure to augment income and for reinvestment (Table 6.22).

Participating in a domestic rice trading cooperative or union is a collective response to pressures from poor prices, deregulation of weights and measures, and local loans which are difficult for individual traders to handle or access. Cooperative and trading unions provide a platform for traders to present a common front, this is needed to: negotiate better prices for members; resolve disputes between traders and buyers, and between traders or buyers themselves; sanction erring members; and, organise internal credit and loan facilities for members to invest and reinvest as such needs arise (see Table 6.22).

Another newly employed strategy among the large traders is sensitisation of the public to the quality and nutritional benefits of eating domestic milled rice. Due to poor food labelling regulations, consumers of most of the imported rice sold in most Nigerian markets are not aware of the expiry date of the rice they consume. Therefore, producers of packaged and branded rice in Nigeria presently use this failure to their advantage; they tell customers about the dangers of consuming imported rice, that its safety cannot be guaranteed by traders. According to one trader, the benefits of sensitisation to the consumption of domestic milled rice are beginning to take root, not only among the large rice traders, but also among the small producers (see Table 6.22).

In addition, some of the large millers in Makurdi, such as MIKAP Nigeria Limited (the producers of MIVA Rice) embark on promoting and advertising their brand. They also seek government interventions at times when: they require capital through loans; they experience low demand and price crashes as a result of foreign rice being smuggled into Nigerian markets; and, they require protection from sabotage by the rice importing companies (see Table 6.22).

Table 6.23. Highlights of adaptive practices employed by rice traders

Pressures	Experiences	Reference
Selling the highest quality rice	…The highest grade is usually offered at the highest price and, in most situations, the most demanded rice. However, even the best varieties of rice, like long grains [e.g., FARO 44 and 52], if not properly milled will be sold for a lower price…	[Trader 20]
	…I do not just sell, but I make sure that what I am selling is the best quality. I do this in order to maintain my customers. I do not allow them to buy and return to complain because I select the best quality and I have minimised credit sales…	[Trader 1]
Switching to stones free rice	…switching to stone-free rice at the time of persistent change in demand, even among low income buyers, saves me from incurring serious losses…	[Trader 9]
Taking turns to sell	"…we also decided that we would sell in turns, such that if a customer comes and it is your turn you just follow the person to the display point and sell. But if any other seller tries to drag the customer away, as is often the case, we decided that such a person should be fined half a bushel of rice...	[Trader 13]
Selling at retail or wholesale, or both	…for me, selling rice at wholesale is most profitable, in fact those who sell on a wholesale basis make more profit and incur less transport expenses than those who sell at retail. The retailers also suffer losses in the event of price changes like we are currently facing...	[Trader 2]
	…when I sell in bulk [wholesale], we make less profit than when we retail [sell in small quantities], but we prefer to sell in bulk because we get profits from the quick turnover. Eventually, selling in bulk creates more gains than retailing. In addition, if I sell at the retail price, I normally use the profit for something else, but selling at wholesale helps me to get profit in both time and in bulk…	[Trader 15]

For social demographic characteristics of milled rice traders, refer to appendix 6.2

Clearly**,** selling the best quality rice attracts more buyers, and subsequently higher prices, therefore traders must strive to do so. This is because the market demand for rice is driven by quality. As a result, marketing of domestic milled rice in the study sites was characterised by a strong preference for high quality milled rice (see Table 6.23). Due to this, milled rice is graded in the market, where: A is the highest quality, with attributes of being stone- and impurity-free, and having long and polished grains; B is the average quality, which means it usually lacks one of the attributes of the A grade rice; and C is the lowest quality, often unpolished and with stones and impurities. Selling the best grade provides quick turn over, moreover, ensuring good quality for sale is easy, cheap, and it does not require formal training.

In addition to selling the highest quality of rice, small traders, especially those selling domestic milled rice, occasionally switch to selling stone-free rice. This practice is reactional and often employed in the short-term during festive periods and when boarding schools are in session, at which times the demand for such quality of rice is high (see Table 6.23).

Also employed is the practice of taking turns to sell rice. This is a reactive strategy that is usually put in place by rice trade unions or associations to manage situations in the face of deregulation of prices, weights and measures. The advantage of taking turns to sell rice is that by enforcing this strategy market supply is controlled and prices are maintained. Thus, during periods of high market supply, the association assigned traders to sell at a given time. At this time, a trader can sell a quarter of the quantity of rice they had expected to sell, and then another group of traders must sell on the same basis.

Lastly, rice traders have reported the practice of selling either on a retail (i.e., small quantities), or on a wholesale (i.e., large quantities) basis, or both. According to some retailers, if they have an opportunity to sell all their rice at once, doing so gains them a higher profit. Conversely, some wholesalers reported selling in small quantities (retailing) because doing so gives them a higher profit. However, in the event of sudden changes in price, which they frequently experience, retailers are often the worst affected (see Table 6.23, above).

In summary, the results of exposure, sensitivity and adaption by sociodemographic characteristics presented above (chapter 5 and this chapter) highlighted, firstly that there is no clear overall pattern to exposure, sensitivity and adaption of RVCs' actors to pressures in Benue State. Consequently, this indicates that there is no single sociodemographic characteristic or variable that seems to be regularly associated with the vulnerability of RVCs' actors (e.g., rice growers, millers and traders) to multiple, combined pressures in Benue State. This leads to the next section: the interactions of the effects of pressures along the parts of the RVCs as revealed in the interviews with the RVCs' actors.

6.10 Interactions of the effects of vulnerability of downstream parts of the RVCs

The analysis of data presented in chapters (i.e., 5 & 6) revealed a number of interactions of the effects of vulnerability on the downstream components of the RVCs. Table 6.24 highlights the various ways by which the exposure, sensitivity and adaptive strategies of growers, millers and traders to multiple pressures affect each other along the chain. These include: (i) low production of rice quantity; (ii) production of low-quality rice; and (iii) processing or milling of low-quality rice.

Table 6.24. Downstream interactions of the effects of growers, millers and traders' vulnerability

Vulnerability interaction	Actor 1	Actor 2	Quotes
The vulnerability of rice growers may result in low production, which is a pressure on millers and traders. The adaptive strategy of millers is often the temporary shut-down of their business.	Rice growers	Millers	….On other occasions, we do stop milling because the raw rice (paddy) is inadequate. …This usually happens in the month of January when the quantity of raw rice supplied is almost nil or very small… sometime this situation continues until March, when normal production resumes…[Miller 19]. …. but we do not have control over drought or rainwater shortages that affects rice yields (quantity produced)… [Grower 21].
The vulnerability of rice growers may result in the production of low-quality rice. This is a pressure on millers, who do not appear to have any adaptive strategy to respond to this pressure.	Rice growers	Millers	….The overall effect of these weather changes on my farm in these years is that there is not enough rainfall during the maturing of the rice; the grain quality is affected…[Grower 1]. ... I experienced weeds …insects, diseases, and rodents…and when these are not managed or controlled …..if I allow weeds to grow they increase the difficulty of harvesting rice and even after the rice is harvested … the rice is not clean. This results in poor quality and price… [Grower 1]. …One thing we do to solve this problem of poor milled quality is that I try to avoid buying unmilled rice that has stones, or that is not properly threshed. This means that buying quality unmilled rice from growers is key to enhancing the quality of milled rice. If you do not get it at the outset, forget it. No matter what you do during milling, the quality will be bad... [Miller 1].

For social demographic characteristics of growers and millers, refer to appendix 5.1

Table 6.24. Downstream interactions……continued

Vulnerability interaction	Actor 1	Actor 2	Quotes
The vulnerability of millers may result in the production of low-quality rice. This is a pressure on traders, who do not appear to have any adaptive strategy to respond to this pressure.	Millers	Traders	…parboiled rice is open dried on tarred road surfaces, as a result small pieces of stone are mixed with the rice, contributing to poor quality during and after milling, which goes right to the market… [Miller 3]. …our reliance on weather [i.e., sunshine] to dry parboiled rice is the reason I and others here always experienced either high moisture content in rice in the rainy season, or very low moisture content in the dry, Harmattan seasons, which causes splitting of rice during milling, and decomposition after milling… so that selling it becomes very difficult…[Miller 10]. ……the quality is also very low, mostly with small pieces of broken stones and impurities [e.g., tiny pieces of rice shale and seeds], although not all rice milled in the small rice mills are in this condition…[Trader 4]
The vulnerability of millers may result in the production of low-quality rice. This is a pressure on traders, who do not appear to have any adaptive strategy to respond to this pressure.	Millers	Traders	…We do rice boiling using firewood. In wet weather condition, the costs of dried firewood goes up. Therefore contributing to high costs parboiling and ultimate high processing costs….[Miller 1] ….We are frequently incurring a lot of losses in milling business because of the rice will often buy from growers do contain high moisture. So by the time we are crushing it, a large quantity is destroyed…So to remain in the business, we had to pass the losses on to traders… [Miller, 6].

For social demographic characteristics of millers and traders, refer to appendix 5.1

6.11 Validation of results

In this section, the results of this study on the vulnerability of rice millers and traders to multiple, combined pressures in Benue State are validated (see Tables 6.25 and 6.26). To do this, two participatory workshops were held with a group of rice millers and traders in Makurdi and Adikpo.

6.11.1 Validation of results on vulnerability of rice millers to pressures

Table 6.25 below presents the results of the validation exercise with rice millers in the two locations.

Table 6.25. Weak spots of the RVCs system identified by rice millers

Site	Weak spots	Main reasons	Other reasons
Makurdi	Milling	-Lack of modern machines	-Lack of spare parts. -Rice supply shortfall
	Milling	-Poor quality milling machines	-Limited access to capital to invest in modern milling facilities
	Milling	-Inadequate investment in milling machines	-Limited storage, electricity, and roads -Less preferred varieties
	Rice trading	-Poor price	-Limited market access -Inadequate farmland
	Production	-Lack of good varieties	-Poor milling quality -Poor storage conditions
	Milling	-Lack of good varieties	-Lack of small milling machines
	Production	-Poor varieties and poor seeds	-Poor milling infrastructure
Adikpo	Milling	-Very low-end milling quality	-Lack of modern milling capacity
	Rice trading	-Poor prices	-Poor condition of rural roads and networks
	Rice trading	Declining household's income	-Lack of good varieties -Lack of improved seeds
	Milling	Poor rice milling infrastructures	-Lack of electricity and roads, and high cost of diesel
	Milling	Artisan equipment	-Limited investment in modern milling technology -Poor rice varieties
	Milling	Use of artisan equipment	-Use of outdated milling machines -Low market access
	Milling	Poor machines	-Poor seeds and varieties

During the workshop, participants from Makurdi and Adikpo identified rice milling as the weakest point in the RVCs in Benue State (see Table 6.25 above). However, some participants identified trading of milled rice and production as the main weak points. Participants highlighted a number of factors they perceive to be responsible for the weakness of rice milling in the region. The most prominent factor, which was cited repeatedly as either a major or 'other' reason in both Makudi and Adikpo, was the lack of modern milling machines and infrastructure in the conventional commercial rice mills which serve the majority of small rice millers across the study sites (see Table 6.25, above).

The second factor is inconsistency in the supply of good rice varieties and uniform grains to the rice mills. According to the millers, this weakness is caused by the use of poor seeds and methods of harvesting, such as the lack of mechanisation, and also by poor storage. While inconsistency in supply of quality paddy to mills stems from rice production, it has ripple effects on the downstream components of the RVCs, the milling and trading of the rice. The last reason cited by the workshop participants was poor prices of domestic milled rice on the market. This is an issue which is believed to be rooted in the poor quality of milled rice resulting from the first and second factors cited above.

The results of the workshop with the millers which has been presented here (see Table 6.25), partly overlap and partly differ from the other results. For example, in the workshops, CCV-related pressures, such as flooding, water shortages, sunshine duration, and the harmattan wind, were not cited. However, the use of obsolete rice milling technologies, lack of mechanization, poor prices, and poor storage conditions with regard to poor quality domestic milled rice were highlighted in both workshop locations, Makurdi and Adikpo. These pressures validate the ones reported by rice millers with respect to their vulnerability (see the VSD in Figure 6.10, above).

6.11.2 Validation of results on the vulnerability of rice traders to pressures

Table 6.26 below presents the results of workshops conducted to validate the results on rice traders' vulnerability to pressures in Makurdi and Adikpo.

Table 6.26. Weak spots of the RVCs identified by rice traders

Actor	Weak spots	Main reasons	Other reasons
Makurdi	Production	-Poor variety	-Rice supply shortfall -Poor rice handling
	Milling	-Lack of quality milling machines	-Use of outdated milling machines
	Milled rice trading	-Low demand for domestic milled rice	-Consumer preference for high quality imported rice
	Milled rice trading	-Lack, or limited numbers, of wholesale buyers	-Lack of investment in packaging by local rice mills -Inability to invest in modern technology
	Milling	-Lack of modern milling technologies	-Poor milled grain quality, i.e., impurities and variable grains
Adikpo	Milled rice trading	-Low demand in certain seasons	-Lack of modern milling capacity
	Milled rice trading	-Poor milled quality	-Poor prices -Varying weights and measures
	Milled rice trading	-Low market demand	-Poor milled end quality
	production	-Poor quality of harvested rice	-Lack of modern machines
	Milled rice trading	-Poor prices	-Weak trading union or cooperative -Low demand for domestic milled rice

The results (see Table 6.26) revealed that trading of milled rice is the weakest aspect of the RVCs. Furthermore, participants equally identified milling and production to be equally weak. However, there were differences in perceptions between the two workshop study locations. In Makurdi for example, participants were of the view that both trading and milling are the weakest points on the RVCs map. However, in Adikpo participants pointed to trading of milled rice as the weakest point on the mentally generated RVCs maps.

Across the sites, low demand and poor prices for domestic milled rice were cited by the majority of participants as the main reason for the trading of milled rice to be perceived as the weakest point on the RVCs maps. Each of these pressures is linked to the poor quality of domestic milled rice, which is caused by the use of artisan and outdated milling technologies and infrastructure. In Makurdi, traders emphasised the poor quality of rice milling technology as undermining the end quality of milled rice on the market. Meanwhile, in Adikpo, some participants expressed a contrary view, they claimed that seasonal changes in demand for domestic milled rice is responsible for the challenges faced by the trade of milled rice in the area.

The pressures highlighted by this workshop are similar to ones identified previously as impacting the vulnerability of rice traders to pressures in Benue State: poor prices; low demand; or low preference for domestic milled rice; and poor milling technologies (see Table 6.26). These notwithstanding, other market pressures, which are either directly or indirectly impactful on the prices of milled rice, were not cited by the workshops' participants, these include: multiple taxation; smuggling of foreign produced rice; and frequent changes in rice trade policy by the Nigerian government.

In summary, the pressures on RVCs presented here correspond to the structural vulnerability of the RVCs. However, the overlaps or divergences among different actors, millers and traders, revealed the differences in perceptions, experiences, and concerns of different actor groups along the RVCs. Thus, the need for wider consultation on policy formulation in the Nigerian rice sector is emphasised, and this is discussed in the following section.

6.12. Discussion

Although rice millers and traders are constantly exposed to pressures arising from severe weather variation, the findings in this chapter showed that rice millers and traders perceived themselves as most vulnerable to market pressures, rather than to climate change. Basing the rest of the discussion on this premise, the perceived weaknesses and strengths of the current adaptation practices employed by rice millers and traders in response to CCV and markets in the three study sites are highlighted to help shed light on the sources of vulnerability. These include four issues: upgrading rice milling technology and infrastructure; addressing uncertainties and/ or trade-offs, especially in rice trade policy; collective adaptive practices; and the adoption of anticipatory (long-term or preventative) adaptive practices. It is suggested here that these correspond to leverage points from which policy discourse on interventions for the reduction of vulnerability and construction of resilience can stem.

6.12.1 Rice milling technology and infrastructure

The capacity of a system to successfully adapt to multiple, simultaneous pressures, increases with the availability of, and access to, technology and infrastructure as investments in structural measures (Ericksen, Ingram, & Liverman, 2009; Laroche Dupraz & Postolle, 2013; Mertz, et al, 2009; Smith & Pilifosova, 2001) More so, recent research into the rice industry in SSA has increasingly demonstrated that the capacity of the rice sector to respond to growing internal demand for high quality rice and to effectively compete, both on the local and global market, depends on upgrading the entire RVC system, from production to milling to marketing (Adjao & Staatz, 2014; Demont & Ndour, 2014; Demont, 2013). Moreover, these studies argued that the modernisation of rice milling technologies and infrastructure should be made a priority to improve the performance and competitiveness of a value chain (Demont & Ndour, 2014; Demont, 2013).

However, in the specific case of Benue State, this study finds that most milling infrastructures and technologies used in the majority of the rice mills, with the exception of MIVA Rice and a few of the Gboko rice mills which have de-stoning machines, were either artisanal or obsolete. As a result, millers frequently engaged in several technical actions, such as: routine maintenance of milling machines; training of machine operators; fixing new spare parts; collaborating with experts for technical advice, e.g., from large millers; and changing drying techniques to enhance milling quality. However, these actions were inadequate to enhance the quality of local milling, to meet the demand for high quality rice and to compete with imported rice.

In most of the rice mills in Benue State, the common artisanal or obsolete equipment used includes: constructed boilers, or drums, that use only firewood as an energy source to soak and steam the rice; cemented slabs and other paved surfaces for drying steamed rice; and Blackstone and Ruston machines to mill the rice (Akpokodje et al., 2001). Each of these technologies is outmoded and can only be manually calibrated, which makes parboiling and milling of high quality grains nearly impossible. This is mainly due to their design limitations which mean they cannot perform certain quality enhancing operations, such cleaning and removing impurities, grading the grains into long or short, and polishing or whitening the grains (Demont et al., 2012; Fiamohe et al., 2015). As a result, the quality of local milling in Nigeria has consistently remained very low, and is therefore unable to meet the demand for high quality rice, especially for urban consumers, or to compete with high quality imported rice on the Nigerian market (Awoyemi, 2004; Demont & Ndour, 2014; Tiamiyu et al., 2014). This has been the situation not only in Nigeria, but in most West African countries, such as Senegal, Togo, Cote d'Ivoire, and Benin, where there is high dependency rice imports (Bamidele et al., 2010; Demont et al., 2012, 2013; Fiamohe et al., 2015). However, it is important to acknowledge that while technological solutions, such as investments in modern rice milling technologies and infrastructures, are key to enhancing the capacity of the RVC system to cope with pressures (e.g., economic/markets, opening markets, others), technological measures alone may be inadequate (Ericksen et al., 2009) and, in some instances, may result in maladaptation (Eakin & Luers, 2006; Niang et al., 2014). This is possible, for example, in situations where investments in technology projects are abandoned as a result of unsustainable political will, frequent changes in government and private sector leadership, and administrative structure in Nigeria.

6.12.2 Uncertainties and tradeoffs

Various scholars (O'Brien & Leichenko, 2000; Ericksen et al., 2009; Ericksen, 2008; Füssel, 2007; Stave & Kopainsky, 2015; Thompson & Scoones, 2009; Vermeulen et al., 2012) have suggested that successful adaptation depends on how the present and future uncertainties in the nature and magnitude of pressures and tradeoffs between and policies and adaptive responses themselves are factored and addressed. Thus, the results of this study revealed that rice milling and trading in Nigeria are characterised by uncertainties not just in the changing weather and market prices, but also in the spare parts market, exchange rates, and rice trading policies. These uncertainties limit private sector investments in the rice sector generally.

Furthermore, in Nigeria Maduabuchi & Arene (2012) have shown that instability in the exchange rate over the years has exacerbated the uncertainties which surround the importation of milling machines and spare parts, hence millers cannot foresee what the future cost of spare parts might be. Similarly, also in Nigeria, Maduabuchi and Arene (2012), Obi-egbedi et al. (2012), and Ogundere (2007) showed that frequent changes in rice trade policy, from liberalised (i.e., no bans) to protectionist (i.e., with bans and tariffs), have created an uncertain atmosphere for investment. This is because these policies affect the supply, especially imports, and demand of locally produced rice on the market and, by extension, its market price and income for actors, especially small rice producers in Nigeria.

Apart from the uncertainties discussed above, millers and traders must make some trade-offs between responses in the face of global changes, such as CCV and economic issues. For example, during the peak rainfall period, when managing moisture content in parboiled rice becomes more challenging owing to uncertainties in weather and the use of artisanal equipment, there is a trade-off between the quantity of rice milled and the end quality of that milled rice. As a result, millers seeking better rice quality often reduce the quantity they normally process in order to manage moisture contents, this means the quality of the rice they process is not compromised, even though it also means their income is reduced.

Moreover, due to poor prices and the low market demand for domestic milled rice, traders seeking to boost their income often have to trade-off between wholesaling (selling in large quantities, but at lower prices) and retailing (selling to households in small quantities at higher prices). Based on the foregoing discussion, a context specific understanding of how rice millers and traders make management decisions in the face of uncertainties and trade-offs might shed more light on their responses to multiple pressures. Such understanding may be helpful to the responses made to pressures, currently and in the future.

6.12.3 Collective action

Successful adaptation hinges on the adoption of collective action, which makes actors, both strong and weak, work in group(s) via mutual leverage of the capacity of others to form a unified force which adapts to pressure more effectively (Aniekwe, 2010; Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2013; Demont & Ndour, 2014; Feola, et al., 2015; Pretty, 2008; Totin et al., 2012). Specifically, in Benue State this study shows that most of the practices employed by rice millers in response to pressures were individual actions. It was only in response to recurring and/or economic/market pressures that collective actions were employed. These pressures included: flooding, wet weather, and limited sunshine; poor prices; and the lack of capital to meet energy costs and invest in new machines and spare parts. Some of the collective actions often employed in such circumstances include: temporarily relocating in the event of flooding; taking turns to dry parboiled paddy during wet weather; and, taking out cooperative loans to meet operational and management costs. In contrast to the millers, this study found that most practices adopted by the traders in response to market pressures were collective actions. For instance, local traders often take advantage of low supply and high demand to raise prices, while weights and measures are reduced. Moreover, other traders embarked on customer relations exercises and dialogues to keep existing customers and win new ones, while others sensitised the public by persuading them to eat domestic milled rice, or they sought financial interventions from government, or took turns to sell their rice during periods of low demand.

While adoption of collective practices have proven helpful in fostering unity among millers in terms of pooling resources to invest in modern post-harvest enhancing technologies (Darnhofer, et al, 2016), their wide adoption is often constrained by the individualistic tendencies of rice millers. Given that the private ownership of rice mills and that social networks, such as growers-millers' or millers-traders' networks, are only just beginning to be formed in Makurdi and are not widely spread to Gboko and Adikpo rice mills, management of issues relating to maintenance and operational costs is often done solely by owners, with no involvement with other millers at the same mills. The inability of millers to work collectively may indicate a lack of, or at least weak, social networks, especially among the small millers.

However, collective adaption practices should be supported, so that in the absence of government support RVCs actors can pool resources together to bridge gaps created by limited support. One common example is that rice millers or traders form networks such as cooperatives, unions, and associations where they collectively invest in modern machines and infrastructures to enhance their milling quality. Similarly, in Cote d'lvoire Becker & Yoboue (2009) showed that local rice networks became the sole source of domestic commercial rice when the state removed subsidies for fertiliser and modern seeds, privatised agricultural extension services, and liberalised prices and import policies. This suggests that, in Benue State, another key means for reducing vulnerability may be to strengthen social networks, such as cooperatives, which would then increase the capacity of millers and traders to access finance for collective investment in machines and equipment (Darnhofer, et al. (2009).

6.12.4 Anticipatory and long-term adaptive practices

The success of adaptation practices or actions depends on timing, especially whether they have been employed well before the pressure occurs (anticipatory or preventive), and they must be long-term to be effective in the curtailment of the adverse effect of pressures (Biagini, et al., 2014; Smit & Skinner, 2002; Smith & Olga, 2001; Tendall et al., 2015).

In the specific case of Benue State, this study (see Tables 6.6 and 6.13) shows that most of the practices employed by rice millers and traders were reactive and short-lived. Thus, they only responded to imminent pressures and once the impact subsided, the practices were discontinued. As this study has revealed, the tendency to employ more reactive, short-lived adaption practices than anticipatory, long-term practices has been observed among RVCs actors, i.e., growers, millers, and traders, in Benue State, just as others have observed among crop growers, wine growers, and wineries in India, California, and Mozambique (Harvey et al., 2014; Nicholas & Durham, 2012; O'Brien et al., 2004). As demonstrated by these studies, anticipatory or preventive actions taken well before pressures occur often require substantial investment, hence most millers, especially small ones with limited capital, may be reluctant to invest in adaptive responses to certain pressures if the effects and benefit are not immediate, in fact they may tolerate these until they reach a certain impact threshold. For example, a miller may not invest in modern milling machines or replace a worn out spare part if it is expensive, except when the machine is completely worn out or the quality of rice produced is likely to be rejected by traders and buyers. Also, rice traders resist entering new markets except when the existing ones prove very unprofitable. This may be some of the reasons why anticipatory and preventive practices, although holding much promise, are employed less often by the majority of millers and traders in the study sites.

Nevertheless, anticipatory and preventive adaptation practices employed on a long-term basis are needed to enhance the capacity of the local milling industries to process high quality rice that can compete with imported rice on the Nigerian market, and as such they should be encouraged. As Demont et al. (2013) pointed out, if they are to be successful, long-term investment to enhance the quality of domestic rice must not be limited to that which aims to increase milling capacity, such as the purchase of modern de-husking machines, but must include improvement in consumers' perceptions of quality, through branding, promoting, and advertising, in order to increase the demand for domestic rice,. In other West African countries, such as Togo, Benin, and Senegal, a number of studies have shown there is hope that long-term investments in such RVCs upgrading will pay off, not only in enhancing the capacity for domestic rice to meet the growing demand for high quality rice, but also in redeeming its bad reputation on the African market, thus enabling it to effectively compete with imported rice (Demont et al., 2012, 2013; Fiamohe et al., 2015).

6.13 Summary and conclusion

This chapter has analysed the components of vulnerability, namely exposure, sensitivity, and adaptive capacity (in this case, adaptive responses or practices) of rice millers and traders to multiple, combined pressures in Benue State, Nigeria. In doing so, the chapter sought answers four research questions (see Section 6.1).

Thus, with regards to the first question (i):

> What pressures are rice millers and traders currently exposed to in Benue State, and how sensitive are they to such pressures?

The findings showed that millers and traders in Benue State are more exposed to economic/market pressures than to prolonged wet conditions, high moisture contents, excess dryness, and water scarcity, the effects of which may have been exacerbated by CCV. The economic/market pressures, i.e., poor milling technology and infrastructure, price volatility and trade liberalization, both contribute to poor quality of domestic rice, and subsequently, to frequent price crashes. However, the sensitivity of both millers and traders to market and technology pressures depended on their continuous use of artisanal milling technologies and selling decisions, including: knowledge about the use and regular maintenance of machines; location of rice mills; quality and quantity of rice sold; and the season in which the rice is milled and sold.

In response to the second question (ii):

What current practices are employed by rice millers and traders in response to combined climate change and agri-market pressures in Benue State?

The findings revealed that rice millers and traders employed a wide-range of practices, which include: temporarily relocating rice mills; taking turns to dry the rice; reducing the quantity and frequency of rice parboiled during flooding; digging wells; and changing drying methods. Moreover, other practices employed include: routinely maintaining milling machines; adjusting prices, weights and measures; embarking on credit sales and minimising these when creditors fail to make repayments.

Furthermore, in answer to the third question (iii):

How do rice millers' and traders' current exposure, sensitivity, and adaptive practices vary across Benue State?

This study found that there were no striking variations between actors or across different parts of the state, with the exception of those between large and small millers. As a result of their limited access to market and their outdated milling technologies and infrastructures, the small rice millers and traders are regarded as more vulnerable to market pressures than to CCV pressures, the latter they manage through the local adaptive practices highlighted above as vulnerability of a system is the function of its exposure, sensitivity, and adaptive capacity (McCarthy, et al., 2001),

Lastly, in answer to the fourth question (iv):

What are the leverage points (weaknesses and strengths) from which adaptive policies which aim to reduce vulnerability and build resilience can stem?

This study has not only helped shed light on the nature of current vulnerability, but has also identified possible leverage points for the initiation of interventions which will reduce vulnerability and construct resilience in Benue State. They are: i) upgrading rice milling technologies and infrastructure; ii) investing for the enhancement of marketing attributes or the extrinsic qualities of domestic rice; iii) adopting more anticipatory (preventive) and long-term (strategic) adaptive practices; iv) employing collective adaptive practices; v) addressing uncertainties and/or trade-offs surrounding the pressures themselves; and, vi) making adaptive and policy responses.

Therefore, it will be interesting for future adaptation research on CCV and markets (i.e., economic liberalisation) to carry out: i) an inventory of adaptive responses to either existing or new sets of pressures that reduce vulnerability in the short-term, but which increase it in the long-term; ii) an inventory of adaptive responses that are highly promising, cost-effective, and easy to practice, and which do not require special training or a large financial investment; iii) an examination as to whether the interaction of certain adaptive responses over time reduces or increases vulnerability (i.e., exposure, sensitivity, and adaptive responses); and, iv) an examination as to whether a combination of adaptive responses could better help millers and traders cope with multiple, combined pressures.

Lastly, while changes in climate and its variability and in the markets (e.g., economic globalisation) are becoming more dynamic and complex, and are likely to continue to do so in the future, the trade-offs and uncertainties surrounding these changes and adaptive practices remain unresolved issues, even among the millers and traders in the three study sites. This makes adaptive decisions more challenging for local RVCs actors with limited knowledge and support than it does for international and large out-sourcing companies. Therefore, it might be interesting for future studies firstly, to investigate whether local traders are aware of these uncertainties and trade-offs surrounding certain adaptive responses, secondly, to discover whether value chain actors have carefully considered them in their adaptive decision making, and thirdly, to show whether they have adequate information to make adaptive decisions that entail trade-offs.

Chapter 7

System models of rice value chains in Benue State: growers, millers, and traders' perspectives

7.1 Introduction

The literature on rice value chains (RVC) in Sub-Saharan Africa (SSA) tends to focus on its specific components (especially production) and/or actors (especially famers) (Terdoo & Feola, 2016), and has largely failed to adopt a system perspective. This hinders the understanding of RVC, e.g. the tensions that exist between systems' components, and the identification of measures which may help to reduce stakeholders' vulnerability to such tensions (Terdoo and Feola, 2016). This chapter aims to fill this gap by specifically exploring different perspectives of the RVC, it does so by eliciting the understanding different actors have of the points along that chain (Henly-Shepard et al., 2015; Hovmand et al., 2012; Mendoza & Prabhu, 2006).

The working hypothesis of this chapter is that different actors have distinct understandings of RVC, and that it is important to uncover these differences to develop support measures for RVC resilience. Thus, this chapter employs a qualitative participatory system mapping approach that uses stock and flow maps to examine these different understandings of the system. The stock and flow maps serve the purpose of providing initial structural thinking about the RVC system, highlighting which component of the system might be exposed to multiple pressures, and increasing understanding of how the effects of pressures on one component transmit through the entire RVC system (Stave & Kopainsky, 2015). In addition, this mapping tool seeks to make explicit the complex linkages and dynamic interactions between different components in the chain which may have shaped the vulnerability or resilience of the RVC system, in the present or future. A system approach is considered suitable for eliciting knowledge about the RVC because of its growing application in tackling messy, complex, dynamic problems (Vennix, 1999).

This chapter answers two research questions:

I. How do different RVC actors (growers, millers, and traders) in Benue State understand the RVC system (i.e., different systems' components, their linkages and interactions)?

II. How do the perspectives of rice growers, millers, and traders compare?

The remainder of this chapter is organised into four major sections. The next section presents the elicitation of actors' understanding of RVC systems. Precisely, the section outlines individual and clustered lists of the major and minor (or sub-) components of the RVC system. This is followed by a description of the mental map diagrams made by different actors along the chain, then an evaluation of the participatory mapping (PM) is presented. Lastly, the implications, in terms of vulnerability and resilience, of different actors' understandings of the RVC systems in the study sites are discussed in the light of current vulnerability and resilience theories and the extant literature.

7.2 Elicitation of different actors' understandings of Rice Value Chain Systems in Benue State

In this section, elicitation of the interpretation of RVC systems is presented as understood by the different actors: growers, millers, and traders at different workshops sessions where the where the information was gattered.

7.2.1 Elicitation of RVC systems' components from growers

Table 7.1 below presents both individual and clustered lists of the components of the RVC system as understood by growers in Makurdi and Adikpo.

Table 7.1. List of the RVC components identified by growers

Study site	Major component	Sub-components	1 P	2 P	3 P	4 P	5P	6P	7 P	Component Clustered
Makurdi	Production		√	√	√	√	√	√	√	Production
		Site selection	√	√	√	√	√	√	√	Area cultivated
		Land clearing	√	√	√	√	√	√	√	
		Land preparation	√	√	√	√	√	√	√	
		Weather					√		√	Weather
		Planting (Seeding)	√	√	√	√	√	√	√	Seeds
		Weed control	√	√	√			√	√	Inputs
		Fertiliser app	√	√	√		√	√	√	
		Insect/pest mngmnt.	√	√	√	√			√	
		Harvesting	√	√	√	√	√	√	√	Harvesting
	Storage	Bagging/sacking	√		√	√	√	√	√	Storage
	Trading/selling				√			√		Trading of rice
	Processing		√	√	√	√		√	√	Processing
		Parboiling	√			√		√		Parboiling
		Milling	√			√		√		Milling
		Winnowing	√			√		√		Winnowing
		Bagging/sacking	√					√	√	Bagging/sacking
	Trading/selling			√	√	√		√	√	Trading
	Consumption			√				√	√	Consumption
Adikpo	Production		√	√	√	√	√	√	√	Production
		Site selection	√	√	√	√		√	√	Area cultivated
		Land preparation	√	√	√	√	√	√	√	
		Weather					√	√		Weather
		Planting (Seeding)	√	√	√	√	√	√	√	Seeds
		Weed control	√	√	√	√	√	√	√	Inputs
		Fertiliser app.	√	√	√		√	√	√	
		Insect/pest mngmnt.		√	√			√		
		Harvesting	√	√	√	√	√	√	√	Harvest
	Transportation					√		√		Transportation
	Storage	Bagging/sacking	√	√		√	√		√	Storage
		Grain storage				√			√	
		Seed								
	Selling paddy		√	√			√	√	√	Trading of milled rice
	Processing			√	√	√	√	√	√	Processing
		Parboiling		√						
		Drying		√						
		Milling		√		√		√	√	
	Selling rice			√	√	√		√	√	Trading
	Consumption				√				V	Consumption

P denotes individual participant; √ symbol denotes major/sub-component identified by a participant.

Three main findings can be identified. First, participants disagreed on what defines the system boundaries. While the different lists made by the participants (see Table 7.1), showed that growers perceived the RVC components to comprise both major and sub or minor-components, the lists tend to focus on the sub-components of rice production. In Makurdi for example, the majority of the rice growers did not consider components such as transportation/distribution, trading or selling of paddy, or consumption of milled rice to be parts of the RVC. When asked for clarification by the facilitator of the workshop at which the information was gathered, the growers disagreed with each other, some argued that transportation/distribution and trading or selling are services that do not necessarily transform rice into a product which attracts more value, in the way that production and milling do, therefore, they cannot be considered as major components, but sub-components that facilitate value addition.

Second, participants had different levels of understanding of the RCV. Further evident in the growers' lists (Table 7.1) above, is the lack of detail about sub-components along the chain other than rice production, an omission which became apparent during the creation of the mental maps. For example, both in Makurdi and Adikpo, growers' lists highlighted less detail about processing or milling and trading of milled rice sub-components. Moreover, lack of detailed understanding of other chain components, such trading and consumption of milled rice, by these rice growers shows a disconnection from one of the most important downstream components of the RVC, where the final value is added. This is a situation that could deter growers' efforts at investment in high yielding and stress resistant seeds, and in mechanisation, to boost the final paddy output and quality of the harvest.

Third, the mental maps reflected different views of the RVC in Makurdi and in Adkipo. While this aforementioned narrow perspective of the components of the RVC system is characteristic of growers in both areas, a few obvious differences exist. For example, in Makurdi transportation of paddy (unmilled) and milled rice to the market was not mentioned. Again, the reason being that ''*most growers in Makurdi either sold their paddy to outsourcing companies they signed an agreement or contract with at the start of farming season who carry out the transportation arrangements and bear the costs by themselves''* [Participant 2, Growers]. Whereas in Adikpo, where such market arrangements are not in place, transportation of paddy was mentioned, but that of milled rice was not as it is often sold at the rice mills. Thus, another important point that was not obvious in these lists, but which later surfaced in the convergent phase when the diagramming of the mental maps was carried out by the rice growers, was the emergence of the two rice trading market channels in Makurdi, i.e., the conventional or the traditional open rice trading market, and the emerging network or programme market.

7.2.2 Elicitation of RVC systems' components from rice millers

Table 7.2 below presents individual and clustered lists of the RVC systems' components as provided by the rice millers in Makurdi and Adikpo.

Table 7.2. List of the RVC components identified by individual millers

Site	Major component	Sub-component	1stP	2nd P	3rd P	4th P	5tt P	6th P	7th P	Clustered Component
Makurdi	Production		√	√	√	√	√	√	√	Production
		Site selection	√	√				√	√	Area
		Land clearing	√	√				√	√	cultivated
		Land preparation	√	√	√	√	√	√	√	
		Planting (Seeding)	√	√	√	√	√	√	√	Seeds
		Weed control	√	√			√	√	√	Inputs
		Fertiliser app.	√					√		
		Harvesting	√	√	√	√	√	√	√	Harvest
	Transportation			√						Transportation
	Storage	Bagging/sacking		√				√	√	Storage
	Trading				√	√	√	√	√	Trading
	Processing		√	√	√	√	√	√	√	Milling
		Soaking	√	√	√	√	√			
		Parboiling	√	√	√	√	√			
		Drying	√	√	√	√	√			
		Milling	√	√	√	√				
		Winnowing		√						Local milling
		Destoning/ polishing	√							Modern milling
		Packaging	√							
	Trading		√	√	√			√	√	Trading
		Retailing	√	√	√			√		
		Wholesaling	√	√	√			√		
	Consumption			√	√					Consumption
Adikpo	Source capital						√			Capital
	Buying of paddy		√	√	√	√	√	√	√	Production
	Transportation		√	√		√	√	√		Transportation
	Processing		√	√	√	√	√	√	√	Processing
		Parboiling	√	√	√	√	√	√	√	
		Milling	√	√	√	√	√	√	√	
		Winnowing							√	
	Trading/selling		√	√	√	√	√	√	√	Trading
		Retailing	√	√	√	√	√	√	√	
		Wholesaling	√	√	√	√	√	√	√	
	Consumption			√	√	√		√	√	Consumption

P denotes individual participant; √ symbol denotes major or sub-component identified by a participant.

Table 7.2 above presents both individual and clustered lists of the understanding of the RVC by the rice millers. The lists of components show that there are two different rice milling systems in operation at the two sites and among the different types of rice millers, small or large. In the Makurdi millers' lists of components, the conventional commercial rice milling system (which uses artisanal milling equipment and old technologies), and the modern commercial mills (which use mechanical processing equipment and new technologies) are shown to co-exist. While in the Adikpo millers' lists of components, only the conventional commercial rice milling system is shown to be operational. Not surprisingly, the conventional system is the most popular, it has been in operation for many decades, and is dominated by the small millers, while the modern mills have recently emerged and are operated by the larger millers.

In summary, millers' perspectives of the RVC systems' components are representative of the current processes carried out in these different rice milling systems. For example, in Adikpo, the process of destoning, polishing, and packaging rice is not cited. However, in Makurdi, these are cited in addition to processes and activities listed as used under the conventional rice milling system, such as soaking, parboiling, drying, and milling (see Table 7.2 above for details).

7.2.3 Elicitation of RVC systems' components from rice traders

Table 7.3 below presents individual listings of RVC components by rice traders in Makurdi and Adikpo. The different lists of components reveal traders' perspectives of the RVC in the study sites.

It can be seen from Table 7.3, unlike the upstream and middle stream stakeholders (i.e., the growers and the millers, respectively), the traders in both study sites listed production as the first and major component of RVC, but they failed to state the sub-components of rice production. Similarly, traders in both sites failed to specify the two rice market channels, periodic and network or programme markets, even in Makurdi where these two market systems clearly existed, although such distinction became obvious later during the diagramming phase.

Table 7.3. List of the RVC components identified by individual rice traders

Study site	Major comp	Sub-comp	1st P	2nd P	3rd P	4th P	5th P	Comp Clustered
Makurdi	Production		√			√	√	Production
	Buying paddy			√	√	√		Trading
	Transportation			√	√	√	√	Transportation
	Storage		√	√			√	Storage
	Processing		√	√	√	√	√	Processing
		Parboiling	√	√	√	√	√	Parboiling
		Milling	√	√	√	√	√	Milling
		Packaging	√				√	Packaging
	Storage		√					Storage
	Trading		√	√	√	√	√	Trading
		Retailing	√	√	√	√	√	Retailing
		Wholesaling	√	√	√	√	√	Wholesaling
	Consumption				√		√	Consumption
Adikpo	Production					√	√	Production
	Sourcing capital		√					Capital
	Buying paddy		√	√	√			Trading
	Transportation		√		√			Transportation
	Processing		√	√	√	√	√	Processing
		Parboiling	√	√	√	√	√	Parboiling
		Drying	√	√	√	√	√	Drying
		Milling	√	√	√	√	√	Milling
	Trading		√	√	√	√	√	Trading
		Retailing	√	√	√	√	√	Retailing
		Wholesaling	√	√	√	√	√	Wholesale
	Consumption			√				Consumption

P denotes individual participant; √ symbol denotes major or sub-component identified by a participant.

Despite the similarities of traders' perspectives in Makurdi and Adikpo highlighted above, there were differences in the listing of the RVC components among rice traders in the two sites. In Makurdi, for example, packaging was listed, this indicates an aspect of modern milling, a channel served by urban consumers. In contrast, packaging was not mentioned in Adikpo, highlighting the lack of modern rice milling in the area. This, in turn, shows that it is the traditional rice milling channel that serves the semi-urban centres and communities in the area. As one trader in Makurdi observed:

> …the co-existence of the two market channels over time proves that the traditional milling system is resilient to pressure [has the capacity to keep production going] since it has continued to supply rice on its own - with government support and amid high quality imported rice… [Participant 2: Trader].

7.3 Diagramming the mental maps by RVC actors

It is important to understand the basis of the maps in sections 7.3.1 and 7.3.2. The stock and flow maps (Figure 7.1a-c and 7.2a-c)[17] highlight a number of similarities and differences in perspectives of the RVC system. First, actors across the sites failed to map certain components. For example, rice wasted/lost along the RVC was not mapped. These differences were not only general, they were evident in specific locations (Makurdi or Adikpo), and among different types of actors (growers, or millers, or traders). For example, rice growers in Adikpo and Makurdi did not map consumption (see Figure 7.1a and 7.2a), whereas rice millers and traders in these locations did (see Figures 7.1b, 7.1c, 7.2b, and 7.2c). Moreover, with the exception of millers in Makurdi (e.g., MIKAP Nigeria Limited), the rest of the actors in both locations did not map polishing and packaging, or branding and advertising of milled rice. The failure to map certain core components indicates the lack of a comprehensive perspective of the RVC system, its activities and processes.

Similarly unmapped is the flow of information (e.g., demand, policy changes, price and quality expectations), which governs how the flow of rice (e.g., quantity added or removed) at each stage of the chain changes the stock of rice, for better or for worse. However, the millers in Makurdi attempted to map economic flow (capital/income) as a factor that governs how rice is taken to mills, but did not demonstrate how it influences the consumption of different qualities of rice in the area. Such an understanding is important to better understand how vulnerability emerges and propagates throughout the system. The inability to explicitly map certain components of the RVC, as well as the information flow, is reflective of the current beliefs, expertise, and experiences of these actors. Participants found it difficult to visualise, and comprehend, the complex interaction of multiple

---

[17] The major components of the RVC system are represented by boxes which stand for the stock of rice at different stages of the RVC, while the minor, or sub-components, are represented by arrow-headed 'pipes', which stand for the flow that leads into and out of the stocks. Lastly, the 'cloud' before and after the flow represents the sources and sinks of the flow. In other words, it shows where the flow is coming from and going to.

factors that may have shaped RVC vulnerability. For example, the interaction of material (e.g., rice taken to the market or the mills), information (e.g., price information and price expectation that may have influenced the amount of rice taken to market), and economic factors (income or family needs that may have influenced a decision to take the rice to market), among others.

Another difference between the two locations is the ongoing changes of the different components of the RVC system. As changes in the components show, the system continues to evolve and transform to enable the chain, and the actors along it, to respond to eminent threats to its existence which are posed by recurring pressures. For example, among the growers, programme farming and network or contract sales of rice have emerged as part of this transformation to help them respond to poor prices and high costs of inputs, a result of pressures which stem from the market and climate change and variability (CCV) (e.g., water shortages and flooding). Furthermore, among the millers, modern industrial milling has emerged in response to the demand for high quality rice among urban rice consumers. While the stock and flow maps of actors in Makurdi (see Figures 7.2a-c) illustrated these changes, the stock and flow maps of the chain actors in Adikpo (Figures 7.1a-c) rarely depicted them. This indicates that the transformation of the RVC system is not widely spread, even among RVC actors in different parts the state.

Lastly, each of the actors along the chain tends to map in detail that part or component of the RVC system in which their interest lies. This may also be indicative of a lack of appreciation of other components of the RVC system, and suggests that tensions may ensue between different components, particularly as each actor perceived, and therefore projected, some components as more important than others.

Figure 7.1a-c presents the mental maps (i.e., stock and flow diagrams) of the RVC system by actors along the chain, namely growers, millers, and traders in Adikpo.

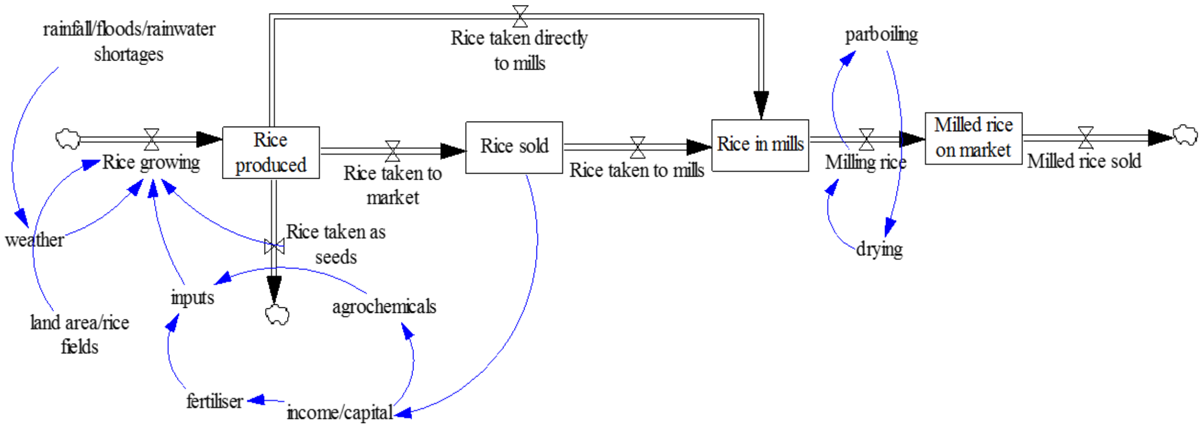


Figure 7.1a: Stock and flow map for the rice growers in Adikpo

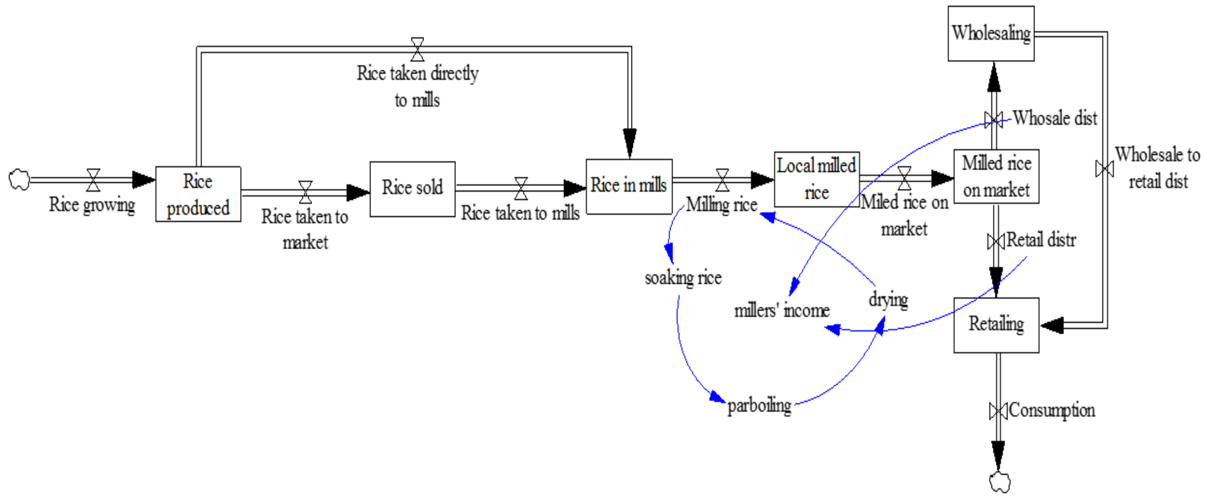


Figure 7.1b: Stock and flow maps for the rice millers in Adikpo

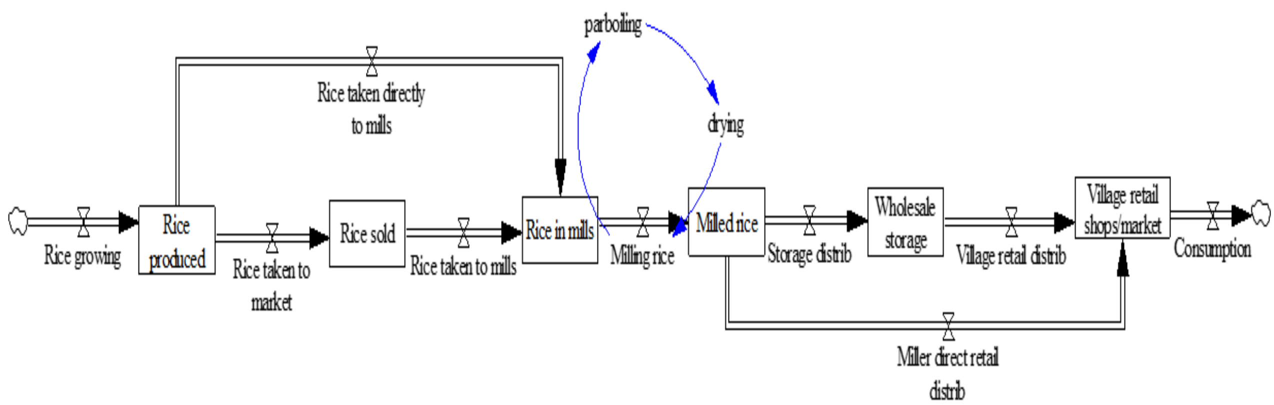


Figure 7.1c: Stock and flow map for the milled rice traders in Adikpo

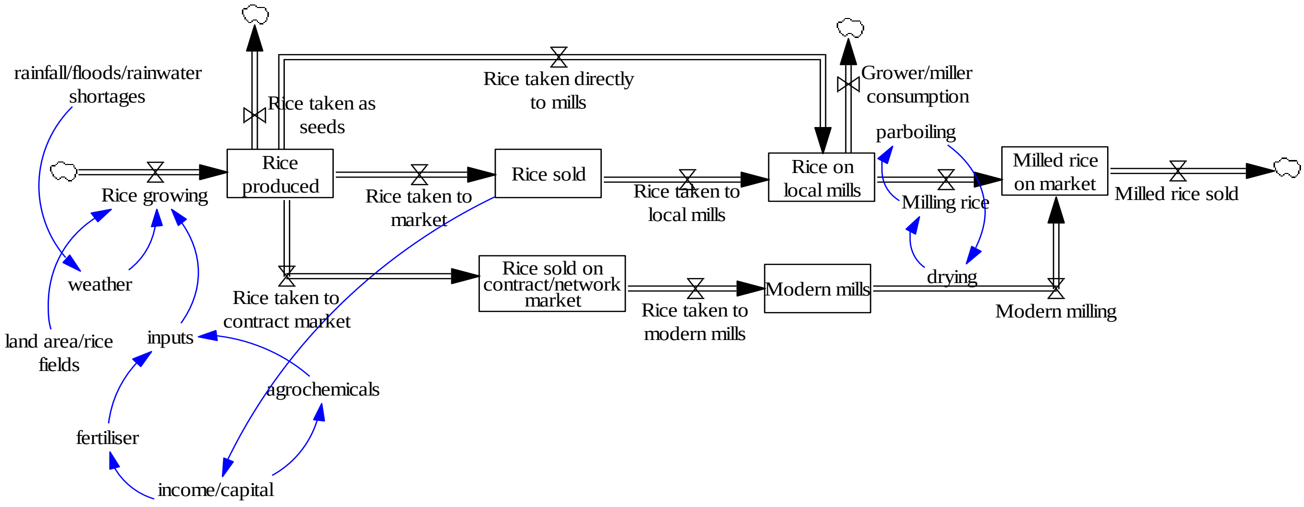


Figure 7.2a: The stock and flow map for the rice growers in Makurdi

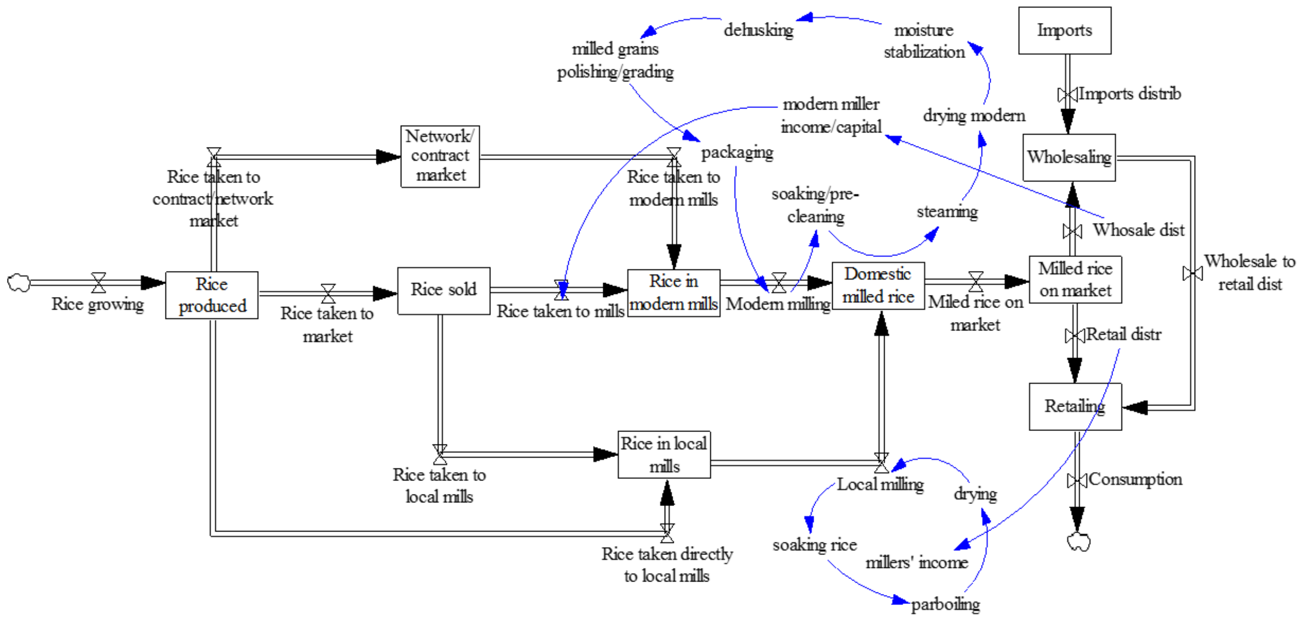


Figure 7.2b: The stock and flow map for the rice millers in Makurdi

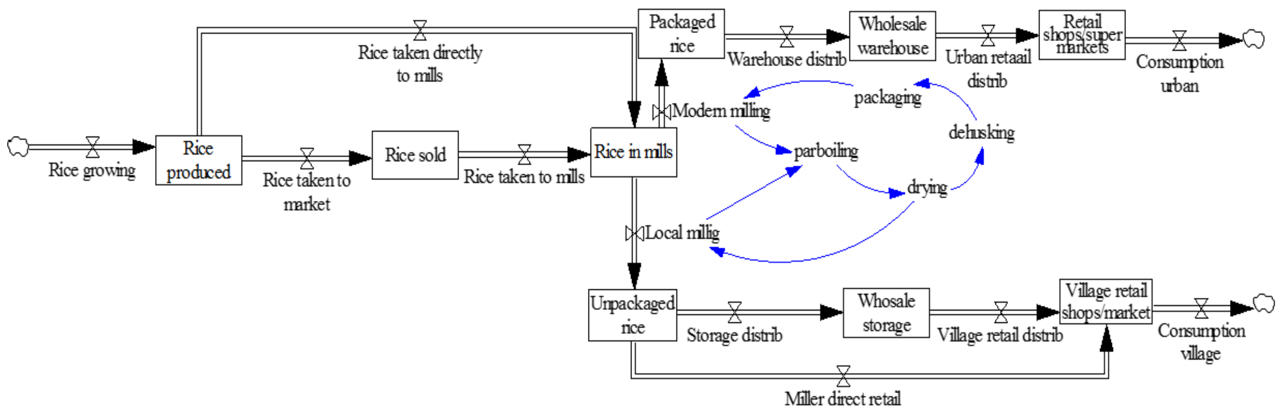


Figure 7.3c: The stock and flow map for the milled rice traders in Makurdi

7.4 Rice value chain actors' evaluations of the participatory mapping (PM)

During the finalisation phase, participants were asked to share their thoughts and comments on the mental maps they generated. Thus, across the sites, participants identified three key positive aspects promoted by the participatory mapping exercises, they included: learning about the RVC system; community problem solving; and informed and better decision-making (see Table 7.4), each of which are discussed in the following sections.

Table 7.4. Positive aspects of the PM as identified by participants

Major aspect	Specific aspect	Highlights of participants' thoughts and comments
Promotes learning about the system	Visualisation of system structure, complexities and challenges, and opportunities	Educative, increases knowledge and enhances learning about the system
		Interesting, engaging, and enlightening
		Helps to visualise the complexity that is otherwise hiding
		Helps see where different components are connected
Promotes community problem solving	Promote synergy, collaboration among diverse actors, and facilitate community problem solving	Inter-component relationships or cross-component interactions
		Not standing alone, but with others
		Appreciation of contributions and challenges of other actors along the chain
Informs better decision-making	Inform individual or group decision-making	Helps see the wider implications of challenges faced
		Makes clear what part of the chain needs immediate intervention which helps make decisions appropriately
		Stimulates an idea of diversification to other parts of the chain
		The maps stimulate for me an idea of engaging in both farming and processing (milling)

7.4.1 Promotes learning about the system

With regards to learning, participants highlighted different aspects of learning about the system that the maps have promoted. The first issue relates to visualising the structure of the RVC system; how the components are connected and linked to each other. One participant commented:

> The map is educative as it has made me see through the entire processes of RVC [e.g., from cultivation to consumption (eating)]. Importantly, it has helped me to see that all these processes are connected and each one is equally important as the other [Participant 5, Grower].

Moreover, another said, "*I see the mental maps to be interesting, engaging and enlightening, especially when all the activities of the rice production chain are drawn on a large sheet of paper like this* [Participant 1, Trader].

Another aspect of learning about the system structure pointed out by participants concerned visualisation of complexities, otherwise not recognised until all components were connected.

> ….I can see that the map is very complex, outlining the different ways we handle rice after harvest, some sell immediately they complete harvest, others leave it in storage for few months for prices to improve before selling, while others still go and have the rice milled before selling. One thing is that we are all trying to make something out of our investments. The same thing is true for other activities, including people who buy rice to eat [Participant 2, Trader].

Other participants said the mental mapping exercise enabled them to visualise challenges at different parts of the system; they could see that when one part of the system is affected, this can affect all the other parts because of how tightly the systems' components are linked to each other. One participant said:

> …I have learnt that all the components, both major and sub-components of the RVC, are interwoven and intrinsically linked and that every component is important, it plays a unique role that altogether puts rice on the table. Therefore, if one component is negatively affected, the entire system is affected because the effect ripples through other parts and components. Just as having a good quality milled rice, for example, starts with growers planting a good rice variety and seeds that in turn produce good quality paddy that goes to the rice mills. Once this is not done, forget it, no matter the quality of milling [i.e., machines

used], the final milled rice product is not going to be of the high quality that consumers will want [Participant 1: Trader].

Furthermore, visualising complexities and challenges helps uncover hidden insights and unexpected relationships which actors ordinarily do not anticipate in unmapped systems. This, in turn, helps develop new knowledge to improve the system performance. In the words of one participant: *"I come to learn about other components, such as packaging of rice, which can potentially increase the volume of milled rice trading, although we are not investing in that now*" [Participant 3: Trader]. Similarly, another participant stated: *"this interaction is important because as a grower I am only exposed to production, but my participation in this workshop has exposed me to different stages of RVC [e.g. milling, distribution, and trading)"* [Participant 4: Growers Group].

7.4.2 Informs better decision making

Another positive aspect of the participatory system mapping exercise identified by the participants is that it informs better decision making in a number of ways. First, it helps see, or confirm, the wider implications of the challenges of the RVC system, which is important in taking appropriate measures to address those challenges. According to one participant:

> …the maps have confirmed some of the challenges that we faced here every season, such as poor seeds or less preferred varieties having negative effects on rice productivity, including quality of the rice harvest, which attracts buyers and higher prices. On the other hand, the maps and discussions we are having here have challenged my beliefs that these challenges [e.g., poor seed varieties and poor quality of harvest] do not only affect growers or affect us. In fact, I now know that the effects go beyond us, even up to the rice millers, the traders on the market, and those who buy and cook the rice too... [Participant 2, Growers].

Not only does the exercise make all implications known, it also makes clear what part(s) of the chain need(s) immediate intervention. This could help in making appropriate decisions in a timely manner. In the words of another participant: *I have come to see that not only production needs immediate government intervention, it is now obvious to me that other activities, such as milling and trading, need interventions too. In fact, they need it simultaneously* [Participant 5: Growers group].

In addition to participants knowing about the wider effects of different challenges, important for informing them when and at which point on the system to intervene, participants highlighted some of the specific decisions that the participatory mapping exercises helped them make. According to one participant: *"the mental maps stimulated an idea of diversification to other* *parts of the chain, especially production to increase my income"* [Participant 1; Trader]. While another said:

> …for me, the maps stimulated an idea of engaging in both farming and processing [milling). I think by engaging in two or more activities of the chain this is the best way for producing high quality rice, a grower should produce and process [mill) the rice himself. In this way, the quality will be high and famers can make a profit at both ends… [Participant 7: Growers Group].

7.4.3 Promotes community problem learning and solving

In relation to community problem solving, participants highlighted that the participatory mapping exercise promoted synergy and collaboration among diverse actors. Thus, PM helped diverse actors along the RVC chain, each with different personal interests, to work together for the benefit of all. In the words of one participant:

> …I have learnt from the lines that link or connect one stage to another that rice production, which I am actively engaged in, does not stand alone, it is connected or affected by the market as other stages affect others too [e.g., milling affects the trade of milled rice)… [Participant 1, Growers' group].

Such recognition creates a sense of the mutual understanding required to build synergy; to work collaboratively with diverse actors along the chain to solve problems. As one of the participants stated:

> ….the mental maps stimulate my thinking about what other actors along the chain usually go through. I can now appreciate the contributions as well as the challenges of each actor along the chain. Their bits of activity culminate in the final milled rice buyers enjoy. Therefore, I can say that these maps have helped me to think outside the area of my primary interest in the chain, which is milled rice trading… [Participant 2: Traders' group].

7.5 Discussion

This chapter has mapped the RVC system in Benue State in accordance with the perspectives held by different actors along the chain. The results highlighted a number of issues that have implications for vulnerability and resilience of the RVC system in the region, and thus answer the two research questions:

I. How do different RVC actors (growers, millers, and traders) in Benue State understand the RVC system (i.e., different systems' components, their linkages and interactions)?

II. How do the perspectives of rice growers, millers, and traders compare?

The process of generating the mental maps revealed disagreement among participants as to what defines the RVC system, i.e., which components should be included. Thus, discussion of inconsistences in beliefs and disagreements/agreements about the RVC system during the mapping process not only helped facilitate structured social learning (Henly-Shepard et al., 2015), but also served as a means of bridging communication barriers, which could further widen collaborative gaps among the RVC stakeholders, if left unaddressed (Reed et al., 2010; Rodela, 2011). Bridging such barriers, in addition, could promote social trust, shared ownership of adaptive practices, and resilience building strategies (Reed et al., 2010). As Fazey et al. (2007) and Henly-Shepard et al. (2015) have emphasised, for social learning by adaptation to occur, actors must be willing to: (1) engage, challenge, and transform the epistemological and cultural ways of thinking, knowledge, and behaviours towards resilience to socio-ecological systems (the RVC system in this case) from the individual to the societal level; and, (2) develop a thorough understanding of how current practices and behaviours influence socio-ecological resilience and redirect them towards more sustainable goals. The small-scale exercise in participatory system mapping presented in this chapter shows that this tool supports social learning among different actors in the RVC in the study sites.

Concerning the understanding of the system, the results of the PSM showed that certain components of the RVC system (e.g., rice wasted or lost, branding, and advertising), including information and economic flow, were not explicitly mapped in either study location. This reveals that that different types of actors (e.g., farmers and processors) had distinct mental maps, and hence distinct understandings of the RVC in each of the two locations. These differences also highlight that farmers, millers, and traders generally lack an overview of the whole RVC, which hinders their ability to understand tensions between systems' components and identification of measures to build resilience of the RVC, especially when collaboration across actors is needed (Ericksen et al., 2010; Kopainsky et al., 2018). This is a limitation of the RVC actors' current understandings, and is an important area for future research as it has been shown that a system perspective of food systems has the potential to develop effective support measures to reduce vulnerability and enhance resilience (Ericksen et al., 2010).

This potential has been demonstrated, for example, in a study of household food security in rural Mali (Rivers III et al., 2017), which identified sources of climatic risk in West Africa (Schmitt

Olabisi et al., 2018), and a study of four cases of sustainable environmental management in the USA (Stave, 2010) (see also Stave, 2002; Mendoza & Prabhu, 2006; Elsawah et al., 2017).

Nevertheless, one important barrier in building a common understanding of RVCs is the politics of knowledge management. The unequal access to knowledge in the system may not only be determined by the differing perspectives of distinct actors (growers, millers, traders), but may depend on specific power positions and interests. For example, rural development initiatives led by international organizations, such as USAID's Global Food Security Response Framework, often work on the assumption that knowledge and the wherewithal (e.g. funds) will be transferred from the Federal to States to all RVCs actors, including small, medium and large land holders as well as the small, medium and large size or industrial millers and traders (FMAWR, 2009). However, this is often not the case, as institutional (e.g. public servants and officers in public institutions) and private actors have been reported to use their role of information (and financial) gatekeepers to retain or redirect information and funds and thereby defend vested interests or consolidate their position (T. Akande, 2001; Akpokodje et al., 2001; Longtau, 2003; USAID, 2009). These dynamics may have resulted in the inability or unwillingness of Benue State government to support extension programmes to transfer knowledge on the RVCs to relevant actors or regulate the rice market in favour of more vulnerable actors.

Social networking is another factor that influences knowledge sharing, whereby better connected actors get access to better or more knowledge than others (FAO, 2014; Hiroyuki, Oyekale, Olatokun, & Salau, 2010; Oladele & Wakatsuki, 2011). Connections may be established on a geographical basis; for example, millers in Adikpo (one of the study areas in this research) are poorly connected to the market and government centres that are located in the capital Makurdi (another study area of this research). Social networks can also be of a more explicit political nature, where it has been observed that politicians in the region have tended to favour their political allies, including some rice companies, which use such preferred connections to disempower prospective competitors-especially the small and medium landholders and small size millers and traders- and maintain a dominant role in the RVCs in Nigeria (Akpokodje et al., 2001; Birner & Resnick, 2010).

While the politics of knowledge management was not a topic of research in this study, the small-scale exercise in participatory system mapping presented in this chapter shows the need to expose the politics of unequal access to knowledge on the system as a key factor determining the success of efforts to build resilience through participatory approaches.

7.6. Summary and conclusion

This chapter mapped the mental model of the RVC system of different actors along the chain in Benue State. It showed that distinct actors (i.e., farmers, millers, traders) have different understandings of the RVC, and specifically, they tend to have a relatively detailed understanding of the parts of the system in which they operate, but a more blurred picture of parts of the systems in which they do not operate. This is a potential barrier for cooperation and coordination which can, therefore, hinder resilience building. On the other hand, PSM also uncovered how RVC is differently configured in the study sites (Makurdi versus Adikpo), which is an important point as different adaptation measures may be needed in different places.

Finally, this chapter showed how a participatory system mapping can promote social learning and inform better decision-making and community problem solving, each of which are needed to build resilience.

Chapter 8

Conclusions

8.1 Introduction

This study conducted a synchronic baseline assessment of the complexities of the RVCs in Benue State, Nigeria. In so doing, it analysed the vulnerability of rice growers, millers, and traders to combined CCV, agricultural markets, and other pressures (Chapters 5 and 6). In addition, it elicited and mapped the different perspectives of the RVC system held by actors along the chain (Chapter 7), and highlighted the limitations and adaptations needed to reduce vulnerability and build resilience of the RVCs. This section summarises the main research findings, highlights the main contributions of this study and suggests avenues for future research.

8.2 Summary of the main research

8.2.1 *Objective (1) to document the current pressures, sensitivity, and adaptive practices of rice growers, millers, and traders in Benue State, Nigeria.*

Firstly, this study identified the current pressures to which RVC actors, namely growers, millers, and traders are exposed across Benue State. These include recurring flooding, rainwater shortages, high moisture content, and excessive dryness, which are CCV related, in addition to weed infestation, disease, pests, and soil infertility. They are also exposed to economic/market pressures, which include price crashes, poor milling technology and infrastructure, the high cost of inputs, competition from foreign rice, the use of inaccurate weights and measures, and market demand for selected varieties.

However, the study suggests that sensitivity of RVCs' actors to the above pressures depended on farm production characteristics, such as: access to technology, e.g., mechanisation and modern rice seeds/varieties, milling technologies; cropping systems, rainfed upland or lowland rice techniques; access to market, such as periodic markets and network/contract markets, and their location; and, seasonality of prices.

Furthermore, the study documented a number of adaption practices, which growers, millers, and traders employed at different points, to respond to climatic, economic, and other pressures. These included: embarking on dry season farming; planting rice twice or thrice in a year; accessing knowledge through experts; entering a farming support programme; entering a market network/contract sales agreement; milling harvested rice before selling it; and, storing rice for a length of time to sell when it becomes scarce on the market.

In addition to the above practices, they routinely maintained milling machines; adjusted prices, weights and measures; embarked on credit sales and minimised these when creditors failed to make repayments; temporarily relocated rice mills; took turns to dry the rice; reduced the quantity and frequency of rice parboiled during flooding; dug wells; and changed drying methods.

8.2.2 *Objective (II): To explore the variability of exposure, sensitivity, and adaptive practices across Benue State.*

The findings revealed that all the farmers in the study sites were exposed and sensitive to similar pressures (CCV, markets, and others). However, the degree of their exposure, sensitivity, and adaptability was largely informed by: their location, Makurdi, Gboko, or Adikpo; their choice of cropping system, rainfed upland or lowland, or mixed and double or triple cropping; and, their identification as a small, medium, or large landholder. For example, growers in Makurdi were more exposed to flooding due to the location of their rice fields in a low-lying topography and within the floodplains of the Benue River, while in Adikpo, growers were more exposed to rainwater shortages due to the employment of mixed cropping systems. This study also suggests that no single socio-demographic or socio-economic variable is clearly associated with exposure, sensitivity or adaptive capacity of growers, millers or traders. Nevertheless, the years of engagement in rice growing, milling or trading, as well as the educational level of the research participant, seem to be associated with lower levels of vulnerability, which suggests experience of the pressures and of ways to respond to them, as well as knowledge associated with formal education, may mark a difference between social groups in the study areas.

Furthermore, among the types of growers, this study showed that growers who are medium/large landholders in Makurdi are less sensitive, more adaptable and, by extension, less vulnerable to pressures. This is due to their ability to access promising adaptive practices, such as: entering a farming support programme or rice selling network/partnership which provides buyback agreements or contracts; weather information; expert knowledge, and farming safety nets, which include crop insurance and a formal credit system. Conversely, small landholder growers in each of the study sites lacked access to the above-mentioned farming safety nets, and thus are more sensitive, less adaptable, and ultimately more vulnerable to the combination of pressures from CCV, markets, and others.

Regarding millers and traders, this study found that there were no striking variations across different parts of Benue State, with the exception of those between large and small millers. As a result of their limited access to market and their outdated milling technologies and infrastructures, the small rice millers and traders are regarded as more vulnerable to market pressures than to CCV pressures, the latter they manage through the local adaptive practices highlighted above.

8.2.3 *Objective (III): To examine current adaptation practices employed by rice growers, millers and traders and assess the (mal) adaptive outcomes of those practices.*

This study also found a number of adaptive practices which increased farmers' exposure and sensitivity to pressures, rather than helped them adapt to their impact. Examples included: avoidance of well-watered rice fields to avoid exposure to flooding, but in turn experiencing rainwater shortages in years of abnormal rainfall; reduction in the quantity and frequency of rice parboiled during flooding, but experiencing reduction in income; a switch in type of market, e.g., from programme/contract sales to periodic market, to sell at higher prices, but instead selling under inaccurate weights and measures and experiencing even more loss of income; purchase of crop insurance, but not being paid when experiencing crop failures; and, planting a market preferred variety, rather the one that is stress resistant, among others.

Not only did specific adaptive practices aimed at a reduction in the impact of pressures actually result in maladaptation outcomes which increased them, but they also affected the manner and ways by which the adaptive practices were employed by the various actors. For example, the growers, millers, and traders tended to employ reactive, short-term practices, which are incapable of offsetting the magnitude of abrupt pressures (e.g., flooding, rainwater shortages, price crashes). Furthermore, there is an issue of insufficient use of planned adaptation which results in exclusion and non-participation, especially of small landholders, often caused by corruption and inadequate public engagement in planning and implementation, particularly if they include government interventions. Other issues include the unwillingness of growers, millers, and traders to respond to pressures collectively or collaboratively and in a coordinated manner; individual efforts are often inadequate to offset pressures occurring rapidly and on a large scale. Lastly, some of the adaptive practices entail tradeoffs, while others are characterised by uncertainties, both of which render them ineffective.

8.2.4 Objective (IV): To elicit the understanding of the RVC system (e.g., chains' components) held by different actors along the chain.

The findings revealed that certain components of the RVC system (e.g., rice wasted or lost), as well as the inclusion of information and economic flow (i.e., demand, policy changes, price and quality expectations), were not mapped in any of the three study locations. However, the study revealed variation in the mapping of components by the various actors in all locations. This indicated that distinct actors in the study locations have different understandings of the RVC, and specifically, that they tend to have a relatively detailed understanding of the parts of the system where they operate, but a more fuzzy picture of parts of the systems where they do not operate. These differences also highlighted that farmers, millers, and traders generally lack an overview of the whole RVC.

8.2.5 Objective (VI): To highlight the implications of the different perspectives of the RVC system for vulnerability and resilience.

The research revealed a number of implications for vulnerability and resilience. First, the lack of an overview of the whole system may obscure an understanding of how vulnerability of the system emerges and propagates throughout its whole. It also hinders the actors' ability to understand tensions between the systems' components and identification of measures to build its resilience, especially when collaboration and collective actions across actors in the RVC are needed. Another implication is that the differences in perspectives of the system could be a potential barrier for cooperation and coordination, which can therefore hinder resilience building.

8.2.6 Objective (VI): To highlight the possible entry points for reducing vulnerability in Benue State.

This study identified seven entry points for a reduction in the vulnerability of rice growers to multiple, combined pressures. These include the need for: (i) information, both short- and long-term, to help with publicity and the diffusion of promising adaptive practices more widely across all parts of the state; (ii) the adoption of anticipatory, or preventive and long-term adaptive practices; (iii) more planned adaptive practices; (iv) greater adoption of collective adaptive practices and coordination; (v) upgraded rice milling technologies and infrastructure. More than these, there is a need for: (vi) assessment of trade-offs between different adaptation practices and the cost implications; and (vii) attendance to uncertainties regarding the pressures themselves, policy options, and certain adaptation practices in the study region

8.3 Contributions of this study

This study has made four main contributions to knowledge.

First, this study has filled a knowledge gap on the agricultural vulnerability and currently adopted adaptation practices in Nigeria. As shown in Chapter 2, the dearth of knowledge on agricultural vulnerability and adaptation is a limiting factor in developing sound vulnerability reduction policies and interventions. By focussing on a key agricultural produce – rice – this study has specifically uncovered that millers and traders in Benue State are more exposed and sensitive to economic pressures than to prolonged wet conditions, high moisture contents, excess dryness, and water scarcity, the effects of which may have been exacerbated not only by CCV but also by their continuous use of artisanal milling technologies and selling decisions. In addition to providing a list of common reactive, short-term adaptive practices often employed in Benue State, this study also uncovered a number of adaptive practices that instead of reducing growers', millers' and traders' exposure and sensitivity to pressures, actually resulted in maladaptation outcomes which increased them. (Chapters 5 and 6). Thus, this study contributes to filling the knowledge gap in this geographical region.

Second, at a more theoretical level, this study has confirmed the need to adopt a multiple exposures framework (Belliveau et al., 2006; Brien & Leichenko, 2000; Leichenko & O'Brien, 2008) in the analysis of vulnerability to global change. While the Multiple Exposures Framework is established in this research field, most studies of vulnerability effectively overlook multiple exposures and attempt to isolate single exposures, usually climate change-related ones (e.g. Adejuwon, 2006; Ajetomobi, Abiodun, & Hassan, 2010; Ayinde, Ojehomon, Daramola, & Falaki, 2013; Matthew, Abiodun, & Salami, 2015; Nwalieji & Uzuegbunam, 2012). By recognizing the embeddedness of farmers and other actors in the RVCs in their socio-ecological context (Feola et al., 2015), this study has confirmed that these actors respond and adapt to multiple exposures simultaneously. Furthermore, this study confirmed that growers, millers and traders must constantly negotiate trade-offs between the effects of their responses to distinct pressures

Third, and further at a theoretical level, this study has shown that it is crucial to use a system approach in vulnerability analysis – here illustrated by the concept of value chain. This has been a limitation of past research (Chapter 2), which has largely investigated production (farming) but overlooked other parts and actors of agri-food systems (e.g. traders, processors). This study shows that a system approach is crucial to understand the vulnerability tensions, spill overs, as well as possible synergies across subsystems (Chapter 7). For example, the effects of pressures on one component interact or transmit through the entire RVC system (Stave & Kopainsky, 2015). Some of interactions of the effects of vulnerability of downstream parts of the RVCs are evident in this study. For example, the vulnerability of growers owing to effects of multiple pressures (e.g. flooding, water shortages, weed infestation, pest and diseases, among others) may result in low production, which is a pressure on millers and traders. The common reactive strategy of millers is often the temporary shut-down of their business, which further creates market supply deficit that results in price spikes. Furthermore, the vulnerability of millers may result in the production of low-quality rice, which is a pressure on traders, who do not appear to have any adaptive strategy to respond to this pressure.

Fourth and last, at methodological level, this study has developed and tested a participatory system-based procedure to elicit system representations from distinct value-chain actors. While it is often assumed in the literature that participatory methods can contribute to resilience building, this study has collected evidence of specific ways in which participatory system mapping can make such contribution (Stave, 2010), which are (i) the promotion of social learning about the RVC system through the visualization of system structures, challenges and opportunities, (ii) information for better decision-making at either individual or group level, through the uncovering of connections and interdependencies between value chain subsystems and, also as a result of the above points (iii) the promotion of community problem solving, through the establishment of a collective space and collaboration platform, and a common language and understanding of the value chain and its vulnerability and potential for change. This modelling approach differs from more commonly used structural process-based ones in that it employs a bottom-up approach throughout the modelling process, which makes it possible to account for multiple perspectives and interpretations of vulnerability and adaptation by diverse stakeholders and actors involved in the RVC system in Benue State-something that is crucially missing in structural models (e.g., Adejuwon 2006; Bosello et al. 2017; Calzadilla et al. 2014; Daccache, et al. 2015; Gerardeaux, et al. 2012; Johnson, et al. 2013; Liu et al. 2008; Lobell et al. 2008; Matthew, et al. 2015; van Oort and Zwart 2018; Zwart 2016). By employing a bottom-up approach, this participatory system-based modelling promotes the consideration of local and experiential knowledge and activates a process of social learning about the RVC that is *actor-centred*; this contrast with, but also complements and expands, structural process-based modelling, which employs a top-down approach and thereby is largely based on scientific knowledge.

8.4 Identification of avenues for future research

While conducting this study a number of issues presented themselves which may be worthwhile for the researcher and others to consider as investigations in the future which will advance the course of vulnerability and adaptation research in Nigeria, and in other areas where similar conditions exist. These include:

1. An inventory of adaptive responses that are highly promising, cost-effective, and easy to implement, and which do not require special training or a large financial investment. These are the 'low hanging fruits' of adaptation in the study area.

2. An investigation of the constraints to the adoption of collective adaption practices by growers in the study region; collective actions may be important to help growers build synergy and pool resources together in response to pressures, and in the absence of government support.

3. An evaluation of the merit of cooperation and competition (and market segmentation) and its role in driving efficiencies in the RVCs.

4. Future research may assess whether trade-offs and costs really do form the bedrock of adaption practices employed by rice growers, traders, and millers in response to CCV, economic/markets in the study region, and whether actors have adequate information to make adaptive decisions that entail trade-offs.

5. An examination of the politics of unequal access to knowledge on the system as a key factor in determining the success of efforts to build resilience through participatory approaches

6. Finally, the development of a fully-fledged quantitative system dynamics model, where different policy options can be evaluated, possibly in a participatory manner.

References

Abiodun, B. J., Lawal, K. A., Salami, A. T., & Abatan, A. A. (2013). Potential influences of global warming on future climate and extreme events in Nigeria. *Regional Environmental Change*, *13*(3), 477–491. http://doi.org/10.1007/s10113-012-0381-7

Adejuwon, J. O. (2006). Food crop production in Nigeria. II. Potential effects of climate change. *Climate Research*, *32*(3), 229–245. http://doi.org/10.3354/cr032229

Adeoti, A. I., & Adeoti, J. . (2008). HIV / AIDS and Farms ' Production Efficiency in Benue State , Nigeria. *African Journal of Biomedical Research*, *11*, 145–153.

Adger, N. W. (1999). Social vulnerability to climate change and extremes in coastal Vietnam. *World Development*, *27*(2), 249–269. http://doi.org/10.1016/S0305-750X(98)00136-3

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. http://doi.org/10.1016/j.gloenvcha.2006.02.006

Adger, W. N., Brooks, N., Bentham, G., & Agnew, M. (2004). New indicators of vulnerability and adaptive capacity. *Change*, *5*, 128. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.2300&rep=rep1&type=pdf

Adjao, R. T., & Staatz, J. M. (2014). Asian rice economy changes and implications for sub-Saharan Africa. *Global Food Security*, 1–6. http://doi.org/10.1016/j.gfs.2014.11.002

Adjognon, S. G., Liverpool-Tasie, L. S. O., & Reardon, T. a. (2017). Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. *Food Policy*, *67*, 93–105. http://doi.org/10.1016/j.foodpol.2016.09.014

Ajadi, A. A., Oladele, O. I., Ikegami, K., & Tsuruta, T. (2015). Rural women's farmers access to productive resources: The moderating effect of culture among Nupe and Yoruba in Nigeria. *Agriculture and Food Security*, *4*(1), 1–9. http://doi.org/10.1186/s40066-015-0048-y

Ajetomobi, J., Abiodun, A., & Hassan, R. (2010). Economic impact of climate change on irrigated rice agriculture in Nigeria. *The Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference* (pp. 1–20). Cape Town, South Africa.

Ajewole, O. O., Ojehomon, V. . E. ., Ayinde O. E, Agboh-Naomishie, A. R., & Digne, A. (2016). Gender analysis of poverty among rice farming household in Nigeria rice hub. *5th International Conference of the African Association of Agricultural Economists (AAAE)* (pp. 1–12). Retrieved from http://ageconsearch.umn.edu/bitstream/249317/2/85.

Akaakohol, M. A., & Aye, G. C. (2014). Diversification and farm household welfare in Makurdi, Benue state, Nigeria. *Development Studies Research*, *1*(1), 168–175. http://doi.org/10.1080/21665095.2014.919232

Akande, T. (2001). An overview of the Nigerian rice economy. *Nigerian Institute of Social and Economic Research (NISER), Ibadan,* (pp. 1–11).

Akande, T., & Ogundele, F. (2009). *African Food Crisis : The Nigerian Case Study*. Nigerian Institute of Social and Economic Research (NISER), Ibadan.

Akinbile, C. O. (2013). Assessment of the CERES-Rice model for rice production in Ibadan, Nigeria. *Agricultural Engineering International: CIGR Journal*, *15*(1), 19–26. http://doi.org/10.1017/S0021859601001319

Akpokodje, G., Lançon, F., & Erenstein, O. (2001). Nigeria's rice economy: state of the art. In *NISER/WARDA Nigerian Rice Economy Stakeholders Workshop, Ibadan* (pp. 1–55). Bouaka, Cote d'Ivoir: West Africa Rice Development Association (WARDA).

Amelia, D. F., Kopainsky, B., & Nyanga, P. H. (2014). Exploratory model of conservation agriculture adoption and diffusion in Zambia : A dynamic perspective. In *32nd International Conference of the System Dynamics Society July 20-24* (pp. 1–17).

Ammani, A. A. (2013). Impact of market-determined exchange rates on rice production and import in Nigeria. *International Journal of Food and Agricultural Economics*, *1*(2), 85–98.

Andersen, D., & Richardson, G. (1997). Scripts for group model building. *System Dynamics Review*, *13*(2), 107–129. http://doi.org/10.1002/(SICI)1099-1727(199722)13:2<107::AID-SDR120>3.0.CO;2-7

Anderson, J. E. (2018). Access to land and permits: Firm-level evidence of impediments to development in transition countries. *Journal of Economics and Business*, (January 2017), 1–20. http://doi.org/10.1016/j.jeconbus.2018.09.001

Aniekwe, C. C. (2010). Agricultural trade liberalization and small-holder development : West African rice farmers in perspective. *Second Africa Rice Congress, Bamako, Mali*, (March), 1–7.

Animashaun, J. O. O., Titilayo, V. E., Muhammad-Lawal, A., & Amolegbe, K. B. (2015). Between foreign direct investment (FDI) and outsourcing: Which policy strategy will enhance the competiveness of the Nigerian rice setor? *International Journal of Food and Agricultural Economics*, *3*(2), 91–105.

Awoyemi, T. T. (2004). Explaining rice price shocks in Nigeria : Implications for policy intervention. *Rural Economics and Development*, *18*(1), 46–52.

Ayinde, O. E., Ojehomon, V. E. T., Daramola, F. S., & Falaki, A. A. (2013). Evaluation of the effects of climate change on rice production in Niger State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *6*, 763–773. http://doi.org/http://dx.doi.org/10.4314/ejesm.v6i6.7S

Badolo, F., & Traoré, F. (2015). Impact of rising world rice prices on poverty and inequality in Burkina Faso. *Development Policy Review*, *33*(2), 221–244. http://doi.org/10.1111/dpr.12099

Bamidele, F. S., Abayomi, O. O., & Esther, O. a. (2010). Economic analysis of rice Consumption patterns in Nigeria. *Journal of Agricultural Science Technology*, *12*, 1–11. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Economic+Analysis+of+Rice+Consumption+Patterns+in+Nigeria#0

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy*, *33*(4), 299–317. http://doi.org/10.1016/j.foodpol.2007.10.005

Barrett, T., Feola, G., Khusnitdinova, M., & Krylova, V. (2017). Adapting Agricultural Water Use to Climate Change in a Post-Soviet Context: Challenges and Opportunities in Southeast Kazakhstan. *Human Ecology*, pp. 1–16. http://doi.org/10.1007/s10745-017-9947-9

Bazerley, P., & Jackson, K. (2013). *Qualitative data analysis with Nvivo*. *SAGE Publications Ltd*.

Becker, L., & Yoboue, N. G. (2009). Rice producer-processor networks in Cote d'lvoire. *American Geographical Society*, *99*(2), 164–185.

Belliveau, S., Smit, B., & Bradshaw, B. (2006). Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change*, *16*(4), 364–378. http://doi.org/10.1016/j.gloenvcha.2006.03.003

Benzie, M., & John, A. (2015). (Rep.). Stockholm Environment Institute. Retrieved from http://www.jstor.org/stable/resrep00394

Bernstein, H. (2017). Political Economy of Agrarian Change: Some Key Concepts and Questions*. *RUDN Journal of Sociology*, *17*(1), 7–18. http://doi.org/10.22363/2313227222017717117718

Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., & McNeeley, S. M. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. *Global Environmental Change*, *25*(1), 97–108. http://doi.org/10.1016/j.gloenvcha.2014.01.003

Birner, R., & Resnick, D. (2010). The Political Economy of Policies for Smallholder Agriculture. *World Development*, *38*(10), 1442–1452. http://doi.org/10.1016/j.worlddev.2010.06.001

Bosello, F., Campagnolo, L., Cervigni, R., & Eboli, F. (2017). Climate Change and Adaptation: The Case of Nigerian Agriculture. *Environmental and Resource Economics*, *69*(4), 1–24. http://doi.org/10.1007/s10640-016-0105-4

Bourke, B. (2014). Positionality : Reflecting on the Research Process. *The Quaitative Report*, *19*(33), 1–9.

Brien, K. L. O., & Leichenko, R. M. (2000). Double exposure : assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change*, *10*, 221–232.

O'Brien, K., Eriksen, S., Schjolden, A., & Nygaard, L. P. (2004). *What's in a word? Conflicting interpretations of vulnerability in climate change research*. *CICERO Working Paper* (Vol. 04). Retrieved from http://dspace.cigilibrary.org/jspui/handle/123456789/7304

Brown, K. (2011). Sustainable adaptation: An oxymoron? *Climate and Development*, *3*(1), 21–31. http://doi.org/10.3763/cdev.2010.0062

Brydon-Miller, M. (1997). Participatory action research: Psychology and social change. *Journal of Social Issues*, *53*(4), 657–666. http://doi.org/10.1111/j.1540-4560.1997.tb02454.x

Bryman, A. (2016). Social Research Methods. *Oxford University Press*. http://doi.org/10.4135/9781849209939

Calzadilla, A., Zhu, T., Rehdanz, K., Tol, R. S. J., & Ringler, C. (2013). Economywide impacts of climate change on agriculture in Sub-Saharan Africa. *Ecological Economics*, *93*, 150–165. http://doi.org/10.1016/j.ecolecon.2013.05.006

Calzadilla, A., Zhu, T., Rehdanz, K., Tol, R. S. J., & Ringler, C. (2014). Climate change and agriculture: Impacts and adaptation options in South Africa. *Water Resources and Economics*, *5*, 24–48. http://doi.org/10.1016/j.wre.2014.03.001

Challinor, A. J., Müller, C., Asseng, S., Deva, C., Nicklin, K. J., Wallach, D., … Koehler, A. K. (2018). Improving the use of crop models for risk assessment and climate change adaptation. *Agricultural Systems*, *159*(August 2017), 296–306. http://doi.org/10.1016/j.agsy.2017.07.010

Chambati, W. (2011). Restructuring of agrarian labour relations after Fast Track Land Reform in Zimbabwe. *Journal of Peasant Studies*, *38*(5), 1047–1068. http://doi.org/10.1080/03066150.2011.632088

Chhetri, N., Chaudhary, P., Tiwari, P. R., & Yadaw, R. B. (2012). Institutional and technological innovation: Understanding agricultural adaptation to climate change in Nepal. *Applied Geography*, *33*(1), 142–150. http://doi.org/10.1016/j.apgeog.2011.10.006

Coady, D., Dorosh, P., & Minten, B. (2009). Evaluating alternative policy responses to higher world food prices: The case of increasing rice prices in Madagascar. *American Journal of Agricultural Economics*, *91*(3), 711–722. http://doi.org/10.1111/j.1467-8276.2009.01266.x

Coker, A. A. A., Akogun, E. O., Adebayo, C. O., & Mohammed, S. (2018). Assessment of implementation modalities of the Anchor Borrowers' Programme in Nigeria. *Agro-Science*, *17*(1), 44–52.

Coker, A. A. A., Akogun, E. O., Adebayo, C. O., Mohammed, S., Nwojo, M., Sanusi, H., & Jimoh, H. O. (2017). Gender Differentials among Subsistence Rice Farmers and Willingness to undertake Agribusiness in Africa: Evidence and Issues from Nigeria. *African Development Review*, *29*, 198–212. http://doi.org/10.1111/1467-8268.12273

Colen, L., Demont, M., & Swinnen, J. (2013). Smallholder participation in value chains: The case of domestic rice in Senegal. In *Rebuilding West Africa's Food Potential* (pp. 391–415).

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013

Daccache, A., Sataya, W., & Knox, J. W. (2015). Climate change impacts on rain-fed and irrigated rice yield in Malawi. *International Journal of Agricultural Sustainability*, *13*(2), 87–103. http://doi.org/10.1080/14735903.2014.945317

Dandedjrohoun, L., Diagne, a, & Biaou, G. (2012). Determinants of diffusion and adoption of improved technology for rice parboiling in Benin. *Review of Agricultural and Environmental Studies*, *93*(2), 171–191. http://doi.org/10.4074/S1966960712002032

Daramola, B. (2005). Government Policies and Competitiveness of Nigerian Rice Economy. In *Workshop on Rice Policy & Food Security in Sub-Saharan Africa*. Cotonou, Republic of Benin: WARDA.

Darnhofer, I. (2014). Resilience and why it matters for farm management. In *European Review of Agricultural Economics* (Vol. 41, pp. 461–484). http://doi.org/10.1093/erae/jbu012

Darnhofer, I., Bellon, S., Dedieu, B., & Milestad, R. (2008). Adaptive farming systems – A position paper. *8th European IFSA Symposium*, (July), 6–10.

Darnhofer, I., Bellon, S., Dedieu, B., & Milestad, R. (2009). Adaptiveness to enhance the sustainability of farming systems. In *Sustainable Agriculture* (Vol. 2, pp. 45–58). http://doi.org/10.1007/978-94-007-0394-0_4

Darnhofer, I., Lamine, C., Strauss, A., & Navarrete, M. (2016). The resilience of family farms: Towards a relational approach. *Journal of Rural Studies*, *44*, 111–122. http://doi.org/10.1016/j.jrurstud.2016.01.013

Dawe, D. (2002). The changing structure of the world rice market, 1950–2000. *Food Policy*, *27*(4), 355–370. http://doi.org/10.1016/S0306-9192(02)00038-6

Demont, M. (2013). Reversing urban bias in African rice markets: A review of 19 National Rice Development Strategies. *Global Food Security*, *2*(3), 172–181. http://doi.org/10.1016/j.gfs.2013.07.001

Demont, M., & Ndour, M. (2014). Upgrading rice value chains: Experimental evidence from 11 African markets. *Global Food Security*, 1–7. http://doi.org/10.1016/j.gfs.2014.10.001

Demont, M., & Rizzotto, A. C. (2012). Policy Sequencing and the Development of Rice Value Chains in Senegal. *Development Policy Review*, *30*(4), 451–472.

Demont, M., Rutsaert, P., Ndour, M., & Verbeke, W. (2013). Reversing Urban Bias in African Rice Markets: Evidence from Senegal. *World Development*, *45*, 63–74. http://doi.org/10.1016/j.worlddev.2012.11.011

Demont, M., Zossou, E., Rutsaert, P., Ndour, M., Van Mele, P., & Verbeke, W. (2012). Consumer valuation of improved rice parboiling technologies in Benin. *Food Quality and Preference*, *23*(1), 63–70. http://doi.org/10.1016/j.foodqual.2011.07.005

Denscombe, M. (2014). The good research guide for small-scale social research projects. *Psychological Science*, *86178035*, 356. Retrieved from http://www.amazon.co.uk/dp/0335220223

Dickinson, T. (2007). *The Compendium of Adaptation Models for Climate Change* (First Edit). Canada: Adaptation and Impacts Research Division Environment Canada.

Dieter, P., Schulze-Specking, A., & Decker, K. (1988). Release of lysosomal enzymes is not correlated with superoxide and prostaglandin production by stimulated rat Kupffer cells in primary culture. *Journal of Hepatology*, *6*(2), 167–174. http://doi.org/10.1016/S0168-8278(88)80028-X

Duryan, M., Nikolik, D., van Merode, G., & Curfs, L. M. G. (2014). Using Cognitive Mapping and Qualitative System Dynamics to Support Decision Making in Intellectual Disability Care. *Journal of Policy and Practice in Intellectual Disabilities*, *11*(4), 245–254. http://doi.org/10.1111/jppi.12095

Eakin, H., & Luers, A. L. (2006). Assessing the Vulnerability of Social-Environmental Systems. *Annual Review of Environment and Resources*, *31*(1), 365–394. http://doi.org/10.1146/annurev.energy.30.050504.144352

Effiong, A. B., Igwe, O., Okoro, U. C., Maduka, R. I., & Ojonugwa, R. A. (2015). Rainfall induced rock-fall debris avalanche in October 2010, at Kwande local Government Area of Benue state, Nigeria. *Journal of the Geological Society of India*, *86*(3), 344–350. http://doi.org/10.1007/s12594-015-0321-5

Emodi, I., & Madukwe, M. (2008). A review of policies, acts and initiatives in rice innovation system in Nigeria. *Journal of Agricultural Extension*, *12*(2), 76–83. http://doi.org/10.4314/jae.v12i2.47052

Enete, A. A., & Amusa, T. A. (2010). Challenges of Agricultural Adaptation to Climate Change in Nigeria: a Synthesis from the Literature. *Field Actions Science Reports*, *4*(4), 1–11.

Erenstein, O., Akande, S. O., Titilola, S. O., Akpokodje, G., & Ogundele, O. O. (2003). *Rice production systems in Nigeria : A survey*. Abidjan, Côte d'Ivoire.

Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. *Global Environmental Change*, *18*(1), 234–245. http://doi.org/10.1016/j.gloenvcha.2007.09.002

Ericksen, P. J. (2008). What Is the Vulnerability of a Food System to Global Environmental Change ? *Ecology and Society*, *13*(2), 14.

Ericksen, P. J., Ingram, J. S. I., & Liverman, D. M. (2009). Food security and global environmental change: emerging challenges. *Environmental Science & Policy*. http://doi.org/10.1016/j.envsci.2009.04.007

Ericksen, P., Stewart, B., Dixon, J., Barling, D., Loring, P., Anderson, M., & Ingram, J. (2012). The value of a food system approach. In *Food Security and Global Environmental Change* (pp. 25–45). http://doi.org/10.4324/9781849776615

Ezedinma, C. (2005). Impact of Trade on Domestic Rice Production and the challenge of Self-sufficiency in Nigeria. In *International Institute of Tropical Agriculture* (pp. 1–14). Ibadan, Nigeria.

FAO. (2008). *Climate change and food security: A Framework document*. *Interdepartmental Working Group on CLimate Change*. Rome. Retrieved from http://rstb.royalsocietypublishing.org/content/360/1463/2139.short

FAO. (2014). *Developing sustainable food value chains-Guiding principles*. *Food and Agriculture Organization of the United Nations*. Rome: FAO. http://doi.org/http://www.fao.org/3/a-i3953e.pdf

Fazey, I., Fazey, J. a, Fischer, J., Sherren, K., Warren, J., Reed, F., … Noss, R. F. (2007). Adaptive leverage capacity for and learning to learn as. *Frontiers in Ecology and Environment*, *5*(7), 375–380. http://doi.org/10.1890/1540-9295(2007)5[375:ACALTL]2.0.CO;2

Federal Ministry Of Agriculture & Water Resources (FMAWR). (2009). *National Rice Development Strategy (NRDS) Federal Republic Of Nigeria*. Abuja, Nigeria.

Federal Republic of Nigeria. (2012). Annual Abstract of Statistics , Federal Republic of Nigeria National Bureau of Statistics. http://doi.org/nigerianstat.gov.ng

Feola, G., Agudelo Vanegas, L. A., & Contesse Bamón, B. P. (2014). Colombian agriculture under multiple exposures: a review and research agenda. *Climate and Development*, 1–15. http://doi.org/10.1080/17565529.2014.934776

Feola, G., Lerner, A. M., Jain, M., Montefrio, M. J. F., & Nicholas, K. a. (2015). Researching farmer behaviour in climate change adaptation and sustainable agriculture: Lessons learned from five case studies. *Journal of Rural Studies*, *39*, 74–84. http://doi.org/10.1016/j.jrurstud.2015.03.009

Fiamohe, R., Nakelse, T., Diagne, A., & Seck, P. A. (2015). Assessing the Effect of Consumer Purchasing Criteria for Types of Rice in Togo: A Choice Modeling Approach. *Agribusiness*, *31*(3), 433–452. http://doi.org/10.1002/agr.21406

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, *16*(3), 253–267. http://doi.org/10.1016/j.gloenvcha.2006.04.002

Füssel, H.-M. (2007). Adaptation planning for climate change: concepts, assessment approaches, and key lessons. *Sustainability Science*, *2*(2), 265–275. http://doi.org/10.1007/s11625-007-0032-y

Füssel, H.-M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, *17*(2), 155–167. http://doi.org/10.1016/j.gloenvcha.2006.05.002

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, *16*(3), 293–303. http://doi.org/10.1016/j.gloenvcha.2006.02.004

Garmann, S. (2014). Does globalization influence protectionism? Empirical evidence from agricultural support. *Food Policy*, *49*, 281–293. http://doi.org/10.1016/j.foodpol.2014.09.004

Gerardeaux, E., Giner, M., Ramanantsoanirina, A., & Dusserre, J. (2012). Positive effects of climate change on rice in Madagascar. *Agronomy for Sustainable Development*, *32*(3), 619–627. http://doi.org/10.1007/s13593-011-0049-6

Gitz, V., & Meybeck, A. (2012). Building resilience for adaptation to climate change in the agriculture sector. In A. Meybeck, J. Lankoski, S. Redfern, N. Azzu, & V. Gitz (Eds.), *Proceedings of a Joint FAO/OECD Workshop* (Proceeding, pp. 19–36). Rome, Italy: FAO.

Gregory, P. J., Ingram, J. S. I., & Brklacich, M. (2005). Climate change and food security. *Philosophical*

Transactions of the Royal Society of London. Series B, Biological Sciences, *360*(1463), 2139–48. http://doi.org/10.1098/rstb.2005.1745

Harrison, P. A., Holman, I. P., Cojocaru, G., Kok, K., Kontogianni, A., Metzger, M. J., & Gramberger, M. (2013). Combining qualitative and quantitative understanding for exploring cross-sectoral climate change impacts, adaptation and vulnerability in Europe. *Regional Environmental Change*, *13*(4), 761–780. http://doi.org/10.1007/s10113-012-0361-y

Harvey, C. a, Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., … Mackinnon, J. L. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *369*(1639), 20130089. http://doi.org/10.1098/rstb.2013.0089

Henly-Shepard, S., Gray, S. a., & Cox, L. J. (2015). The use of participatory modeling to promote social learning and facilitate community disaster planning. *Environmental Science & Policy*, *45*, 109–122. http://doi.org/10.1016/j.envsci.2014.10.004

Hilhorst, T., Van Liere, M., Ode, A. V., & de Koning, K. (2006). Impact of AIDS on rural livelihoods in Benue State, Nigeria. *Sahara J*, *3*(1), 382–393. http://doi.org/10.1080/17290376.2006.9724864

Hiroyuki, T., Oyekale, A., Olatokun, S., & Salau, S. (2010). Demand Characteristics for Improved Rice , Cowpea , and Maize Seeds in Nigeria : Policy Implications and Knowledge Gaps. *International Food Policy Research Institute*.

Hovmand, P. S., Andersen, D. F., Rouwette, E., Richardson, G. P., Rux, K., & Calhoun, A. (2012). Group model-building "scripts" as a collaborative planning tool. *Systems Research and Behavioral Science*, *29*(2), 179–193. http://doi.org/10.1002/sres.2105

Howe, P. D., Yarnal, B., Coletti, A., & Wood, N. J. (2013). The Participatory Vulnerability Scoping Diagram: Deliberative Risk Ranking for Community Water Systems. *Annals of the Association of American Geographers*, *103*(2), 343–352. http://doi.org/10.1080/00045608.2013.754673

Hufschmidt, G. (2011). A comparative analysis of several vulnerability concepts. *Natural Hazards*, *58*(2), 621–643. http://doi.org/10.1007/s11069-011-9823-7

Hulu, M. a. (2010). Population dynamics and vegetation change in Benue State, Nigeria. *Journal of Environmental Issues and Agriculture in Developing Countries*, *2*(1), 53–70. http://doi.org/10.13140/2.1.4805.1847

Ibekwe, N. (2018, June 4). SPECIAL REPORT: Fraud allegations, unremitted loans, crop failure, other anomalies dog Nigerian govt's "rice revolution." *PREMIUM TIMES*. Retrieved from https://www.premiumtimesng.com/investigationspecial-reports/270923-special-report-fraud-allegations-unremitted-loans-crop-failure-other-anomalies-dog-nigerian-govts-rice-revolution.html

Ike, D. N. (1984). The System of Land Rights in Nigerian Agriculture. *American Journal of Economics and Sociology*, *43*(4), 469–480. http://doi.org/10.1111/j.1536-7150.1984.tb01875.x

Ikejiofor, U. (2006). Equity in informal land delivery: Insights from Enugu, Nigeria. *Land Use Policy*, *23*(4), 448–459. http://doi.org/10.1016/j.landusepol.2005.02.005

Inam, A., Adamowski, J., Halbe, J., & Prasher, S. (2015). Using causal loop diagrams for the initialization of stakeholder engagement in soil salinity management in agricultural watersheds in developing countries: A case study in the Rechna Doab watershed, Pakistan. *Journal of Environmental Management*, *152*, 251–267. http://doi.org/10.1016/j.jenvman.2015.01.052

Ingram, J.S.I. (2009). Food system concepts. In, Rabbinge, R. and Linneman, A. (eds.) ESF/COST

Forward Look on European Food Systems in a Changing World. *European Science Foundation*, Strasbourg.

Ingram, J. (2011). A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, *3*(4), 417–431. http://doi.org/10.1007/s12571-011-0149-9

Ingram John, Ericksen, P. J. & Liverman, D. M (2010). *Food Security and Global Environmental Change*. London: Earthscan.

Jain, M., Naeem, S., Orlove, B., Modi, V., & DeFries, R. S. (2015). Understanding the causes and consequences of differential decision-making in adaptation research: Adapting to a delayed monsoon onset in Gujarat, India. *Global Environmental Change*, *31*, 98–109. http://doi.org/10.1016/j.gloenvcha.2014.12.008

Johnson, M. (2016). Policy options for moderniz ing the milling sector. In K. Gyimah-Brempong, M. E. Johnson, & H. (Eds. . Takeshima (Eds.), *The Nigerian rice economy: Policy options for transforming production, marketing, and trade* (pp. 139–158). Washington, D.C.: International Food Policy Research Institute (IFPRI). Retrieved from http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130487

Johnson, M., & Dorosh, P. (2015). *Optimal Tariffs with Smuggling : A Spatial Analysis of Nigerian Rice Policy Options* (IFPRI Nigeria Strategy Support Program II Working Paper No. 29). Washington, D.C.

Johnson, M. E., & Dorosh, P. (2017). Tariffs, smuggling and economic welfare: A spatial analysis of Nigerian rice policy options. *Journal of African Economies*, *26*(4), 516–538. http://doi.org/10.1093/jae/ejx008

Johnson, M., Takeshima, H., & Gyimah-Brempong, K. (2013). *Assessing the potential and policy alternatives for achieving rice competitiveness and growth in Nigeria*. *IFPRI Discussion Paper 01301*. Washington, DC.

Johnson, M., Takeshima, H., Gyimah-brempong, K., Kuku-shittu, O., Diao, W. X., Dorosh, P., … Ajibola, A. (2013). *Policy Options for Accelerated Growth and Competitiveness of the Domestic Rice Economy*. IFPRI Discussion Paper 1301. Washington, D.C.

Kakwagh, V. V, Aderonmu, J. A., & Ikwuba, A. (2011). Land Fragmentation and Agricultural Development in Tivland of Benue State , Nigeria. *Journal of Social Sciences*, *3*(2), 54–58.

Kaplinsky, R., & Morris, M. (2000). *A handbook for value chain research*. IDRC.

Katic, P. G., Namara, R. E., Hope, L., Owusu, E., & Fujii, H. (2013). Rice and irrigation in West Africa: Achieving food security with agricultural water management strategies. *Water Resources and Economics*, *1*, 75–92. http://doi.org/10.1016/j.wre.2013.03.001

Kelly, P. M., & Adger, W. N. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change*, *47*(4), 325–352.

Kima, A. S., Traore, S., Wang, Y.-M., & Chung, W.-G. (2014). Multi-genes programing and local scale regression for analyzing rice yield response to climate factors using observed and downscaled data in Sahel. *Agricultural Water Management*, *146*, 149–162. http://doi.org/10.1016/j.agwat.2014.08.007

Knox, J., Hess, T., Daccache, A., & Wheeler, T. (2012). Climate change impacts on crop productivity in Africa and South Asia. *Environmental Research Letters*, *7*(3), 34032. http://doi.org/10.1088/1748-9326/7/3/034032

Kopainsky, B., Tribaldos, T., & Ledermann, S. T. (2018). A Food Systems Perspective for Food and Nutrition Security beyond the Post-2015 Development Agenda. *Systems Research and Behavioral Science*, *35*(2), 178–190. http://doi.org/10.1002/sres.2458

Laroche Dupraz, C., & Postolle, a. (2013). Food sovereignty and agricultural trade policy commitments: How much leeway do West African nations have? *Food Policy*, *38*, 115–125. http://doi.org/10.1016/j.foodpol.2012.11.005

Leichenko, R. M., & O'Brien, K. L. (2008). *Environmental Change and Globalization: Double Exposures*. New York: Oxford University Press. http://doi.org/10.1093/acprof:oso/9780195177329.001.0001

Liersch, S., Cools, J., Kone, B., Koch, H., Diallo, M., Reinhardt, J., … Hattermann, F. F. (2013). Vulnerability of rice production in the Inner Niger Delta to water resources management under climate variability and change. *Environmental Science & Policy*, *34*, 18–33. http://doi.org/10.1016/j.envsci.2012.10.014

Liu, J., Fritz, S., van Wesenbeeck, C. F. a., Fuchs, M., You, L., Obersteiner, M., & Yang, H. (2008). A spatially explicit assessment of current and future hotspots of hunger in Sub-Saharan Africa in the context of global change. *Global and Planetary Change*, *64*(3-4), 222–235. http://doi.org/10.1016/j.gloplacha.2008.09.007

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science (New York, N.Y.)*, *319*, 607–610. http://doi.org/10.1126/science.1152339

Longtau, S. R. (2003). *Multi-agency partnerships in West African agriculture: A review and description of rice production systems in Nigeria*. Overseas Development Institute (ODI), Jos, Nigeria.

Lowder, S. K., Skoet, J., & Raney, T. (2016). The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*, *87*, 16–29. http://doi.org/10.1016/j.worlddev.2015.10.041

Luers, A. L., Lobell, D. B., Sklar, L. S., Addams, C. L., & Matson, P. a. (2003). A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico. *Global Environmental Change*, *13*(4), 255–267. http://doi.org/10.1016/S0959-3780(03)00054-2

Luna-Reyes, L. F., Martinez-Moyano, I. J., Pardo, T. A., Cresswell, A. M., Andersen, D. F., & Richardson, G. P. (2006). Anatomy of a group model-building intervention: Building dynamic theory from case study research. *System Dynamics Review*, *22*(4), 291–320. http://doi.org/10.1002/sdr.349

Maduabuchi, M., & Arene, C. J. (2012). Trade liberalization, exchange rate changes, and the competitiveness of carbohydrate staple markets in Nigeria. *International Journal of Agricultural Management & Development (IJAMAD)*, *2*(2), 121–136.

Matthew, O. J., Abiodun, B. J., & Salami, A. T. (2015). Modelling the impacts of climate variability on crop yields in Nigeria: Performance evaluation of RegCM3-GLAM system. *Meteorological Applications*, *22*(2), 198–212. http://doi.org/10.1002/met.1443

Mbétid-Bessane, E. (2014). Adoption et intensification du Nouveau Riz pour l ' Afrique en Centrafrique. *Tropicultura*, *32*(1), 16–21.

McCarthy, J. J., Canziani, O. F., Leary, D. J., Dokken, D. J., & White, K. S. (Eds.). (2001). Climate change 2001: impacts, adaptation, and vulnerability. *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, 1–1042.

Meadows, D. H. (2008). Leverage points--Places to intervene in a system. *Thinking in Systems: A Primer*, 145–165. http://doi.org/10.1017/CBO9781107415324.004

Mendez del Villar, P., & Lançon, F. (2014). West African rice development: Beyond protectionism versus liberalization? *Global Food Security*, 1–6. http://doi.org/10.1016/j.gfs.2014.11.001

Mendoza, G. A., & Prabhu, R. (2006). Participatory modeling and analysis for sustainable forest management: Overview of soft system dynamics models and applications. *Forest Policy and Economics*, *9*(2), 179–196. http://doi.org/10.1016/j.forpol.2005.06.006

Merriam, S. B., Johnson-Bailey, J., Lee, M. Y., Kee, Y., Ntseane, G., & Muhamad, M. (2001). Power and positionality: Negotiating insider/outsider status within and across cultures. *International Journal of Lifelong Education*, *20*(5), 405–416. http://doi.org/10.1080/02601370120490

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel. *Environmental Management*, *43*(5), 804–816. http://doi.org/10.1007/s00267-008-9197-0

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., … Nelson, D. (2010). Resilience and vulnerability: Complementary or conflicting concepts? *Ecology and Society*, *15*(3). http://doi.org/11

Minot, N. (2014). Food price volatility in sub-Saharan Africa: Has it really increased? *Food Policy*, *45*, 45–56. http://doi.org/10.1016/j.foodpol.2013.12.008

Minten, B., Randrianarison, L., & Swinnen, J. F. M. (2009). Global Retail Chains and Poor Farmers: Evidence from Madagascar. *World Development*, *37*(11), 1728–1741. http://doi.org/10.1016/j.worlddev.2008.08.024

Moreno, A., & Becken, S. (2009). A climate change vulnerability assessment methodology for coastal tourism. *Journal of Sustainable Tourism*, *17*(4), 473–488. http://doi.org/10.1080/09669580802651681

Moseley, W. G., Carney, J., & Becker, L. (2010). Neoliberal policy, rural livelihoods, and urban food security in West Africa: a comparative study of The Gambia, Cote d'Ivoire, and Mali. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(13), 5774–5779. http://doi.org/10.1073/pnas.0905717107

Mumuni, E., & Oladele, O. I. (2012). Farmers' assessment of donor support for rain-fed Lowland rice production in Ashanti and Northern Regions in Ghana. *Life Science Journal*, *9*(3), 377–381. www.dx.doi.org/10.7537/marslsj090312.52

National Bureau of Statistics Nigeria. (2017). *Nigerian Gross Domestic Product Report*. Abuja, Nigeria. Retrieved from file:///Users/ipinmiakinkugbe/Downloads/GDP_Report_Q3_2017.pdf

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annual Review of Environment and Resources*, *32*(1), 395–419. http://doi.org/10.1146/annurev.energy.32.051807.090348

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T., … Lee, D. (2009). *Climate Change Impact on Agriculture and Costs of Adaptation*. *IFPRI Food Policy Report*. Washington, D.C. Retrieved from http://www.ifpri.org/publication/climate-change-1

Nelson, G., Rosegrant, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., … Lee, D. (2009). Climate change: Impact on agriculture and costs of adaptation. International Food Policy Research Institute (IFPRI), 19. http://doi.org/10.1002/9781119240822.ch3

Niang, I., Ruppel, O. C., Abdrabo, M. a., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014).

Africa. *In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.

Nicholas, K. A., & Durham, W. H. (2012). Farm-scale adaptation and vulnerability to environmental stresses: Insights from winegrowing in Northern California. *Global Environmental Change*, *22*(2), 483–494. http://doi.org/10.1016/j.gloenvcha.2012.01.001

Nicholas, W. (2010). *Research Methods : The Basics*. *Roultedge*. http://doi.org/doi:10.4324/9780203836071

Nicita, A., Olarreaga, M., & Porto, G. (2014). Pro-poor trade policy in Sub-Saharan Africa. *Journal of International Economics*, *92*(2), 252–265. http://doi.org/10.1016/j.jinteco.2014.01.001

Nigerian meteorological agency (NIMET). (2012). *Nigeria Climate Review Bulletin*. NIMET, Abuja, Nigeria.

Nwachukwu, J. U. (2017). *The political economy of agricultural development in Nigeria*. Columbia University. Retrieved from http://0-search.proquest.com.wam.leeds.ac.uk/docview/1845882659?accountid=14664

Nwalieji, H. U., & Uzuegbunam, C. O. (2012). Effect of Climate Change on Rice Production in Anambra State , Nigeria. *Journal of Agricultural Extension*, *16*(2), 81–91. http://doi.org/http://dx.doi.org/10.4314/jae.v16i2.7

Nwilene, F. E., Nacro, S., Tamò, M., Menozzi, P., Heinrichs, E. A., Hamadoun, A., … Togola, A. (2013). Managing Insect Pests of Rice in Africa. In Wopereis, M.C.S., Johnson, D.E., Ahmadi, N., Tollens, E., Jalloh, A. (Eds), *Realizing Africa's Rice Promise* (pp. 229–240). Wallingford (UK): CABI. CAB International.

Nwilene, F. E., Oikeh, S. O., Agunbiade, T. A., Oladimeji, O., Ajayi, O., Sié, M., … Touré, A. D. (2008). *Growing lowland rice : a production handbook*. Cotonou, Benin: Africa Rice Center (WARDA). Retrieved from http://www.fao.org/fileadmin/user_upload/ivc/docs/Growing lowland rice_ production handbook_prepress final version_19-05-08_low res.pdf

Nyantakyi-Frimpong, H., & Bezner-Kerr, R. (2015). The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. *Global Environmental Change*, *32*, 40–56. http://doi.org/10.1016/j.gloenvcha.2015.03.003

O'Brien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy*, *7*(1), 73–88. http://doi.org/10.1080/14693062.2007.9685639

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*, 303–313. http://doi.org/10.1016/j.gloenvcha.2004.01.001

Obi-egbedi, O., Okoruwa, V. O., Aminu, A., & Yusuf, S. (2012). Effect of Rice Trade Policy on household welfare in Nigeria. *European Journal of Business and Management*, *4*(8), 160–171.

Obi-egbedi, O., Okoruwa, V. O., Yusuf, S. a, & Kemisola, O. (2013). Rice Trade Protectionism Versus Liberalization in Nigeria : A CGE Analysis of Economic and Welfare Effects. *4th International Conference of the African Association of Agricultural Economists* (pp. 1–22). Hammamet, Tunisia.

Obiora, D. N., Ajala, A. E., & Ibuot, J. C. (2015). Evaluation of aquifer protective capacity of overburden unit and soil corrosivity in Makurdi, Benue state, Nigeria, using electrical resistivity method. *Journal of Earth System Science*, *124*(1), 125–135. http://doi.org/10.1007/s12040-014-0522-0

Ochieng, J., Kirimi, L., & Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. *NJAS - Wageningen Journal of Life Sciences*, *77*, 71–78. http://doi.org/10.1016/j.njas.2016.03.005

Ogundari, K., Ojo, S. O., & Ajibefun, I. A. (2006). Economies of Scale and Cost Efficiency in Small Scale Maize Production : Empirical Evidence from Nigeria. *Social Science*, *13*(2), 131–136. http://doi.org/10.1080/09718923.2006.11892541

Ogundere, F. (2007). Trade liberalization and import demand for rice in Nigeria : A dynamic modelling. *Journal of Economics and Rural Development*, *16*(1), 34–45. Retrieved from http://purl.umn.edu/147538

Ogungbenro, S. B., & Morakinyo, T. E. (2014). Rainfall distribution and change detection across climatic zones in Nigeria. *Weather and Climate Extremes*, *5*(1), 1–6. http://doi.org/10.1016/j.wace.2014.10.002

Ojanuga, A. G., & Ekwoanya, M. A. (1995). Temporal Changes in Land Use Pattern in the Benue River Floodplain and Adjoining Uplands at Makurdi , Nigeria. In Escadafal, et al. (Ed.), *Proc. ISSS. Int. Symp. Monitoring soils in the environment with remote Sensing and GISemote Sensing and GIS* (pp. 417–425). Ouagadougou, Burkina Faso: ORSTOM Publications, Paris.

Okodua, H. (2017). *Assessing the Impact of Rice Sector Policy Reforms on the Income Mobility of Rural Households in Nigeria* (AGRODEP Working Paper No. 0039). Washington. D.C.

Oladele, O. I., & Wakatsuki, T. (2011). Learning Alliances in Sawah Rice Technology Development and Dissemination in Nigeria and Ghana. *Life Science Journal*, *8*(2).

Olam International. (2013). *Scaling up Rice production for local markets in Nigeria – Olam Experience Rice Value Chain Initiative – Benue / Kwara States*. Presentation to the USAID Global Learning Experience and Exchange on Scaling Up Adoption and Use of Agricultural Technologies. Addis Ababa, Ethiopia.https://www.agrilinks.org/sites/default/files/resource/files/George.Regi_.GLEE%20USAID.%20Addis.Presentation.December.3.2013.pdf

Olawale Ajimotokan. (2018). Survey Ranks Niger Leading Rice Producing State in 2017. *THISDAYLIVE*, 3–4. https://www.thisdaylive.com/index.php/2018/03/01/survey-ranks-niger-leading-rice-producing-state-in-2017/

Olsson, P., Galaz, V., & Boonstra, W. J. (2014). Sustainability transformations: a resilience perspective. *Ecology and Society*, *19*(4), art1. http://doi.org/10.5751/ES-06799-190401

Peel, M. C., Finlayson, B. L., & Mcmahon, T. A. (2007). Updated world map of the Koppen-Geiger climate classification. *Hydrol. Earth Syst. Sci. Discuss*, *4*, 439–473. http://doi.org/10.1127/0941-2948/2006/0130

Polsky, C., Neff, R., & Yarnal, B. (2007). Building comparable global change vulnerability assessments: The vulnerability scoping diagram. *Global Environmental Change*, *17*(3-4), 472–485. http://doi.org/10.1016/j.gloenvcha.2007.01.005

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *363*(1491), 447–65. http://doi.org/10.1098/rstb.2007.2163

QSR International. (2013). NVivo qualitative data analysis Software; Version 11, Doncaster, Victoria, Australia.

Rashid, S., Minot, N., Lemma, S., & Behute, B. (2010). Are Staple Food Markets in Africa Efficient? Spatial Price Analyses and Beyond. In *COMESA policy seminar "Food price variability: Causes, consequences, and policy options"* (pp. 1–35). Maputo, Mozambique.

Reed, M. S., Evely, A. C., Cundill, G., Fazey, I., Glass, J., Laing, A., … Stringer, L. C. (2010). What is social learning? *Ecology and Society*, *15*(4). http://doi.org/10.5751/ES-03564-1504r01

Rickards, L., & Howden, S. M. (2012). Transformational adaptation: Agriculture and climate change. In *Crop and Pasture Science* (Vol. 63, pp. 240–250). http://doi.org/10.1071/CP11172

Risbey, J., Kandlikar, M., Dowlatabadi, H., & Graetz, D. (1999). Scale, context, and decision making in agricultural adaptation to climate variability and change. *Mitigation and Adaptation Strategies for Global Change*, *4*(2), 137–165. http://doi.org/10.1023/A:1009636607038

Rivers III, L., Sanga, U., Sidibe, A., Wood, A., Paudel, R., Marquart-Pyatt, S. T., … Liverpool-Tasie, S. (2017). Mental models of food security in rural Mali. *Environment Systems and Decisions*, *38*(1), 33–51. http://doi.org/10.1007/s10669-017-9669-y

Rodela, R. (2011). Social learning and natural resource management: The emergence of three research perspectives. *Ecology and Society*. http://doi.org/10.5751/ES-04554-160430

Rodenburg, J., Zwart, S. J., Kiepe, P., Narteh, L. T., Dogbe, W., & Wopereis, M. C. S. (2014). Sustainable rice production in African inland valleys: Seizing regional potentials through local approaches. *Agricultural Systems*, *123*, 1–11. http://doi.org/10.1016/j.agsy.2013.09.004

Roudier, P., Sultan, B., Quirion, P., & Berg, A. (2011). The impact of future climate change on West African crop yields: What does the recent literature say? *Global Environmental Change*, *21*(3), 1073–1083. http://doi.org/10.1016/j.gloenvcha.2011.04.007

Rowhani, P., Lobell, D. B., Linderman, M., & Ramankutty, N. (2011). Climate variability and crop production in Tanzania. *Agricultural and Forest Meteorology*, *151*(4), 449–460. http://doi.org/10.1016/j.agrformet.2010.12.002

Saito, K., Dieng, I., Toure, A. a., Somado, E. a., & Wopereis, M. C. S. (2014). Rice yield growth analysis for 24 African countries over 1960–2012. *Global Food Security*, *2008*, 1–8. http://doi.org/10.1016/j.gfs.2014.10.006

Sarriot, E., Morrow, M., Langston, A., Weiss, J., Landegger, J., & Tsuma, L. (2015). A causal loop analysis of the sustainability of integrated community case management in Rwanda. *Social Science and Medicine*, *131*, 147–155. http://doi.org/10.1016/j.socscimed.2015.03.014

Schmitt Olabisi, L., Liverpool-Tasie, S., Rivers, L., Ligmann-Zielinska, A., Du, J., Denny, R., … Sidibé, A. (2018). Using participatory modeling processes to identify sources of climate risk in West Africa. *Environment Systems and Decisions*, *38*(1), 23–32. http://doi.org/10.1007/s10669-017-9653-6

Schröter, D., Polsky, C., & Patt, A. G. (2005). Assessing vulnerabilities to the effects of global change: An eight step approach. *Mitigation and Adaptation Strategies for Global Change*, *10*(4), 573–596. http://doi.org/10.1007/s11027-005-6135-9

Schutt, R. K. (2012). *Investigating the social world: The process and practice of research*. *Investigating the social world*. http://doi.org/10.1080/09502389300490051

Scoones, I., Leach, M., Smith, A., Stagl, S., Stirling, A., & Thompson, J. (2007). *Dynamic Systems and the Challenge of Sustainability* (STEPS Working Paper 1). Brighton. STEPS Centre.

Seck, P. a., Tollens, E., Wopereis, M. C. S., Diagne, A., & Bamba, I. (2010). Rising trends and variability of rice prices: Threats and opportunities for sub-Saharan Africa. *Food Policy*, *35*(5), 403–411. http://doi.org/10.1016/j.foodpol.2010.05.003

Smit, B., & Pilifosova, O. (2001). Adaptation to Climate Change in the Context of Sustainable Development and Equity. In *Working Group II: Impacts, Adaptation and Vulnerability* (pp. 880–912). http://doi.org/10.1167/iovs.12-11207

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: A typology. *Mitigation and Adaptation Strategies for Global Change*, *7*(1), 85–114. http://doi.org/10.1023/A:1015862228270

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. http://doi.org/10.1016/j.gloenvcha.2006.03.008

Stave, K. (2010). Participatory system dynamics modeling for sustainable environmental management: Observations from four cases. *Sustainability*, *2*(9), 2762–2784. http://doi.org/10.3390/su2092762

Stave, K. a, & Kopainsky, B. (2015). A system dynamics approach for examining mechanisms and pathways of food supply vulnerability. *Journal of Environmental Studies and Sciences*, (1), 321–336. http://doi.org/10.1007/s13412-015-0289-x

Stave, K. A., & Kopainsky, B. (2014). Dynamic thinking about food system vulnerabilities in highly developed countries: Issues and initial analytic structure for building resilience. In *Proceedings the 32nd International Conference of the System Dynamics Society*. http://doi.org/10.1353/tech.2003.0050

Sterman, J. D. (2001). System Dynamics Modeling: Tools for Learning in a Complex World. *California Management Review*, *43*(4), 8–25. http://doi.org/10.2307/41166098

Tashikalma, A. K., Giroh, D. Y., & Ugbeshe, V. . (2014). Swamp rice production in Ogoja Local Government Area of Cross River State , Nigeria : An imperative for rice value chain of the agricultural transformation agenda. *International Journal of Agricultural Policy and Research*, *2*(8), 281–287.

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, a., Le, Q. B., … Six, J. (2015). Food system resilience: Defining the concept. *Global Food Security*, *6*, 17–23. http://doi.org/10.1016/j.gfs.2015.08.001

Terdoo, F., & Feola, G. (2016). The Vulnerability of Rice Value Chains in Sub-Saharan Africa: A Review. *Climate*, *4*(3), 47. http://doi.org/10.3390/cli4030047

Thompson, J., & Scoones, I. (2009). Addressing the dynamics of agri-food systems: an emerging agenda for social science research. *Environmental Science & Policy*, *12*(4), 386–397. http://doi.org/10.1016/j.envsci.2009.03.001

Tiamiyu, S. A., Usman, A., & Ugalahi, U. B. (2014). Adoption of on-farm and post-harvest rice quality enhancing technologies in Nigeria. *Tropicultura*, *32*(2), 67–72.

Tollens, E. (2006). *Markets and Institutions for Promoting Rice as a Tool for Food Security and Poverty Reduction in Sub-Sahara Africa.* Working Paper No 95, Centre for Agricultural and Food Economics, Katholieke Universiteit Leuven, 2006. Dar-es-Salaam, Tanzania. http://www.biw.kuleuven.be/aee/clo/wp/tollens2006b.pdf

Tomlins, K. I., Manful, J. T., Larwer, P., & Hammond, L. (2005). Urban consumer preferences and sensory evaluation of locally produced and imported rice in West Africa. *Food Quality and*

Preference, *16*(1), 79–89. http://doi.org/10.1016/j.foodqual.2004.02.002

Totin, E., van Mierlo, B., Saïdou, a., Mongbo, R., Agbossou, E., Stroosnijder, L., & Leeuwis, C. (2012). Barriers and opportunities for innovation in rice production in the inland valleys of Benin. *NJAS - Wageningen Journal of Life Sciences*, *60-63*, 57–66. http://doi.org/10.1016/j.njas.2012.06.001

Tuler, S. P., Webler, T., & Polsky, C. (2013). A rapid impact and vulnerability assessment approach for commercial fisheries management. *Ocean and Coastal Management*, *71*, 131–140. http://doi.org/10.1016/j.ocecoaman.2012.09.013

USAID. (2009). *Attachment IV to the global food security response West Africa rice value chain analysis: Global food security response Nigeria rice study*. microREPORT#159. https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/GFSR_Nigeria_Rice_VC_Analysis.pdf

van Oort, P. a. J., Saito, K., Tanaka, a., Amovin-Assagba, E., Van Bussel, L. G. J., van Wart, J., … Wopereis, M. C. S. (2015). Assessment of rice self-sufficiency in 2025 in eight African countries. *Global Food Security*, 1–11. http://doi.org/10.1016/j.gfs.2015.01.002

van Oort, P. A. J., & Zwart, S. J. (2018). Impacts of climate change on rice production in Africa and causes of simulated yield changes. *Global Change Biology*, *24*(3), 1029–1045. http://doi.org/10.1111/gcb.13967

Velde, K. Vande, & Maertens, M. (2014). Impact of contract-farming in staple food chains : the case of rice in Benin. In *Agri-Food and Rural Innovations for Healthier Societies* (pp. 1–16). Ljubljana, Slovenia: EAAE 2014 Congress.

Vennix, J. A. M. (1999). Group model-building : tackling messy problems. *System Dynamics Review*, *15*(4), 379–401.

Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., … Wollenberg, E. (2012). Options for support to agriculture and food security under climate change. *Environmental Science and Policy*. http://doi.org/10.1016/j.envsci.2011.09.003

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience , Adaptability and Transformability in Social – ecological Systems. *Ecology and Society*, *9*(2).

Ward, P. S., Florax, R. J. G. M., & Flores-Lagunes, A. (2014). Climate change and agricultural productivity in Sub-Saharan Africa: a spatial sample selection model. *European Review of Agricultural Economics*, *41*(2), 199–226. http://doi.org/10.1093/erae/jbt025

Zossou, E., Van Mele, P., Vodouhe, S. D., & Wanvoeke, J. (2009). Comparing Farmer-to-Farmer Video with Workshops to Train Rural Women in Improved Rice Parboiling in Central Benin. *The Journal of Agricultural Education and Extension*, *15*(4), 329–339. http://doi.org/10.1080/13892240903309561

Zwart, S. J. . (2016). *Projected climate conditions for rice production systems in Africa*. Africa Rice GIS Report – 1. Africa Rice Centre Cotonou, Benin. http://dx.doi. org/10.13140/RG.2.2.13172.14728.

Appendix 2.1. Models on vulnerability and adaptation of RVCs to impacts of CCV and markets pressures

Models type	Name of model(s) used	Publication title	Publication	Authors
Physiological and Crop models	*Environmental Policy Integrated Climate (EPIC) model*	Food crop production in Nigeria. II. Potential effects of climate change	Climate Research	Adejuwon, 2006.
	General Large Area Model (GLAM)	Modelling the impacts of climate variability on crop yields in Nigeria: performance evaluation of RegCM3-GLAM system	Meteorological Applications	Matthew, et al., 2015.
	Crop Environment Resource Synthesis (CERES)-Rice model	Assessment of the CERES-Rice model for rice production in Ibadan, Nigeria	Agric Eng Int: CIGR Journal	Akinbile, 2013.
	Cropping system model (CSM) (e.g. the Spatial Production Allocation Model (SPAM), Global Agro-ecological Zones (GAEZ), and Global Map of Irrigation Areas (GMIA)	Assessing the Potential and Policy Alternatives for Achieving Rice Competitiveness and Growth in Nigeria	IFPRI	Johnson, et al., 2013.
	General Circulation Models (GCMS)	Projected climate conditions for rice production systems in Africa. AfricaRice GIS Report – 1.	Africa Rice Center	Zwart, 2016.
	ORYZA2000 model	Impacts of climate change on rice production in Africa and causes of simulated yield changes	Global Change Biology	van Oort & Zwart, 2018.
	(CERES)- Rice Crop model	Climate change impacts on rain-fed and irrigated rice yield in Malawi	International Journal of Agricultural Sustainability	Daccache, Sataya, & Knox, 2015.
	(CERES)-Rice crop model	Positive effects of climate change on rice in Madagascar	Agron. Sustain. Dev	Gerardeaux, et al., 2012.
Economic models	Intertemporal Computable Equilibrium System (ICES)-a recursive-dynamic CGE model	Climate change and adaptation: the case of Nigerian agriculture	CIP - Climate Impacts and Policy Division; Environmental and Resource Economics	Bosello, et al., 2017.
	Economy wide multimarket (EMM) model	Assessing the Potential and Policy Alternatives for Achieving Rice Competitiveness and Growth in Nigeria	IFPRI	Johnson et al., 2013.

Appendix 2.1. Models on vulnerability cont'd……

Models type	Name of model(s) used	Publication title	Publication	Authors
Economic models cont'd	Spatial market equilibrium model	Optimal Tariffs with Smuggling: A Spatial Analysis of Nigerian Rice Policy Options	IFPRI	Johnson & Dorosh, 2015.
	Rice milling model (RMM)	Policy options for modernizing the milling sector. In K. Gyimah-Brempong, M. E. Johnson, & H. (Eds. . Takeshima (Eds.), *The Nigerian rice economy: Policy options for transforming production, marketing, and trade*	IFPRI	Johnson, 2016.
	GIS-based Environmental Policy Integrated Climate (GEPIC) model	A spatially explicit assessment of current and future hotspots of hunger in Sub-Saharan Africa in the context of global change	Global and Planetary Change	Liu, et al 2008
	Statistical crop models and climate projections from 20 general circulation models	Prioritizing climate change adaptation needs for food security in 2030.	Science	Lobell et al, 2008
	Eco-hydrological modelling system such as SWIM (soil and water integrated model) and STAR (statistical regional climate model)	Vulnerability of rice production in the Inner Niger Delta to water resources management under climate variability and change	Environmental Science & Policy	Liersch, et al.2013
	The GTAP-W model	Climate change and agriculture: Impacts and adaptation options in South Africa	Water Resources and Economics	(Calzadilla, et al., 2014)
	The IMPACT and GTAP-W Model	Economywide impacts of climate change on agriculture in Sub-Saharan Africa	Ecological Economics	Calzadilla, et al., 2013
	The IMPACT and DSSAT model	Climate Change Impact on Agriculture and Costs of Adaptation	IFPRI	Nelson et al., 2009.
	Computable general equilibrium (CGE) model	Assessing the Impact of Rice Sector Policy Reforms on the Income Mobility of Rural Households in Nigeria	IFPRI	Okodua, 2017.

Appendix 3.1. Interview Guide for rice growers, miller and trader

1. Introduction

1.1 Research project title: Vulnerability of rice value chains (RVCs) to multiple, combined pressures in Benue State, North-Central, Nigeria

a. *About my research project*

My research project focuses on assessing the vulnerability of the RVC to simultaneous pressures from climate change and markets in Nigeria. The research primarily seeks to uncover the dynamics (changes) that make the RVC system vulnerable and/or resilient, and thus to provide policy-relevant recommendations to reduce its vulnerability. The research process requires the use of both primary and secondary data to develop a vulnerability scoping diagram (VSD) which will be used to assess the vulnerability of the RVC system in the face of a changing world climate and economic globalisation (e.g., markets) in the study region.

b. ***About the information you supply***

The University of Reading will keep any information you supply in a secure place until September 2017, at which time it will be destroyed. Nothing that you tell us in this research project will be disclosed to anyone other than my dissertation supervisors and markers. All information will be treated in the strictest confidence.

c. ***About this interview***

The reason for this interview is to understand how rice farmers are experiencing climate change and variability in Benue state, Nigeria. To do this, we divide the interview into three sections. In the first section, we would like to understand your exposure to climate change and variability. You will do this by simply discussing with us weather-related events, such as changes in rainfall patterns, floods, temperature rise (heat stress), and drought, that pose risks to rice growing, milling and trading in your area.

In the second section, we shall discuss the sensitivity of rice growing, milling and trading to these weather-related hazards which pose risks for rice growing, milling and trading in your area. You will tell us your experience with these hazards and the conditions that contribute to the degree to which rice growing, milling and trading is easily affected by them in your area.

Lastly, in this section, we shall want to know how you are adapting your rice production, currently and in past years, despite these weather-related hazards in your area.

You shall do this by discussing with us the decisions you make and the strategies you employ to cope with, or to minimize, the severity of these hazards on your rice farm.

2. Interviewee's data

Name of person(s): ___________________________________
Title(s): ____
Address (location): ______________________________________

3. Climate change and variability hazards and risks

3.1 General information about rice growing, milling and trading and challenges

1. Let us first talk about your rice growing, milling and trading generally. How do you grow rice?

2. What are the main problems that rice farmers in this region are facing? (or that you as a rice grower/miller/trader is facing)

3.2 Assessing exposure

1. How is the weather in your area?
2. Is the weather suitable/optimal for rice production? Why?
3. Has the weather changed in the past 5-10 or more years? Why? Are these changes concerning you?

3.3 Assessing sensitivity

1. How do you experience these weather-related events, like changes in rainfall patterns, floods, temperature rise (heat stress), and drought? How easily, and how often, are your rice decisions and farming activities (i.e., from land area choice and preparation, planting, maintaining planted rice fields, to storage) affected by these events, and why?
2. In your opinion, what rice growing, milling and trading decisions and activities (e.g., from choice of land area and preparation through to harvesting and storage) are mostly impacted by weather-related events and variability, and why?

3.4 Assessing adaptive capacity

3. What did you do when floods/changes in rainfall patterns/heat stress happened?
4. As a rice farmer, are there resources available (in terms of information, institutions, and public support) to help you manage the challenges posed by weather-related events in your area?
5. To what extent have you used such resources, if they exist? And, how have you continued to grow rice in their absence?
6. What stands in your way as you go about managing your rice farm from the risks posed by each of the weather-related events?

Other possible follow-up questions:
Why/why not?
What do you mean by X?
Could you explain X to me?

So, how did you feel about X?

Appendix 3.2. Rice value chains actors' workshop, 2017. Workshop protocol and facilitation guide designed to elicit the understanding of rice value chains by different actors (e.g., rice growers, processors and traders) Benue State, Nigeria.

Workshop information

- *Workshop objective*: to map the components of the rice value chain and their interactions in Benue State, Nigeria.
- *Duration of the workshop*: One day per site/location
- *Language and facilitation*: The workshop shall be conducted in the Tiv language, however, participants will be free to mix English language, if they have the capacity to do so.
- *Number of facilitators*: The workshop will be facilitated by three facilitators, myself and two others. I will play the role of conducting the workshop generally, while the other two facilitators will take notes and capture session results in workbooks, administer workshop materials, help maintain order, and assist as needs arise during the course of the workshop.
- *Representation of rice value chain actors*: Three groups of actors will be represented in the workshop. These are the rice growers, processors, and traders. The workshops will be conducted in two of the three study sites/locations, Makurdi and Adikpo. A total of 20 RVC actors will be invited. The participants shall be a mixture of both male and female actors of different capacity and scale (e.g., small, medium, or large).

Workshop Materials

- Tape
- 23 Marker pens
- 23 booklets + 23 pens to take notes
- 5 x 50 coloured cards per workshop (Yellow, Green, Blue, Purple, and Orange)
- Camera
- Voice recorder
- Name tags (sticky paper)
- Registration list for participants

Administrative issues preceding the workshop:

- Workshop venue with one big room, sufficient tables, chairs, etc.
- Invitations to be sent at least two weeks before the workshop; reminders sent a few days in advance; telephone contact recommended
- List of confirmed participants (ensure equal representation of the three stakeholder groups)

- Transportation allowances for some participants from far villages
- Organise tea and lunch breaks

Workshop phases

- Introduction phase: this shall comprise of two major activities. The total expected duration of the excerises is 30 minutes
  - Activity 1. Welcoming of participants and establishment of group relations (10 minutes)
  - Activity 2. Discussion of the workshop goal (20 minutes)
    - Key activities
      - Start time: 9.00 am.
      - Objective: To introduce the workshop and participants.
      - Activity 1. Welcoming of participants and establishment of group relations. The Participants will be welcomed and given the opportunity to get to know each other.
      - Activity 2. Discussing the workshop goal.
      - The role of faciltators. The faciliator welcomes participants and helps them to get to know each other. Secondly, the facilitator familiarises the participants with the workshop objectives and how the workshop will be conducted.
      - Tea break: 9.30 am.
    - Materials needed:
      - Name tags
      - Marker pens
      - List of participants
      - 30 Booklets to write notes + 30 pens
      - Printed workshop programme
      - Coloured cards (5 cards per participant)
    - Potential challenges: delay in the start of the workshop

- Divergent phase: Brainstorming about components of rice value chain (80 minutes)
  - Activity 1. Creation of a general list of components (40 mins)
  - Activity 2. Determination of components to form final list (40 mins)
    - Key activities

- Time: 9: 45 am.
- Objective: To identify the main components of the rice value chain.
- Activity 1. Participants will be asked first to write the major components of the RVC system either on a coloured card or white paper and stick it on the board (e.g. rice production, rice assemblage/marketing, rice processing and rice trading).
- Activity 2. Participants (e.g., rice growers) will be asked to focus on a particular component (e.g., rice production) and write the components that constitute the system on a piece of paper to stick on the board (e.g., rice growers). This same procedure will be applied to all the other components listed in the first instance. In the two activities, paricipants will be expected to explain their choice of component. This will be done verbally or in a note.
- The role of facilitators. During these activities, facilitators will walk round explaining the activities and helping participants who have questions or need further support.

o Materials needed:

- Name tags
- Marker pens
- List of participants
- 30 Booklets to write notes + 30 pens
- Printed workshop programme
- Coloured cards

Potential challenges: firstly, participants who cannot read or write; secondly, participants who need support to think these issues through, they may not think systemically.

▪ Convergent phase: Identifying linkages between different components (120 mins)

- Time: 10: 45
- Cluster components
- Relate/link components to each other

- Identify relations

o Key activities

- Time: (120 mins)

- Objective: To identify relations between main components and the sub-components of the RVC.
- Activity: Participants will be asked to use the marker pens and indicate links by drawing lines between the components.
- The role of facilitators. Facilitators will provide a guide to the exercise, helping participants to draw correct links and asking them to make notes about why they think the relations exist.

o Materials needs
  - Voice recorder
  - Booklets to write notes
  - Pens
    Markers pens

o Potential challenges: some components may have more than one or two links; also, participants who cannot read or write, and again, inability of some participants to think systemically.

- Lunch break: 12: 45 pm

▪ Finalization phase (1:15 mins)
  - Objective**:** Get thoughts and comments on the mental maps developed during the workshop (60 minutes)

    o Key activity
      - Activity 1. An open discussion with the participants to reflect on the mental map of the RVC developed in the workshop. This activity will centre on the following questions (30 mins).
      - How do participants see mental maps now that they have gone through the process?
      - What thinking do the maps stimulate?
      - Have the exercises helped participants to learn anything?
      - Do they feel they have better understood, challenged, or confirmed their beliefs?
      - Activity 2. Use the drawings of the mental maps to discuss weak spots (30 mins.)
      - Where are the weak spots (and why are they considered to be weak spots)?
      - Activity 3. Discuss possible actions on the RVC (30 mins.)
      - What are the possible actions on the RVC?

- Facilitator role. Facilitators will help the participants to understand and respond to the above questions by providing explanations where necessary. In addition, facilitators shall stimulate and challenge the thinking of participants to respond appropriately if necessary.

- Materials needed
  - Voice recorder
  - Booklets to write notes
  - Pens
  - Markers pens
- Potential challenges: participants who cannot read or write.
  - End time: 2.30 pm.

Appendix 5.1. Social demographic characteristics of rice growers in Benue State

Study sites	Number	Gender	Age	Education level	Income class	Ethnicity	Farm size (Ha)	Years engaged as rice grower	Rice growing system	Labour access	Land access or tenure type
Makurdi	1	M	40-44	Higher	Medium	Tiv	10	7	Lowland	Hired/family	Rent from communal
	2	M	45-49	Secondary	Low	Tiv	6	5	Lowland	Hired/family	Rent from communal
	3	F	60-64	None	Low	Tiv	2	20	Upland	Family	Communal
	4	M	50-54	Higher	Medium	Tiv	1.7	39	Upland	Family	Communal
	5	M	70-74	Primary	Low	Tiv	1.8	40	Lowland	Family	Communal
	6	M	45-49	Secondary	Medium	Tiv	>30	12	Lowland/upland	Hired	Rent from government
	7	M	50-54	Higher	High	Tiv	>50	15	Lowland	Hired	Communal/government rent
	8	M	30-34	Higher	Medium	Tiv	>25	20	Lowland	Hired	Rent from government
	9	M	55-59	Higher	Low	Tiv	12	23	Lowland	Hired/family	Rent from communal
	10	M	45-49	Secondary	Low	Tiv	3	17	Lowland	family	Communal
	11	M	40-44	Higher	Low	Tiv	2	26	Upland	Family	Communal
Gboko	12	M	40-44	Primary	Low	Tiv	1.5	11	Lowland	Family	Communal
	13	M	45-49	Primary	Low	Tiv	5	8	Lowland	Hired/family	Communal
	14	M	60-54	None	Medium	Etolu	30	21	Lowland	Hired/family	Communal/government rent
	15	M	45-49	None	Low	Tiv	.5	13	Lowland	Family	Communal
	16	M	35-39	Secondary	Low	Tiv	2	9	Upland	Family	Communal

Appendix 5.1. Social demographic characteristics of rice growers continued…..

	17	M	40-44	Higher	Low	Tiv-Etolu	8	12	Lowland	Family/hired	Communal
	18	F	50-54	None	Low	Tiv	3	8	Upland/Lowland	Family	Communal
	19	M	45-49	Secondary	Low	Tiv	3	12	Upland/Lowland	Family	Communal
	20	M	50-54	Higher	High	Tiv	8	26	Lowland	Hired	Rent from Communal
Adikpo	21	M	35-39	Secondary	Low	Tiv	1.5	5	Lowland	Family	Communal
	22	M	45-49	Primary	Low	Tiv	3	9	Lowland	Family	Communal
	23	M	40-44	Primary	Low	Tiv	I.3	5	Lowland	Family	Communal
	24	M	50-54	Higher	Medium	Tiv	15	11	Lowland/Upland	Hired/family	Communal
	25	M	35-39	Secondary	Low	Tiv	.5	4	Lowland/upland	Family	Communal
	26	M	50-54	Primary	Low	Tiv	3	12	Lowland/upland	Family	Communal
	27	M	45-49	primary	Low	Tiv	2	21	Lowland/upland	Family	Rent from communal
	28	M	45-49	primary	Low	Tiv	5	10	Lowland/upland	Family/hired	Communal
	29	M	65-69	primary	Low	Tiv	1.2	21	Lowland/upland	Family	Communal
	30	M	40-44	Primary	Medium	Tiv	4.5	7	Lowland	Family/hired	Communal

Appendix 6.1. Social demographic characteristics of rice millers in Benue State

Study sites	Number	Gender	Age	Education level	Income class	Ethnicity	Identification as millers (size)	Years engaged as rice miller	Rice processing machines used
Makurdi	1	F	40-44	Secondary	Low	Tiv	Small	16	MPDB
	2	M	45-49	Primary	Low	Tiv	Small	21	MPDB
	3	M	45-49	Secondary	Low	Tiv	Small	12	MPDB
	4	F	50-54	primary	Low	Tiv	Small	25	MPDB
	5	F	50-54	primary	Low	Tiv	Small	18	MPDB
	6	M	40-44	Higher	Higher	Tiv	Large	8	MIRMM
	7	F	45-49	Secondary	Low	Tiv	Small	17	MPDB
Gboko	8	M	55-59	Secondary	Low	Tiv	Small	8	MPDB
	9	M	40-44	Secondary	Low	Tiv	Small	8	MPDDM
	10	M	45-49	Secondary	Low	Tiv	Small	15	MPDB
	11	M	35-39	Primary	Low	Idoma	Small	12	MPDB
	12	F	40-44	primary	Low	Tiv	Small	5	MPDB
	13	F	50-54	Primary	Medium	Tiv	Medium	25	MPDDM
	14	M	45-49	Secondary	Low	Tiv	Medium	8	MPDDM
Adikpo	15	M	50-54	secondary	Low	Tiv	Small	11	MPDB
	16	M	55-59	Primary	Low	Tiv	Small	22	MPDB
	17	M	45-49	primary	Low	Tiv	Small	7	MPDB
	19	M	40-44	Secondary	Low	Tiv	Small	10	MPDB
	20	M	35-39	Secondary	Low	Tiv	Small	9	MPDB
	18	M	45-49	Secondary	Low/Medium	Tiv	Small	18	MPDB
	21	M	50-54	Primary	Low	Tiv	Small	21	MPDB

MPDB=stands for use of artisanal parboilers, dryers and blackstone dehusker without separating stones and impurities from rice grains; MIRMM=stands for modern integrated rice milling machines which can remove all impurities, sort, polish and grade rice grains; and MPDDM=stands for use of artisanal parboilers, dryers and destoning machines capable of removing stones and impurities from rice.

Appendix 6.2. Socio-demographic characteristics of milled rice traders in Benue State

Study sites	Number	Gender	Age	Education level	Income class	Self-identification of trading scale	Ethnicity	Years of trading rice	Type of rice sold on the market	Most important ways of selling rice
Makurdi	1	M	40-45	primary	Low	Small scale	Etulo	5	local	Retailer/wholesalers
	2	M	35-39	Secondary	Low	Small scale	Tiv	7	Local	Retailer/wholesalers
	3	M	50-55	Secondary	Medium	Small scale	Igbo	23	Foreign	Retailer/wholesalers
	4	F	40-44	secondary	Low	Small scale	Tiv	16	Local	Retailer/wholesalers
	5	M	45-49	Higher	Higher	Large scale	Tiv	7	Local stone free	Wholesaler/Retailer
	6	M	55-59	None	medium	Small scale	Hausa	13	Foreign	Wholesaler/Retailer
	7	M	50-55	None	Medium	Small scale	Hausa	7	Foreign rice	Wholesaler/Retailer
	8	F	50-54	Secondary	Low	Small scale	Tiv	19	Local stone free	Retailer/wholesalers
Gboko	9	M	45-49	Secondary	Low	Small scale	Tiv	13	Local	Retailer/wholesalers
	10	F	40-44	Primary	Low	Small scale	Tiv	8	Local	Retailer/wholesalers
	11	F	45-49	Secondary	Low	Small scale	Tiv	11	Local	Retailer/wholesalers
	12	M	50-54	Primary	Low	Small scale	Tiv	15	Local stone free	Retailer/wholesalers
	13	M	45-49	Secondary	Low	Small scale	Tiv	7	Local	Retailer/wholesalers
	14	M	40-44	Higher	Medium	Medium scale	Tiv	11	Local stone free	Wholesale/Retailer
	15	F	50-54	Primary	Medium	Medium scale	Tiv	16	Local/stone free	Wholesaler/Retailer
	16	M	45-49	Secondary	Low	Small scale	Tiv	13	Stone free	Retailer/wholesalers
Adikpo	17	M	45-49	Secondary	Medium	Medium scale	Tiv	8	Local	Wholesaler/Retailer
	18	F	40-44	primary	Low	Small scale	Tiv	13	Local	Retailer/wholesalers
	19	F	40-44	Primary	Low	Small scale	Tiv	12	Local	Retailer/wholesalers
	20	M	45-49	Secondary	Low	Small scale	Tiv	8	Local	Retailer/wholesalers
	21	F	40-44	Primary	Low	Small scale	Tiv	7	Local	Retailer/wholesalers