ORGANIC REVOLUTION: COTTON AND ITS IMPACT ON POVERTY, INEQUALITY AND SUSTAINABILITY IN TANZANIA

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and approved by

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ABSTRACT OF THE DISSERTATION

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With organic consumption booming, proponents of organic agriculture argue that it presents a viable development alternative for African farmers that were sidestepped by the Green and Biotechnology revolutions. While ecological and human benefits of organic agriculture are better known, scholarship is lacking on the socio-economic impacts of organic export production on certified and non-certified farmers in Africa. Positioning organic agriculture as an innovation, this dissertation addresses critical omissions by asking: What impact does the Organic revolution have on poverty, inequality and sustainability? It draws on and contributes to bodies of literature on Agricultural Development and Inequalities in Africa, Agricultural Sustainability, and Multidimensional Poverty. Based on a survey of 122 organic and conventional cotton farmers in Meatu District, Tanzania, organic agriculture’s potential as a pro-poor development intervention is evaluated. Quantitative analyses were coupled with participatory econometrics, which included focus groups and semi-structured interviews during follow-up visits.

Main findings include organic farmers owning on average larger farms and being wealthier compared to their conventional counterparts. Lower levels of human capital were not identified as a barrier towards the diffusion of organic methods, which are traditionally more labor- and knowledge-intensive compared to the capital-intensive
nature of previous agricultural revolutions. Lack of access to land was a key reason the poorest conventional farmers were unable to join. Organic farmers on average had lower prevalences, breadths and depths of poverty. Unidimensional and multidimensional poverty analyses showed that the intercropping of mungbeans - introduced into organic farming for its nitrogen-fixing properties - had a positive impact on lowering inequalities between organic and conventional farmers due to widespread adoption by both groups. The dissertation makes significant empirical contributions by providing a comparative study of organic and conventional farmers in sub-Saharan Africa, evaluating who becomes an organic farmer, and measuring the impact of organic agriculture on poverty, inequality and sustainability. These findings have important implications of the potential for the Organic revolution to act as a viable pro-poor development alternative.
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Dedication

To my family - old and young, original and new - but especially my mom and dad, Rosmarie and Christian, who have encouraged me to finish before their retirement.
Table of Contents

Abstract ................................................................. ii
Acknowledgements ....................................................... iv
Dedication ................................................................. vi
List of Tables ............................................................ xiv
List of Figures ............................................................ xvi

1. Introduction: An Organic Revolution in Africa ................. 1
   1.1. Problem Statement and Overview of Research Project ...... 2
   1.2. Methodological Contributions .................................. 4
   1.3. Empirical Contributions .......................................... 6
   1.4. Theoretical Contribution ......................................... 6
   1.5. Dissertation Structure .......................................... 7

2. Review of Literature and Research Design ......................... 9
   2.1. Review of Theoretical and Empirical Literature .......... 10
       2.1.1. Agricultural Development and Inequalities in Africa .. 10
              Agriculture’s Role in Development in Africa ........... 11
              Pro-Poor Agricultural Growth ............................... 12
              Impact of Agricultural Innovations ....................... 14
              Contract Farming .............................................. 17
       2.1.2. Agricultural Sustainability ............................... 19
              Defining Organic Agriculture and its Ecological Benefits . 20
              Measuring Organic Sustainability ............................ 24
       2.1.3. Multidimensional Poverty .................................. 25
3. Agricultural Interventions in Tanzania ............................ 62
  3.1. Cotton as a Development Intervention .............................. 64
    3.1.1. Traditional Usage of Cotton ................................. 64
    3.1.2. German and British Push for Production ..................... 65
      Motivation and Cotton Production under German Rule .......... 66
      Motivations and Cotton Production under British Rule ....... 70
    3.1.3. Postcolonial Developments in the Agricultural Sector .... 76
      Cotton under Ujamaa ............................................ 76
      Cotton under Liberalization .................................. 78
      Agriculture after Liberalization ............................... 83
  3.2. History of Agricultural Production ............................. 86
    3.2.1. Traditional Agricultural Production ....................... 87
    3.2.2. Intensification ............................................. 88
    3.2.3. Role of Livestock .......................................... 90
    3.2.4. Role of Geography .......................................... 90
    3.2.5. Role of Culture ............................................ 93
  3.3. Summary .................................................................. 97

4. Who is an Organic Farmer? Adoption of an Organic Innovation .... 99
  4.1. Socio-Economic Differences of Farming Households .............. 100
  4.2. Modeling who Becomes an Organic Farmer ......................... 103
    4.2.1. Logit Model .................................................. 104
    Discussion ............................................................ 107
    4.2.2. Count Model .................................................. 110
  4.3. Differences in Incomes of Farmers ............................... 116
    Calculation of Income and Labor .................................. 116
    4.3.1. Net income from Cotton at the Household-Level ........... 117
    4.3.2. Net Income from Cotton per Contributing Household Member . 123
    4.3.3. Total Income at the Household-Level ....................... 124
5. Measuring Sustainability of Organic Agriculture ................. 137

5.1. Review of Agricultural Sustainability Indicators ................. 138
  Common Characteristics of Sustainability Indicators .......... 139
  Importance of Scale of Analysis .......................... 142
  Top-down versus Bottom-up Indicators ....................... 143

5.1.1. Criteria for Indicators ................................ 145

5.1.2. Scoring Criteria for Indicators ........................... 148
  First Dimension of Minimizing Off-Farm Inputs .............. 149
  Second Dimension of Minimizing Non-Renewable Inputs ..... 150
  Third Dimension of Maximizing Natural Biological Processes .... 150
  Fourth Dimension of Promoting Local Biodiversity .......... 151

5.2. Farm-Level Sustainability Index .............................. 152
  5.2.1. Description of Farm-Level Sustainability Index ........ 152
  5.2.2. Comparison of Sustainability Score by Type of Farmer .... 157
  Spider Graph of Average Farmer ............................ 158
  Spider Graph of Top and Bottom 5 Farmers .................. 159
  Spider Graph on Highest and Lowest Individual Farmer ....... 161
  Summary .................................................... 162

5.3. Predicting Farm-Level Sustainability .......................... 163
  Multiple Regression Model: Sustainability Levels ............. 165
  5.3.1. Multiple Regression Model: Profitability ............... 169
  Comparing Net income per Acre with Sustainability ........... 169
  Predicting Net income per Acre from Cotton .................. 173
5.4. Summary and Discussion .................................................. 175

6. The Impact of Organic Production on Inequality and Poverty .... 177
   6.1. Method for Calculating Poverty and Inequality ...................... 178
      6.1.1. Identification .................................................. 178
      6.1.2. Aggregation ................................................... 181
      6.1.3. Decomposition ............................................... 182
      6.1.4. Dimensional Cutoffs and Weights .............................. 183
             Weights used in Multidimensional Calculations ............... 183
   6.2. Unidimensional Poverty ............................................. 185
      Choice of Basic Need Line ........................................ 185
      6.2.1. Assessing the Basic Needs .................................. 186
             Basic Need Levels with Cotton Income ..................... 187
             Basic Need Levels with Total Income ..................... 188
      6.2.2. Unidimensional Poverty Scores .............................. 189
             Poverty Headcount ....................................... 189
             Poverty Gap ............................................. 190
   6.3. Multidimensional Poverty .......................................... 192
      6.3.1. Basis of Multidimensional Factors ........................... 192
      6.3.2. Multidimensional Poverty Scores ............................ 194
             Multidimensional Poverty Headcount ..................... 194
             Multidimensional Poverty Gap ............................ 195
      6.3.3. Decomposition of Multidimensional Poverty ................. 198
   6.4. Principal Component Analysis ..................................... 208
      6.4.1. Justification and Method for PCA ........................... 208
      6.4.2. Results ................................................... 209
      6.4.3. Analysis of First Principal Component (PC) ............... 212
             Comparison of Weights ..................................... 215
      6.4.4. Comparing Total Scores for PCA and Multidimensional Index .. 218
6.5. Discussion ....................................................... 223
   6.5.1. Temporal Analysis: Impact of Commodity Boom on Poverty and
           Inequality .................................................. 224
           Impact on Poverty Reduction and Inequality ................. 226
6.6. Summary ....................................................... 233

7. Conclusions ...................................................... 236
   7.1. Research Findings .......................................... 237
   7.2. Policy Implications ........................................ 241
   7.3. Limitations of the Study ................................. 243
   7.4. Directions for Future Research ............................ 246
       7.4.1. Theoretical Avenues for Future Research .............. 246
       7.4.2. Empirical Avenues for Future Research ............... 247
           Adopters of Organic Innovations ......................... 247
           Measuring Sustainability .................................. 248
           Multidimensional Poverty ................................. 249
           Impact of GM Cotton ..................................... 250

Appendix A. Household Survey ..................................... 253

Appendix B. Calculations of Net Income for Cotton ............... 261

Appendix C. Calculation of Total Income .......................... 266
           Additional Income from Sales of Crops ..................... 266
           Additional Income from Sale of Livestock ................. 267

Appendix D. Categories of Labor and their Importance .......... 269

Appendix E. Calculations of Multidimensional Poverty Index .... 271
   E.1. First Dimension: Economic Sustainability .................. 271
       E.1.1. Monetary ............................................... 271
       E.1.2. Non-Monetary ......................................... 271
E.2. Second Dimension: Social Sustainability ........................................ 272
   E.2.1. Self-sufficiency ................................................................. 272
   E.2.2. Social Capital ................................................................. 272
   E.2.3. Health ............................................................................. 273
   E.2.4. Human Capital in Agriculture ............................................. 273
E.3. Third Dimension: Vulnerabilities .................................................. 274
E.4. Design of Multidimensional Index ................................................ 274
   E.4.1. Scoring Criteria ................................................................. 274
E.5. Older Poisson Regressions with Overdispersion .............................. 278
E.6. Principal Components Data ......................................................... 280

Appendix F. Analysis of the 11 Principal Component Scores ................. 282

Appendix G. Spatial Analysis of Poverty ........................................... 286
   Poverty Score across the Villages ............................................... 286
   Poverty Score and Distance of Farming Household ....................... 289

References ...................................................................................... 293

Vita .................................................................................................. 309
List of Tables


2.2. Comparison of Organic Production from India and Tanzania (Remei 2011) ................................................................. 49

4.1. Definition of Variables Chosen ............................................. 100

4.2. Comparisons of Socio-Economic Indicators Means Across Farmer Types 101

4.3. Logit Model of Who is an Organic Farmer .......................... 105

4.4. Correlation Across Variables ............................................. 106

4.5. Revised Logit Model of Who is an Organic Farmer (with cattle) 107

4.6. Revised Logit Model of Who is an Organic Farmer (with acres owned) 108

4.7. Comparisons of Socio-Economic Indicators Means across Education of Household Heads .................................................. 110

4.8. Adjusted Poisson Model Predicting Years with bioRe .................. 111

4.9. Poisson Model Predicting Years with bioRe and Assets (all farmers) . 113

4.10. Poisson Model Predicting Years with bioRe and Assets (bioRe farmers only) ................................................................. 114

4.11. Descriptive Statistics on Net Income from Cotton .................... 118

4.12. Descriptive Statistics on Organic Net Income from Cotton ........... 120

4.13. Descriptive Statistics on Conventional Net Income from Cotton ...... 120

4.14. Descriptive Statistics on Organic Net Income from Cotton per Contributing Household Member ............................................. 123

4.15. Descriptive Statistics on Conventional Net Income from Cotton per Contributing Household Member ..................................... 123

4.16. Descriptive Statistics on Total Income ................................... 124
List of Figures

2.1. Operational Indicators for Agricultural Sustainability (adapted from Zhen and Routray 2003, p.43) ................................................................. 26
2.2. Components of the Human Development Index (UNDP 2011) ........... 30
2.3. Map of Meatu District in the Shinyanga Region (Source: Pattni 2010) . 42
2.4. The Sukuma Cantena: General Shape and Sequence of Soil Types (Source: ICRA 2003, p.2) ................................................................. 43
2.5. Histogram of Main Source of Income in Shinyanga Region ............... 46
2.6. bioRe/Remei Cotton Value Chain (Pattni 2010, p.100) .................... 50
2.7. Training of extensionists at bioRe headquarters in Mwamishali ........ 51
2.8. Innovation in action: farmer ox-weeding in Ng’hoboko while using cellphone 54
2.9. Sample Size by Village and Farm Type ........................................... 57
3.1. Jubilant cotton trader in Mwamishali during purchasing season ........ 63
3.2. Pre-Colonial Cotton Usage Depicted in Koponen (1988, p.265) ........ 64
3.3. Cotton Production Statistics Based on Saylor (1970) ....................... 74
3.4. Production Figures since 1985 of Cotton in Tanzania (Tschirely et al. 2009) ......................................................................................... 80
3.5. Comparative Categorization of Tanzanian Cotton Sector as Competitive 82
3.6. Decline in Agricultural Productivity per Capita from 1960 - 2007........ 84
4.1. Histograms of Net Income from Cotton ........................................... 119
4.2. Histograms of Net Income from Cotton per Contributing Household Member .............................................................. 122
4.3. Histograms of Total Income ............................................................. 125
4.4. Conventional farmer earning additional income selling water in Sanga-Itinje129
4.5. Future Decisions on Mungbean by Conventional Farmers .............. 130

xvi
6.8. Comparison of Squared Censured Adjusted Poverty Gap Score ...... 197
6.9. Decomposition of Poverty by First Dimension ......................... 200
6.10. Decomposition of Poverty by Second Dimension ....................... 203
6.11. Decomposition of Poverty by Third Dimension ....................... 206
6.12. Approximate Comparison of Weights by Index Methods ............... 216
6.13. Difference in Weights ranked from Over- to Underestimation ......... 217
6.14. Correlation between PCA Score and Multidimensional Index ........ 220
6.15. Correlation between PCA Score and Multidimensional Index ........ 222
6.16. Cotton Leading the Way in Second Commodity Boom ................. 225
6.17. Change in Cotton Acreages planted between 2008-09 season and 2009-10 season .................................................. 227
6.18. Increase in Cotton Purchase Price in 2010 after stagnant first 4 weeks . 228
6.19. Chart drawn by Focus Group to Discuss the Relationship between Cattle and Cotton ..................................................... 231
A.1. Household Survey .......................................................... 253
A.2. Household Survey (cont.) .................................................. 254
A.3. Household Survey (cont.) .................................................. 255
A.4. Household Survey (cont.) .................................................. 256
A.5. Household Survey (cont.) .................................................. 257
A.6. Household Survey (cont.) .................................................. 258
A.7. Household Survey (cont.) .................................................. 259
A.8. Household Survey (cont.) .................................................. 260
E.1. Eigenvectors for Principal Component Analysis ....................... 281
E.2. Eigenvectors cont. ......................................................... 281
G.1. Ranked villages according to average number of years with bioRe .... 287
G.2. Strong relationship between years with bioRe and poverty scores at the village levels ................................................... 288
G.3. Relationship between Distance from Village Center and Poverty Gap Score .............................................................. 290

xviii
G.4. Relationship between Distance from Village Center and Poverty Gap

Score for Conventional Farmers only ........................................... 291
Chapter 1

Introduction: An Organic Revolution in Africa

Organic agriculture is booming. Despite the recent global food and financial crises, the production and consumption of organic goods has defied common trends. Statistics on consumption by the Organic Trade Association (2010) show that in the United States, growth in organic food sales was twice as much compared to the conventional sector in 2009, reaching a four percent market share. This growth was outpaced by the non-food segment, where organic sales increased nearly 10 percent in 2009 compared to a slight decline in the conventional non-food segment (Ledermann and Leichenko forthcoming).

In regards to production, organic agriculture has expanded beyond its European origins into developing countries. While Africa only contains around 3 percent of global organic land, it had more than 500,000 producers, the largest number by world regions (FiBL 2011). In terms of acreage, the largest countries were Uganda (at more than 200,000 hectares) - producing organic cotton, coffee, pineapple and vanilla - and Tunisia (at more than 150,000 hectares) - producing organic olives. Most of these products are destined for European export markets, with Ugandan export value estimated at 37 million US$ alone in 2009/10 (FiBL 2011). The case of Tanzania illustrates this boom. Traditionally the cotton exports of Tanzania, while important to its domestic economy, have only a minor share of the global market. Its organic cotton sector, however, grew in recent years to become the fifth largest of the world in terms of total cotton exported.

Heralded as the beginning of an Organic revolution in sub-Saharan Africa (Beintema et al. 2009; Biovision 2011; Dowd 2008; UNEP-UNCTAD 2008), this agricultural development strategy of increasing smallholders’ productivity using locally adapted methods holds vast promise for two interrelated reasons: First, previous agricultural revolutions - the Green and Biotechnology revolutions - have largely sidestepped the
continent as a whole and small-scale farmers in particular. Second, even in the context of a long history of failure and exploitation, agriculture-led development remains a main avenue for alleviating poverty.

While activists for a long time have promoted organic agriculture (Paarlberg 2008a,b), calls for sustainable agriculture as a pathway forward gained legitimacy and traction after its prominent endorsement by the *International Assessment of Agricultural Knowledge, Science and Technology for Development* (IAASTD 2009). Following through on this perceived paradigmatic shift away from energy-intensive industrial agriculture towards organic agriculture – with a focus on agriculture’s multifunctional role – is believed to result in “reducing hunger and poverty and improving rural livelihoods reality” (Biovision 2011). Benefits of a spread of organic agriculture include increased biodiversity, improved soil fertility and pest management, increased moisture content, carbon sequestration, and reduced health risks (Eyhorn et al. 2005; Niggli 2010; IAASTD 2009b).

While these ecological and human benefits are better known, scholarship has been lacking on the impacts of organic export production on the poverty and inequality of African farmers (see Bolwig et al. 2009 for an exception). Inequality especially has received little to no attention, even though previous agricultural revolutions - the *Green* and *Biotechnological revolutions* - have revealed uneven and unintended socio-economic impacts of the diffusion of new agricultural technology on small-scale farmers across the globe (Birkenholtz 2009; Das 2002; UNEP-UNCTAD 2008). Furthermore, analyses on the ecological sustainability of organic agriculture - via the measurement of adoptions of organic methods by organic and conventional farmers - have only been explored to a limited extent in sub-Saharan Africa (see Zhen and Routray 2003).

### 1.1 Problem Statement and Overview of Research Project

This dissertation addresses these critical omissions by asking the following: What impact does this *Organic revolution* have on poverty, sustainability and inequality? This question is answered via a comparative study of 122 organic and conventional cotton
producers in the remote Shinyanga region, the heartland of traditional cotton production in Tanzania and the current site of booming organic cotton production orchestrated by one of the world’s largest organic cotton companies, Remei. Fieldwork was undertaken in iterative steps, with a preliminary visit in 2009 followed up by surveys and focus groups in 2010. In 2011, two return visits were made to share preliminary findings and investigate interannual changes.

In order to provide answers on the sustainability, poverty and inequality of organic agriculture, the research draws on and contributes to three interrelated bodies of literature: Agricultural Development and Inequalities in Africa, Agricultural Sustainability, and Multidimensional Poverty. The first research question - Who is an organic farmer? - compares the organic and conventional farming groups, identifying whether differences exist in joining certified organic export production. It draws and contributes to a vast literature on the pro-poor role of agricultural development. By analyzing the introduction of organic agriculture as an innovation, it provides novel empirical insights into what type of farmers are able to take advantage of this alternative development strategy.

The second research question - Are organic farming practices sustainable? - critically assesses these organic methods by studying their adoptions and their assumed impacts on agricultural sustainability. By including conventional farmers, it specifically researches how their sustainability levels compare to certified counterparts. Building on previous work in assessing agricultural sustainability, it connects to the previous literature on agricultural development by investigating if even poorer, non-organic farmers can benefit from the introduced innovations via their adoption. Although organic methods are assumed to be ecologically superior, this provides unique insights into the differences existing between organic farmers that are certified and conventional farmers that are deemed de facto organic as they operate in a traditionally low input environment.

The third research question - What is the impact of organic agriculture on poverty and inequality? - expands the ecological sustainability analysis to social and economic dimensions, including vulnerability. It completes the analysis by investigating the introduction of organic agriculture on poverty and inequality within and between organic
and conventional farmers. The literature which primarily informs this analysis draws from recent advances made under the umbrella of *multidimensional poverty*. Since organic agriculture is a holistic production system, the analysis of its impact on poverty should also move beyond a classical unidimensional focus on monetary income. This connection succeeds in linking the multifunctionality in organic agriculture – analyzed via the *agricultural sustainability* literature – with the advances in the study of the multidimensionality in poverty research that draw on economic, social and vulnerability dimensions. The findings from answering this last question consequently allows us to link back to the literature on agricultural development and fill the gap on the *Organic revolution*’s impact on poverty and inequality in Africa.

By drawing and building on these three interrelated bodies of literature, this dissertation makes the following methodological, empirical and theoretical contributions.

### 1.2 Methodological Contributions

This dissertation contains two significant methodological contributions: *participatory econometrics* and *multidimensional poverty measurement*.

**Participatory Econometrics**  As outlined, the fieldwork included four separate trips to the research area between 2009 to 2011. This iterative approach allowed for engaging in *participatory econometrics* and answers calls made by geographers to combine advanced quantitative analyses - which rest at the heart of this dissertation - with qualitative data gathering and participatory methods (for example see Barnes 2009). As coined by Rao (1998), this underutilized method differs from other mixed methods in that “the econometric analysis is central to the exercise [and] has the participatory aim of making respondents important players in the analytical work” (Rao 2002, p. 1887). This research contributes to the methodology by highlighting three areas where *participatory econometrics* was beneficial: First, a strict reliance on econometrics often only provides limited evidence on causality. Undertaking focus groups with farmers to share these findings results in a better understanding on interpreting the magnitude and directionality of the findings. Sharing results and entering a dialog also fosters a healthy
and longstanding relationship that facilitated (the value of) subsequent visits. Second, econometric analyses are often riddled by problems of highly influential data - outliers. Since the surveys were undertaken without the aid of enumerators, specific attention was paid to the individual story of the farmer. Sharing the data with farmers furthermore allowed to make more informed decisions on excluding or including certain data. Third, and most relevant for this research, the application of participatory econometrics involved allowing qualitative data and findings to influence the data or econometric analysis at all research stages. For example, during the first visit, consultations were made with staff members on key areas of concern, as well as conversations were held with farmers at a buying post. In the second visit, prior to the beginning of the survey, the questionnaire was reviewed in a sample village and shared with key stakeholders. This allowed to identify several novel areas, such as the role of mungbeans, that later became a key part of the research. At the end of the second, and during the third and fourth visit, the preliminary findings were shared with farmers, village members, and extension officers. Focus groups were held with selected farmers to investigate specific findings from the multivariate analyses, yet also discuss interannual changes that were not captured by the survey.

**Multidimensional Poverty Measurement**  A second methodological contribution comes from the successful application of Alkire and Foster’s (2011a,b) multidimensional measurement and their multidimensional poverty index. Although they focus on the national level, they welcome its application across levels, including the village or the state. Given the novelty yet prominence of the measurement, this research is the first to apply it to the local level by drawing on differences found across the six study villages based on household data. This index – given its subjective weighting – is compared to a principal component analysis (PCA) in order to obtain a more rigorous understanding of the components determining poverty and inequality.
1.3 Empirical Contributions

In addition to the two methodological contributions, this dissertation contains four empirical contributions that were identified based on existing gaps in the literature. First, the research provides unique insights by undertaking a comparative study between organic and conventional farmers in a *de facto* organic environment (see Bolwig et al. 2009 for the exception). Second, it evaluates specifically who becomes an organic farmer in a developing context, work that previously was undertaken only in Europe (see Läpple and Van Rensburg 2011). Third, it fills an important gap as it provides scholars and especially policy makers with a better understanding of the impact of organic agriculture on poverty and inequality. This includes an investigation on who is able to benefit and who fails to, including an identification of the relevant reasons. Given the push for an Organic revolution (vis-à-vis a potent imminent introduction of biotechnology), obtaining a better understanding of its potentials and limits for achieving pro-poor growth is of great value. This research offers a fourth empirical contribution by transferring the farm-level sustainability measure developed by Rigby et al. (2001) in Europe to the local scale in a sub-Saharan African context. This application involves the development of a scoring system based on the theoretical impact of organic methods widely applied in sub-Saharan tropical agriculture. As such, the analysis contributes to our understanding of the assumed impact of organic agriculture on sustainability and creates a building block for future comparative studies by practitioners\(^1\) and scholars alike.

1.4 Theoretical Contribution

Finally, the research also contributes towards the literature on innovations by positing organic agriculture as an *innovation*. This connects the agricultural technology with a long-standing literature on (agricultural) adoption and diffusion. Since organic agriculture is more knowledge- and labor-intensive, as opposed to the capital-intensive nature of previous agricultural revolutions, an analysis using Rogers (2003) classical framework

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\(^1\)Based on this work, bioRe Tanzania and Remei developed an organic score index to monitor a sample annually of their farmers.
of self-selection, early- and late-adopters and their properties (wealth, age, education) is of great interest. This theoretical contribution builds on recent studies on differences between adopters of organic agriculture previously limited to the European context (see Flaten et al. (2006) for Norway, Best (2008) for Germany, and Läpple and Van Rensburg (2011) for the Republic of Ireland). Understanding the importance of education, age and wealth in the adoption of organic agriculture will be a key component towards establishing the viability and potential limitations of this Organic revolution reaching its intended target audiences: smallholder farmers in sub-Saharan Africa.

1.5 Dissertation Structure

This dissertation contains seven chapters.²

Chapter 2 reviews the literature and introduces the research design. It includes four sections. Section 2.1 reviews the theoretical and empirical literature, including the review of three interrelated multidisciplinary bodies of literature: Agricultural Development and Inequalities in Africa, Agricultural Sustainability, and Multidimensional Poverty. Section 2.2 lists the three research questions on Who is an organic farmer?, Are organic farming practices more sustainable?, and What is the impact of organic agriculture on poverty and inequality?. It is followed by an introduction to the research area in section 2.3 and the data and methodology used in section 2.4.

Chapter 3 provides a history of past interventions aimed at agricultural development in Tanzania. It includes three sections. Section 3.1 describes the rise of cotton from its precolonial origin to the major colonial and post-colonial development interventions that have resulted in its current status as the king of the cash crops. Section 3.2 provides a brief introduction into the agricultural production methods that existed over the span of more than a century in order to discuss their diversity and situate the potential novelty of organic agriculture as an innovation. Section 3.3 provides a summary of the key findings.

²It also includes seven appendices, which are referenced in each relevant section.
Chapter 4 answers the first research question on Who is an Organic Farmer? It includes four sections. The first subsection 4.1 focuses on the key socioeconomic difference existing between the two groups. Section 4.2 models who becomes an organic farmer. Section 4.3 provides an analysis of the differences in net income existing between the two groups. Section 4.4 provides a discussion and a summary.

Chapter 5 measures the sustainability of organic agriculture. It answers the second research question and contains four sections. The first section 5.1 is an extension of the review of the literature on agricultural sustainability indicators. The second section 5.2 operationalizes the farm-level sustainability measure previously developed by Rigby et al. (2001). The third section 5.3 analyzes the aggregate index score via multiple regression analysis in order to predict sustainability levels. The fourth section 5.4 provides a discussion and a summary.

Chapter 6 answers the third research question regarding the impact of organic production on poverty and inequality. It contains six sections. Section 6.1 introduces the methods upon which the index is based. Section 6.2 undertakes a unidimensional measurement of poverty and inequality using the basic need level as a cutoff. Section 6.3 undertakes the same calculations via the multidimensional poverty methodology. This analysis is contrasted to the principal component analysis described in section 6.4. Section 6.5 includes a discussion of the findings, including additional temporal analysis. Section 6.6 provides a summary.

Chapter 7 concludes the dissertation. It includes four sections. The first section 7.1 synthesizes the previous chapters and provides a cohesive summary of the research findings on the viability of the Organic revolution. The second section 7.2 introduces policy recommendations. Section 7.3 discusses four broad limitations of the research. Section 7.4 highlights theoretical and empirical avenues for future research based on these limitations.
Chapter 2

Review of Literature and Research Design

Over the course of history, agriculture and the respective revolutions that increased output have been an important source of growth for economies (Ruttan 2001). Moving into the 21st century, “agriculture continues to be a fundamental instrument for sustainable development and poverty reduction” (World Bank 2007 p.1). While the impact of the latest revolution - the Gene or Biotechnology revolution - are continuously debated, the impact of the previous revolution - the Green Revolution - on poverty and inequality is one of the largest research topics in Geography (Das, 2002). The introduction of improved hybrid seeds and external inputs has increased productivity at the global scale, yet widened the gap in productivity between sub-Saharan Africa and the rest of the world, especially Asian countries (World Bank 2007). Given the failure to improve productivity, the World Bank argues for a “productivity revolution in smallholder farming [...that] will have to be different from the Asian green revolution” (ibid., p.1). One potential revolution is to provide advanced genetically engineered second- or third-generation seeds that are for example drought-tolerant. Another is to increase productivity via organic agricultural methods that allow for the capturing of price premiums in Western market. It is this second revolution that is the focus of this study and the review.

This research will contribute to three interrelated bodies of literature in order to analyze the impact of organic export production on multidimensional poverty and inequality in Tanzania: Agricultural Development and Inequalities in Africa, Agricultural Sustainability, and Multidimensional Poverty. The first section 2.1.1 provides an overview of past work on agricultural development. It includes a review of its impact on poverty and inequality. While drawing on empirical findings on agriculture across the
globe, it is focused on organic agriculture and sub-Saharan Africa. The second section 2.1.2 provides a definition of agricultural sustainability and investigates past attempts at measuring organic agriculture. The third section 2.1.3 details the literature of multidimensional poverty, including its origins and applications, that is important for the poverty and inequality analysis.

This chapter is organized as follows. Section 2.1 reviews the theoretical and empirical literature, including the three bodies of *Agricultural Development and Inequalities in Africa*, *Agricultural Sustainability*, and *Multidimensional Poverty*. Section 2.2 lists the three research questions on *Who is an organic farmer?*, *Are organic farming practices more sustainable?*, and *What is the impact of organic agriculture on poverty and inequality?*. It is followed by an introduction to the research area in section 2.3 and the data and methodology used in section 2.4.

### 2.1 Review of Theoretical and Empirical Literature

#### 2.1.1 Agricultural Development and Inequalities in Africa

This section will review the limited information existing on the impact of organic agriculture on poverty and inequality. Although critical scholars agree that agricultural export production under the Green Revolution increased inequalities (Das, 2002; Freebairn, 1995; for dissenting view see Hayami and Ruttan 1985, Ruttan 2004), studies on organic agriculture, poverty and inequality are either lacking quantitative data (Dowd, 2008; Getz and Shreck, 2006; UN, 2008) or fail to research the question at all (Bargawi, 2008; Gibbon and Bolwig, 2007).¹

The review is organized into four sections: Section 2.1.1 deals with the importance of agriculture in development, with a specific focus on Africa. The first subsection highlights the pro-poor growth role of agriculture. The second subsection studies the impact of introducing new agricultural innovations on poverty and inequality. The

¹This limited attention is especially problematic in regards to inequality, as a growing literature has documented its negative impacts on economic growth poverty reduction (Kanbur and Venables, 2005; Ravallion, 2003), national security (Sachs, 2001), and support systems under environmental or economic stress (Leichenko and O’Brien, 2008; Sen and Foster, 1997; Watts, 1983).
third subsection reviews the role of agricultural innovations, while the fourth subsection focuses on contract farming, which plays a prominent role in the diffusion of organic agriculture. This form of development intervention has also increased in prominence given the (declining) low levels of public spending on the agricultural sector in general and research in particular.

**Agriculture’s Role in Development in Africa**

Although the Green Revolution technologies initially bypassed sub-Saharan Africa\(^2\) agriculture continues to play a key role across multiple levels on the continent (Lederer 2007). At the local level, it is the most important source of both formal and informal income for a majority of the households. Production is characterized as being dependent on rain, with only four percent of land irrigated. Input usage is the lowest in the world, with fertilizer input amounting to less than 10 kg per ha (IAASTD 2009a, p.5). Organic agriculture is listed as one of the potential solutions towards improving soil productivity, although the IAASTD report notes that “further studies are required to determine the conditions and incentives required for farmers to adopt these methods” (IAASTD 2009a, p.6).

At the national scale, although natural resource revenues have risen, agriculture continues to remain a key source of foreign exchange earnings, given that most production is exported. At the global level, African nations have become net-food importers over the last thirty years (Peacock 2005), exposing the African governments and its citizens to commodity market volatilities. Due to stagnating or reduced yields\(^3\) and export orientations of the sector, global changes in supply and demand are rapidly transmitted onto the ground. The consequences of the global food crises in 2008 and 2010, and the drought in the Horn of Africa in 2011, are evidence of this interrelatedness of African markets in a global economy.

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\(^2\) Dorward et al. (2004, p.76) mentions “more difficult agro-climatic conditions, [lower] population density, human capital and communications infrastructures [as] a major cause of the lack of any agricultural transformation in many of today’s poorest rural [African] areas.”

\(^3\) According to the IAASTD (2009a), overall per capita yields have declined between 1970 and 1980 - key years during the Green Revolution - and then roughly remained at the same level.
As a result, many African governments have undertaken two efforts: First, they have tried to reduce or limit exports of key staples and to provide subsidies to lower prices. De Janvry and Sadoulet (2011) highlight African governments' limitations in counteracting these trends via price controls and subsidizing food. Second, they have pushed for new efforts at strengthening or modernizing their agricultural sector, which includes the subsidized provisioning of inputs and farm implements (see for example Kilimo Kwanza - Agriculture First - initiative in Tanzania as articulated in the second PRSP of the United Republic of Tanzania (2010, p.42-43)). The timing consequently is ripe for studying the experience of organic production in an environment that is dominated by low-input intensive agriculture, yet where governments are active in pushing increased production of agriculture with the aim of combating rural poverty.4

Pro-Poor Agricultural Growth

Besides governments, development policymakers and scholars in recent years have debated the feasibility of achieving pro-poor agricultural growth (see for example Dorward et al. (2004) and World Bank (2007)). The economic theory of agriculture’s core potential towards achieving pro-poor growth in sub-Saharan Africa is well-articulated in a simplified model by Dercon (2009), which relies on an Eswaran and Kotwal (1993) framework.5 He constructs a two-sector (agriculture and industry), two-goods (food and shirts) model with a closed economy produced in a rural and urban area respectively. The assumption is that poor people will always first purchase enough food prior to consuming any other goods. Thus improvements in producing shirts fails to reduce poverty as the price of food remains high and only the rich would be able to consume

4According to the Global Hunger Index (GHI) developed by IFPRI, Tanzania is classified as a country with an alarming situation in 2011 (von Grebmer et al., 2011). The situation has improved over the last ten years, yet nearly 35 percent of the people continue to suffer from undernourishment with the prevalence of underweight children under five years having dropped significantly to less than 20 percent by 2011. This food poverty is the largest in the rural areas, where 18.4 percent of the population failed to obtain the minimum calories during 2007. This was slightly lower than in 2000/01, where it was 20.4 percent. Given the important linkages between agriculture and improving basic needs and food poverty respectively, the PRSP highlights that "agriculture is central to poverty reduction in general and hunger/food poverty in particular" (United Republic of Tanzania, 2010, p.6).

5Dercon (2009) finds support for the pro-poor growth thesis within works on classical input output models from Johnston and Mellor (1961) and more recently by Timmer (2007).
more ‘luxury’ goods. Agricultural growth consequently is pro-poor, as progress that occurs in the agricultural sector would translate into increased availability of food per worker. Coupled with a slight decrease in prices, this would allow for some increased consumption of shirts and stimulate growth not just in agriculture, but ultimately also industry.

Given the assumption of a closed economy, the growth linkages of agriculture translates the best to resource-poor, landlocked countries, or those where domestic policies influence openness of the economies. In the case that countries have open economies, “poverty reduction can then be achieved by any source of increased domestic competitiveness relative to the rest of the world” (Dercon 2009, p.9).

For Tanzania, the second PRSP foresees increasing productivity in the agricultural sector, achieving a targeted growth rate of 6 percent by 2015 from 3.2 percent in 2009 (United Republic of Tanzania 2010, p.43) via improved labor productivity as the sector “shift[s] away from small scale farming, thus release agricultural labor to non-farm sectors” (United Republic of Tanzania 2010, p.43).

Not only are such interventions intended to benefit the poor, they are also likely to reduce inequalities. Cross-country studies show that one percent of agricultural GDP growth lifts the expenditures of the five poorest deciles by an average of 3.7 percent, which is substantially more than the 0.9 percent increase from one percent of non-agricultural sector growth in GDP (Ligon and Sadoulet 2007, cited in Byerelee et al. 2009). Ortega and Lederman (2005, cited in Byerelee et al. 2009, p.6) showed that “an increase in overall GDP coming from agricultural labor productivity is on average 2.9 times more effective in raising the incomes of the poorest quintile in developing countries than an equivalent increase in GDP coming from nonagricultural labor productivity.”

As a result, Byerlee et al. (2009) argue that a return to investments in agriculture is warranted given its ability in "triggering economic growth, reducing poverty, narrowing income disparities, providing food security, and delivering environmental services." (p.1)
Impact of Agricultural Innovations

A key question in the quest for achieving pro-poor growth via agriculture surrounds the nature of the agricultural technology introduced. In Tanzania, this includes plans on shifting away from rain-fed agriculture, introducing mechanization, and improved inputs, including seeds, pesticides and fertilizers. Juxtaposing these innovations to the non-agricultural sector, a key difference is that agricultural innovations focusing on increased input usage, such as fertilizer or pesticides, can have only a one-time benefit on yield, and thus the potential to fail to provide sustainable growth (Dercon 2009). This technology supply push model (see Kline and Rosenberg, 1986; Chambers and Jiggins, 1987) was successful during the Green Revolution, under the condition of often subsidizing the inputs. According to the IAASTD (2009b), it “has not served nearly as well [in] resource-poor areas that are highly diverse, rain fed, and risk prone, and that currently hold most of the world’s poor” (ibid., p.481). While these marginal developing farmers - especially in sub-Saharan Africa - have been unable to benefit from these market-led technologies as of yet, farmers in more developed countries have been captured in the global treadmill where they obtain higher profits via improving their economies of scale under heavily subsidized conditions (IAASTD 2009b). In contrast

According to the IAASTD (2009b), the push of improved technologies that increase supply “relies on the agricultural treadmill”, so termed by Cochrane (1958, cited in IAASTD, 2009b, p.481). Hayami and Ruttan describe how this agricultural treadmill works. They point out that with declines in product prices due to increased supply, farmers

“try to reduce production costs by introducing new technology. The early adopters of innovations enjoy entrepreneurial profits. But as the innovation is diffused the aggregate supply curve shifts to the right, resulting in a fall in prices and the elimination of excess profits. The late adopters are forced to adopt the new innovations so as to avoid incurring losses.” (Hayami and Ruttan 1985, p.353).

They however are careful in noting that this effect only takes place in economies “where farmers market almost all their production and the domestic demand for farm commodities is very inelastic.” (ibid., p.352). In semisubsistence economies, on the other hand, the situation is different, as

“[...] a large fraction of the commodity is consumed in the households of producers or in the villages in which it is produced. In such economies a large fraction of consumers’ surplus resulting from technological progress accrues to the producers. Even if producers’ surplus decreases according to the treadmill effect, the loss may be more than compensated for by the increase in consumers’ surplus accruing to producers, particularly small producers and landless laborers.” (ibid., p.353)

According to the IAASTD (2009b), even a removal of these subsidies would not yield a significant benefit to the poor: “As long as the global treadmill is operating, even with all OECD subsidies removed,
to the Tanzanian *Kilimo Kwanza* initiative, the IAASTD highlights organic production as a pro-poor intervention to improve the institutional setting under which these rural developing farmers compete:

“Similarly [to Fair Trade], certified organics can work as an effective policy instrument to promote broader rural development and environmental protection goals. Policy options exist to make institutional and policy environments more conducive to certified organic agriculture and less conducive to energy intense (net energy consuming) agriculture.” (IAASTD 2009b, p.460)

To support their case, the IAASTD cites only one case study - Eyhorn (2007) - and one summary report from the FAO *International Conference on Organic Agriculture and Food Security*. The FAO (2007) report finds that when converting to organic agriculture “from traditional low external input farming to organic agriculture, input costs decrease, while yields and income tend to rise” (p.4). Specific evidence cited however is scant or non-existent. The work by Eyhorn (2007) focused on organic cotton production in India\(^8\), a higher-input environment, where land sizes are small (and thus agricultural intensification is preferable, i.e. via the integration of farm yard manure (FYM)). Comparing organic and conventional farmers over two years, he finds that although yields were not statistically significantly different, the production costs for organic farmers were significantly less due to lower pest management and fertilizer costs. As a result, the gross margins from cotton plots were nearly 50 to 60 percent higher than conventional farmers.\(^9\) Unfortunately, his excellent study was overshadowed by unusually high decertification rates. In the first year, 2003, 45 percent of the farmers had to be excluded, as they were decertified mainly for synthetic fertilizer usage. In 2004, another 27 percent defaulted, mostly due to the use of genetically modified cotton.

\(^{8}\) He studied the sister-organization of bioRe Tanzania, bioRe India.

\(^{9}\) When focusing on the field gross margins, which includes revenue obtained from planting wheat after harvesting and uprooting the cotton early, he finds that they are between 30-45 percent higher.
varieties which were introduced in the region (Eyhorn et al. 2005, p.18). Although Eyhorn paid very careful attention to replace these lost farmers within a new sample, it nevertheless showcases the difference to an African environment, where access to these synthetic inputs and improved seed varieties are much more limited.

Ruttan (2004) highlights the importance of understanding the institutional environment to assess whether or not innovations will increase or decrease income inequality. In rural settings marked by highly uneven land ownership, technologies that will be land-saving and labor-using are expected to “raise the economic return to labour relative to land [and] have the effect of equalizing the income distribution between the landless and the land-owning class” (Ruttan 2004, p.46). Since organic agriculture is more labour-as opposed to capital-intensive, his theory adds another opening for analysis in this dissertation.10

No matter the type or impact of the innovation introduced, a sub-category of studies focus on the rates of their adoption or diffusion. These literatures stretch a wide range of fields, including agricultural economists and geographers (Birkenholtz, 2009; Pardey and James, 2007; Rogers, 2003; Zimmerer, 2007). The pioneering study was provided by Ryan and Gross (1943) on hybrid seed corn in the US Midwest. Roger’s (2003) work stands out as the standard compendium for the study of the diffusion and innovation of agricultural technologies. He states that every innovation carries with itself both desirable and undesirable consequences (Rogers 2003, p.442), as well as anticipated and unanticipated consequences (ibid., p.448) that are difficult to manage. The spread of innovations consequently tended to enlarge the wealth gap between early and late adopters, with early adopters encompassing wealthier, better educated farmers with larger farms (ibid., p.288). Three of the main reasons for this inequality-increasing diffusion include: the windfall profits earned by early adopters (adoption rent); the self-selection of early adopters that are often more actively searching for innovation; and that innovations tend to trickle across (within a social strata) rather than down (between social strata). A special category of this study on the diffusion is social capital.

10The labour question in itself is not the focus of this dissertation. Rather the sample used includes farmers that do not own any or few land.
Moving outside the traditional *treadmill* described above, which relies on the role of extension services, works by Conley and Udry (2005) and Foster and Rosenzweig (1995) highlight the importance of learning from neighbors. In organic agriculture, these can include the sharing of “information, expertise, equipment, political lobbying power, and processing infrastructure” (Parker and Munroe, 2007, p.822). The ability to adopt an innovation in organic agriculture is also limited by the necessity to create buffer zones (in order to protect against contamination) (Bichler et al. 2005). These requirements have been shown to result in clusters of production (Lewis et al. 2008).

Positioning organic agriculture as an innovation, there is a need for studies to focus on who exactly is becoming an organic farmer and adopting this innovation in a developing country setting. This question is answered by investigating whether significant differences exist across socio-economic dimensions between organic and conventional farmers, with the ability to differentiate between early and late adopters amongst the organic farmers themselves. The evidence that exists to date is sparse and limited to European countries (see Flaten et al. (2006) for Norway and Best (2008) for Germany). Läpple and Van Rensburg (2011), focusing specifically on differences in adoption as opposed to mere differences within organic farmers, find early adopters to be younger farmers that are not motivated solely by profits, whereas late adopters were more risk-averse. All adopters exhibited high environmental awareness or motivations.

**Contract Farming**

In addition to innovation and its adoption (or diffusion), a key debate in the literature is in regards to the ability for contracting schemes to actually benefit the poor. While geographers have historically associated contract farming with increased structural and socio-economic unevenness (Little and Watts, 1994), empirical findings by Grossman (1993) on export-oriented contract farming showed that this does not have to be the case. Small-scale farmers in particular have displayed their agency by manipulating contracts, i.e. through side-selling of their cash crop outside of the contract (Ledermann, 1993).

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11See also contemporary studies by Bassett (2010), Freidberg (2004), Guthman (2004), and Mutersbaugh (2005).
2009) or including non-certified crop from neighbors (see Getz and Shreck, 2006). Furthermore, with public investments declining and lack of ability for farmers themselves to obtain credit in Africa, contract farming has received a revival “since it increases economies of scale and thereby reduces private traders’ transaction costs” (Bolwig et al. 2009, p.1094). The IAASTD (2009b) for example highlights the possibility of creating so-called brokered long-term contractual arrangements (BLCA) that could be to the benefit of the poor:

“BCLA’s, under favorable social conditions with transparency and strong farmer organization, provide a policy option for public sectors to invest in the creation of opportunities for poor farmers. Synergies between long term contractual arrangements and the organic and fair trade markets increase when such types of contractual arrangements are coupled with group certification of small-scale organic producers. Policy options include [...] creating legal, financial and technical support for emerging new BLCAs that are pro-poor” (p.482).”

The study previously cited by Eyhorn (2007) and Eyhorn et al. (2005) is one example of an original study on organic agriculture in India. The most applicable study to date13 focused on the ability for organic agriculture to yield benefits to the poor under an innovative contract farming scheme in Africa is done by Bolwig et al. (2009). Their case study is on nearly 4,000 organic coffee farmers in Uganda that are contracting with Kawacom, a subsidiary of an international commodity trader. Farmers in the group are able to sell all their coffee to the buyer, although without a fixed or pre-negotiated organic premium, and receive extensive extension service and some input provisioning. Comparing 112 organic farmers and 48 non-organic farmers acting as a control group, they find that certified farmers earn on average a 75 percent higher net coffee revenue, which amounts to 12.5 percent of the average household income (Bolwig et al. 2009,

12Such an arrangement is the organic operation of bioRe Tanzania investigated in this dissertation.

13Bolwig et al. (2009) find no other study that used surveys for budget data obtained at the farm-level for organic agriculture in the tropics.
They furthermore identify a positive return to applications of organic methods, with each additional organic method resulting in an increase of net coffee revenue of around 9 percent. A key factor throughout is the ability for farmers to obtain the organic premium, which is around 15 percent of the total harvest. Acknowledging the benefits of introducing low-cost techniques to improve yields, they suggest as an additional avenue of research for “more detailed work on the economics of organic farming techniques in tropical Africa. Which techniques are most readily adopted, and why? Which generate the highest returns, and why?” (Bolwig et al, 2009, p.1103). This dissertation aims at answering the first question - which techniques are adopted and why - via an analysis of the sustainability of organic production in Chapter 5. That relevant theoretical and empirical literature is discussed next.

2.1.2 Agricultural Sustainability

Compared to the socio-economic impacts of organic agriculture discussed above, ecological impacts are generally perceived to be better understood. With the start of the 21st century and the rapid increase in organic consumption in developed countries, the research field boomed and organic production has received prominent platforms as viable alternatives on the international development scene (such as in the IAASTD (2009a,b) reports cited earlier). As a result, providing an all-encompassing review is beyond the scope of this work. Rather, it focuses on providing a foundation for what exactly entails organic agriculture in this dissertation, which includes a discussion of its agronomic characteristics in addition to a global overview of its current status. This includes a review of success, potentials and challenges. A second section is concerned with attempts at measuring agricultural sustainability. It is in this section that the major gaps are located that are to be addressed in Chapter 5 with the second research question: Are organic practices sustainable?

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Important aspects excluded are critical studies of organic or alternative consumption (i.e. Bryant and Goodman 2004; Clarke et al. 2008), the value chains (i.e. Morgan and Murdoch 2000, Nadvi 2008, Rieple and Singh 2010), or studies of the role of certification (i.e. Mutersbaugh 2005; Getz and Shreck 2006).
Defining Organic Agriculture and its Ecological Benefits

A formal definition for organic agriculture comes from the Codex Alimentarius Commission. According to it,

“Organic agriculture is a holistic production management system that avoids use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and production of interdependent communities of plants, animals and people.”

(cited in Müller-Lindenlauf, 2009, p.4)

Key in an understanding of organic agriculture and its sustainability is its holistic nature. Organic agriculture is classified as a holistic cultivation method that moves across multiple levels. This includes the level of the plant or the seed, which is not chemically treated, to the level of the farmers themselves, who are not exposed to chemicals, to the ecosystem at large, which is not polluted. IFOAM, the International Federation of Organic Agriculture Movements - the global representative body of organic agriculture - shares this holistic approach by building organic agriculture on four pillars of health, ecology, fairness and care (IFOAM 2010). A striking difference of these definitions is how they differ from colloquial understandings of organic agriculture, which focuses mostly on the first component listed by the Codex Alimentarius Commission: “avoids use of synthetic fertilizers, pesticides and genetically modified organisms”. Systems, such as a low-input environment where farmers are lacking access to synthetic fertilizers or pesticides (not even to mention genetically modified seeds) are consequently classified as de facto organic (see for example Paarlberg 2008a, 2008b, or Bolwig et al. 2009).

While this simplification is tempting, it is avoided in this dissertation for two reasons: First, in order not to confuse the reader, the usage of the term organic is limited to certified organic agriculture. As seen in the previous section, de facto organic farmers fail to benefit from the most important economic component, which is the organic premium associated with certification. Raynolds (2004) provides a list of organic standards in Table 2.1 that need to be taken into account throughout the chain from buyer
Table 2.1: Basic Organic Standards (adopted from Raynolds 2004, p.731; Sources cited: IFOAM, FAO, WHO, ITC, CTA.)

<table>
<thead>
<tr>
<th>Conversion</th>
<th>At least a 1 year conversion period before start of annual production cycle; 2 years for perennials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification and monitoring</td>
<td>Initial inspection followed by annual visits to each farm unit by monitors from accredited certifying organization</td>
</tr>
<tr>
<td>Documentation</td>
<td>Map and list of registered fields. Complete records of farm input use and yield</td>
</tr>
<tr>
<td>Planting material</td>
<td>Must be chemically untreated; no genetically modified organisms (GMOs)</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>Organic soil enhancing processes must be used. No synthetic fertilizers or sewage sludge</td>
</tr>
<tr>
<td>Plant and disease control</td>
<td>Use of synthetic herbicides, fungicides, and pesticides prohibited except those on approved list</td>
</tr>
<tr>
<td>Livestock</td>
<td>Feed must be 100 % organic; use of antibiotics prohibited. Some restrictions on animal concentrations.</td>
</tr>
<tr>
<td>Transport and Handling</td>
<td>Chain of custody must be maintained: no co-mingling with non-organic products</td>
</tr>
<tr>
<td>Processing</td>
<td>No irradiation. Synthetic additives can be used from approved list</td>
</tr>
<tr>
<td>Labeling</td>
<td>Products labeled organic must have &gt;95 percent organic inputs</td>
</tr>
</tbody>
</table>

Second, and more fundamentally, although certification places a key weight on the lack of these synthetic applications, organic agriculture is thought of as an active practice (Ledermann and Leichenko 2010). As communicated by an organic agriculture consultant, traditional African agricultural practices of slash-and-burn and shifting cultivation without adding any external inputs stop short of achieving organic agriculture’s goals of increasing soil fertility and the overall health of ecosystems (pers. comm. Morganti 2010). A range of methods are generally employed to achieve this. These include, but are not limited to: crop rotation; intercropping strategies to either increase the soil fertility (via planting of nitrogen-fixation of legumes) or devise an alternative pest management strategies (via planting an either push or pull crop, i.e. sunflowers); using of green manure (via pure stand nitrogen-fixing legumes) or farm yard manure; measures to combat soil erosion; etc. (Müller-Lindenlauf, 2009, p.4). To illustrate the holistic nature, intercropping not only is believed to increase soil fertility and reduce
pests, but also increases food self-sufficiency and security of farmers - a key question in organic agriculture (Halberg et al. 2005) - by increasing yields, having an additional crop source, and maintaining biodiversity in the long-run.

Organic agriculture, consequently consists of a range of (innovative) methods that previously are adopted by farmers beyond the adherence to lack of synthetic input applications. These methods - which are knowledge- and labor-intensive as opposed to capital-intensive - are the focus of this dissertation’s attempt at measuring organic agriculture’s impact on sustainability since they can be adopted by both organic and non-organic conventional farmers. It consequently connects back with literature on the efficiency and sustainability of smallholder agriculture (see for example Netting 1993, Brookfield 2001). Netting’s (1993) work stands out in showing how small-scale farmers can produce efficiently outside of the industrial agriculture that is biased towards economies of scale (see earlier discussion by IAASTD 2009b). In his research, he finds an inverse relationship between productivity of land and farm size, as smallholders

”use their fields more frequently and produce larger yields than larger landholders in the same environment and with the same technology and crops. Just as it is profitable for a big landowner to produce lower yields of specialized market crops or beef cattle by extensive, labor-saving methods, so it is to the smallholder’s advantage to produce in a more diversified, continuous, skilled labor-demanding manner in order to make fullest use of more restricted resources” (Netting 1993, p.322).

One important point of contention within the literature is whether or not the widespread adoption of these methods by themselves are actually more ecologically sustainable compared to traditional, conventional or biotechnological alternatives. In the literature, significant gaps exist in the evaluation of organic agricultural methods

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15 Although some of these could be traditional methods, they are often traditional methods that are introduced from outside of the area yet similar agro-ecological environments, in this case sub-Saharan Africa.

16 The term conventional farmer is preferred in this dissertation to traditional farmers, given the long history of interventions discussed in Chapter 3 in the region, thus undermining a clear sense of what exactly is a traditional agricultural practice and what is not.
vis-à-vis conventional farmers at the farm-level scale in general, and in a developing nation context in particular given the time and cost constraints. One of the rare and most promising current studies are comparative long-term trials in Kenya, Bolivia and India under the leadership of the Research Institute of Organic Agriculture (FiBL). These 15-20 year field trials offer a unique comparison of organic versus conventional versus biotechnological\textsuperscript{17} agriculture (FiBL 2010), with early economic results\textsuperscript{18} indicating that lower cotton yields during conversion periods are offset by higher gains due to the organic premium (FiBL 2010). Undertaking an analysis of the ecological sustainability is especially warranted by the fact that organic agriculture should not be thought of as being synonymous with increased sustainability by default. Even synthetic fertilizer does not have to be unsustainable by default when analyzed with a focus on increasing soil fertility and ultimately net income and productivity. Zhen and Routray (2003) cite evidence from China (Liu 1995, 2000, Chen 2000, Wu 1999), where low synthetic fertilizer application increased the plant residue that was returned to the field, thus leading to increased soil fertility. Furthermore, even organic methods of crop protection can fail to be (strictly) sustainable, as the inputs are potentially obtained from non-renewable resources manufactured via processing and marketed via extensive transportation (Edwards and Howells 2001 cited in Zhen and Routray 2003). The feasibility of organic agriculture to achieve high yields using organic manure is another large point of contention (see for example the debates between Badgley (2007a), Avery (2007) and their response (Badgley 2007b)), especially in regards to broad claims of feeding the world (Kirchmann et al. 2008). This discussion has become especially heated in the context of the rapid rise of adoption of GM cotton in major regions of organic production - India in Asia and Burkina Faso in Africa - which is threatening the viability of certified organic production.\textsuperscript{19}

\textsuperscript{17}Only in the case of cotton in India.

\textsuperscript{18}Updates on the research are posted at http://www.systems-comparison.fibl.org/.

\textsuperscript{19}Since the introduction of GM cotton is only planned in Tanzania for 2014, this investigation provides a promising avenue for future research that is currently beyond the scope of this dissertation. The reader however is referred to the works by Ledermann and Leichenko (forthcoming) and Novy et al. (2011) for some insights.
Measuring Organic Sustainability

As noted above, although ecological benefits are generally accepted to be large compared to previous input-intensive agricultural revolutions, measurement of them in terms of sustainability is difficult. Consequently, at the outset of any study, there would need to be agreement on the definitions of sustainability and sustainable agriculture in the first place. In a review of the field by Zhen and Routray (2003), they identified over 70 definitions of sustainable agriculture. As a result, the understanding of sustainability has grown so broad, that the term itself runs danger of losing its meaningfulness both within academia and policymaking (Leach et al. 2010).

One of the most promising attempts of creating an organic sustainability measurement was undertaken by Rigby et al. (2001). They created a comprehensive index that builds on three categories of sustainable agriculture. These are that it improves farm-level social and economic sustainability, improves the wider social and economic sustainability, and results in increased yields and reduced losses. A comprehensive review of this and similar measurements of sustainability is at the beginning of Chapter 5. What is important for this review is that although the index had its limitations - the scoring for example focuses not on observed benefits (i.e. via costly and time-consuming soil probes) but rather assumed benefits based on the adoption of a technique or method - it failed to stir the debate as was hoped for after its publication. Given the rise of organic agriculture - especially as a development option for poor farmers - over the last ten years since its publication, a revision and application of it seems currently lacking in the literature. One exception is Zhen and Routray (2003), which developed an operational measurement of agricultural sustainability for developing countries. While Rigby et al. (2001) applied their index to a sample of 80 organic and 157 conventional producers in the United Kingdom, Zhen and Routray (2003) however fail to follow through with an application.

An application is important for two reasons: First, it aids in the assessment of the actual ecological impact of organic methods and differences existing within and between

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A novel approach, discussed in Chapter 5, was undertaken by Reed et al. (2006).
organic and conventional farmers. The weighing of the individual methods, furthermore, negates the perfect substitutability that is assumed in the currently leading study by Bolwig et al. (2009) who focused only on number of measures adopted. Second, an operationalization that includes easy to interpret visualizations allows for an improved understanding of the current status of organic production on the ground. The interested audience include the provider of the organic extension service, but also the farmer. This approach allows for moving beyond the singular focus on certification (or lack thereof) towards improving organic agriculture as an active practice. Developing such a measure of sustainable agriculture - which includes the development of criteria and creation of the sustainability index -

“provide[s] decision-makers with an evaluation of global to local integrated nature-science systems in short and longterm perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable” (Kates et al. 2001 cited in Ness et al. 2007, p. 499; emphasis theirs).

2.1.3 Multidimensional Poverty

In this section, the literature on multidimensional poverty is reviewed, which includes debates - similar to the sustainability literature - surrounding not just the meaning or definition of multidimensional poverty, but especially its measurement. The concept of moving beyond a singular, uni-dimensional approach measuring poverty biased towards economic indicators is not a novel one. As discussed in the introduction to a special issue on the topic of multidimensional poverty in the journal of World Development, the origin of this research field, including an acknowledgment of the ”many facets to poverty and deprivation”, have at least a 25 years long history: These include work by Sen (1985) or Nussbaum (2000) on capabilities, Atkinson and Bourguignon (1999) on absolute and relative approaches to poverty, or even dating as far back as to the 19th century social philosopher Alexis de Tocqueville (cited in Kakwani and Silber 2008).

The multidimensional approach is relevant to this work for several reasons. For
example, pro-poor growth - discussed earlier in Section 2.1.1 for agricultural growth - is best analyzed from a multidimensional poverty perspective (Grosse et al. 2008 and Son and Kakwani 2008). According to Grosse et al. (2008, p. 1021), “a central shortcoming of current pro-poor growth concepts and measures is that to date they have been completely focused on the income dimension of poverty, thus ignoring critical non-income aspects of well-being”. They cite Kakwani and Pernia (2000) to argue that “it would be “futile” if one operationalize poverty reduction via pro-poor growth using just one single indicator because poverty is a multidimensional phenomenon, and thus pro-poor growth should also be understood as a multidimensional phenomenon” (Grosse et al. 2008, p.1021).

Given that this study is undertaken also in the area of agricultural sustainability, the previous discussion in Section 2.1.2 is key in order to further guide, expand and ultimately develop a multidimensional understanding of relevant variables. Zhen and Routray (2003) acknowledge directly how sustainability is a dynamic concept, in that it differs across space but also evolves across time. They propose a set of operational indicators to measure the three main categories of ecological, economic and social sustainability at the farm-level in a developing country (see Figure 2.1). The applicability of the variables are reviewed in Chapter 6.

<table>
<thead>
<tr>
<th>Economic Sustainability</th>
<th>Social Sustainability</th>
<th>Ecological Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop productivity</td>
<td>Food self sufficiency</td>
<td>Amount of fertilizers/pesticides used per unit of cropped land</td>
</tr>
<tr>
<td>Net farm income</td>
<td>Equality in income and food distribution</td>
<td>Amount of irrigation water used per unit of cropped land</td>
</tr>
<tr>
<td>Benefit-cost ratio of production</td>
<td>Access to resources and support services</td>
<td>Soil nutrient content</td>
</tr>
<tr>
<td>Per capita food grain production</td>
<td>Farmers’ knowledge and awareness of resource conservation</td>
<td>Depth to groundwater table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality of groundwater for irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water use efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nitrate content of groundwater and crops</td>
</tr>
</tbody>
</table>

Figure 2.1: Operational Indicators for Agricultural Sustainability (adapted from Zhen and Routray 2003, p.43)

Given the focus on multiple dimensions, the next section reviews the classical approach of a uni-dimensional measurement of poverty. It is followed by a discussion of the relevant literature on multidimensional poverty, which includes a discussion of
two prominent examples: the Human Development Index (HDI) and a new measure proposed by Akire and Foster, the Multidimensional Poverty Index (MPI).

**Unidimensional Poverty**

Unidimensional poverty focuses on identifying, aggregating and evaluating who are the poor using a single indicator. Up until the 1990s, this approach was dominated by using economic data. The most common and best known measure is the *headcount ratio*, which calculates a percentage of the poor. Based on this measure, a second measure - *poverty gap* - can be calculated. It differs in that instead of just identifying the poor and non-poor in the *headcount ratio*, it includes their difference to a poverty level (Alkire and Foster 2010a,b).

These two measures were critiqued early on by Sen (1976, cited in Bourguignon and Chakravarty 2003). He argued that poverty measurement contained the two challenges of identifying who is poor and aggregating these characteristics into an aggregate indicator. He argued that they fall short since they are “insensitive to the redistribution of income among the poor” (Bourguignon and Chakravarty 2003, p.25), especially since they would not change if the situation of the poor would worsen.

One remedy was proposed by Foster et al. (1984 cited in Alkire and Foster 2009), who identified that squaring the poverty gap - which creates the Foster Greer and Thorbeck (FGT) measure - “diminishes the relative importance of smaller shortfalls and augments the effects of larger ones [... emphasizing] the conditions of the poorest in society.” (Alkire and Foster 2009, p.3-4)

Sen’s early critique and the FGT measure, however, ignored the rising tendency amongst policymakers and scholars alike that poverty is defined not solely by monetary, but especially non-monetary factors.

The section below reviews the relevant literature that not only takes these non-monetary factors into account, but also accounts for the critiques on the measuring methodologies.
Multidimensional Poverty

Multidimensional poverty is slowly becoming the new mainstream tool for interpreting poverty. Its roots can be identified in literature on basic need, which includes non-monetary needs\(^{21}\), or capabilities, which focuses on the economic and non-economic abilities\(^{22}\) of an individual.

Chakravarty et al. (2008) - for example - argue that

“[...] the well-being of a population and hence its poverty, which is a manifestation of insufficient well-being, is a multidimensional phenomenon, income being only one of the many attributes on which the well-being depends. Examples of such attributes are food, housing, clothing, education, health, provision of public goods, and so on. While it is true that with a higher income a person is able to improve the position of some of his non-monetary attributes, it may as well be the case that markets for certain attributes do not exist, for instance, in the case of some public goods. Examples are flood control program and malaria prevention program in an underdeveloped country.”

As mentioned above, Zhen and Routray (2003) created three categories of social, economic and ecological dimensions that are relevant in regards to agricultural development. These categories are similar to the literature on sustainable livelihoods framework (i.e. Department for International Development 1999), especially including ideas such as human and social capital under Zhen and Routray’s (2003) Social Sustainability dimension. As emphasized by Kakwani and Silber (2008, p.987), this inclusion of such variables moves beyond

“a first dimension of the capability space, where poverty is defined in absolute terms and refers to income levels which do not guarantee that basic

\(^{21}\)For example in the importance of nutrition (Lipton and Ravallion 1995 as cited in Chakravarty et al. 2008)

\(^{22}\)For example, these are literacy, life expectancy and education that are part of the Human Development Index (HDI) critiqued further below (Chakravarty et al. 2008)
physical needs will be covered, and a second dimension emphasizing a relative approach to poverty and considering those income levels which do not allow individuals to “function properly” in their social environment. The second aspect stresses evidently the by now very popular concept of social exclusion.”

In the policy arena, most key international development actors are embracing a multidimensional poverty framework. The UN (2005, p.20) cites the World Bank (2000) development report on *Attacking Poverty* as evidence that "some of the multidimensional aspects of poverty, including exposure to vulnerability and risk, low levels of education and health, and powerlessness” are embraced within even this previous stalwart of unidimensional poverty.23 This is reflected in the shift with the PRSP, which includes a focus on reducing inequalities and social dimension of poverty, in addition to it being a country-owned strategy of development (IMF 2000). Another recent source focusing on the Millenium Development Goals (MDGs), which focus explicitly on non-income poverty, such as improvements in education and health that have been shown to need interventions beyond just increasing economic poverty reduction (Klasen 2000 or Grimm et al. 2002, as cited in Grosse et al. 2008; Alkire and Santos 2010).

In addition to these economic and social dimensions by Zhen and Routray (2003), Calvo (2008) highlights vulnerability as a key component to measure the impact of how poverty and inequality changes over time (see also Calvo and Dercon 2005). The definition of vulnerability includes a "combination of poverty (failure to reach a minimum outcome) and risk (dispersion over states of the world)", with a key emphasis on identifying future threats leading to poverty (Calvo 2008, p. 1013-4).24

Furthermore, the work by Duclos et al. (2004) provides a good example of combining spatial differences (between urban and rural areas) as a component in the analysis of multidimensional poverty. Their application is a good stepping stone for future

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23 Another source cited as laying at the origin is the 1997 Human Development Report (cited in Alkire and Foster 2011a).

24 As such vulnerability is focused heavily on the theme of poverty and marginalization as opposed to society-environment interactions (i.e. see Leichenko and O’Brien 2008), which have been identified by Hogan and Marandola (2005) as the other key theme of vulnerability research.
research and not considered explicitly in this dissertation. This research however draws upon their comparison of their multivariate poverty measurement with the Human Development Indicators (Duclos et al. 2004, p.10), which is reviewed next.

**Example of Human Development Indicators**

The Human Development Index (HDI) is one of the best known composite indices. Its popularity, from its inception in 1990 with the aid of Amartya Sen, is attributed to its simplicity, accessibility, but also its revolutionary inclusion of non-monetary poverty measurements (Klugman et al. 2011). In its latest version, it includes four indicators that are used to measure three dimensions: living standards; education; and health. These are aggregated, via calculating a geometric mean, to yield the HDI score. Figure 2.2 depicts this composition (UNDP 2011).

![Figure 2.2: Components of the Human Development Index (UNDP 2011)](image)

According to the latest 2010 HDI score, Tanzania was ranked 148 out of 169 countries. Its progress was on pace with other sub-Saharan African countries (UN 2011).

25 its situation would be slightly improved compared to the African counterparts if factoring in income inequality, which is relatively low in Tanzania at a Gini coefficient of 34.6, via an inequality-adjusted HDI value (ibid.).

In her review of recent changes to the HDI and the value of indices in general, Lustig (2011) highlights two main criticisms. They focus on either the choice of the variables
or the functional form of the index (ibid., p.227-8).26

**Critique of Choice of Variables** In regards to the choice of the variables, the development of an index needs to be preceded by a careful discussion of the variables chosen. This includes their definitions, and their strengths and limitations. The methods for choosing variables should be based on both past work on similar indices, in addition to expert insights.27 This subjective approach towards choosing variables is contrasted to a computational approach. Using a factor analysis (Ferro Luzzi et al. 2006) or a principal component analysis (Collicelli and Valerii 2000, Slottje 1991 cited in Ferro Luzzi et al. 2006), variables are selected based on their ability to explain maximum variances. Ferro Luzzi et al. (2006, p.6) for example use factor analysis to “let the data determine how many latent factors are to be used, as well as the weights imposed by them.” Similarly, for principal components analysis Reig-Martinez et al. (2011) note that researchers prefer PCA “to avoid subjectivity in the determination of weights and proceed to determine them endogenously” (p.3). Principle component analysis is also often used in data sets where a large set of data is expected to be correlated. With the use of PCA, a few variables are highlighted as being the most important to explain a large amount of the variance as the original dataset would (Abeyasekra 2004).28 This

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26For another discussion of the new versus old HDI measurements, see Klugman et al 2011. They focus also on issues of redundancy and robustness, which is not included here.

27In this dissertation, the multidimensional poverty index focuses on the past work by Alkire and Foster (2011a,b), without drawing on expert insight. This differs from the Farm-Level Sustainability index, where expert insight was considered. While the survey outlined below was designed with the goal of obtaining the three dimensions needed for a multidimensional poverty index, the Farm-Level Sustainability index is more limited. The latter is not based on measures of actual outcomes, which would be preferred, but rather practices undertaken that are hypothesized to achieve a certain outcome. In summary, while it is important to acknowledge and welcome discussion on the choice of variables, the variables for both indices have been chosen deliberately and within the realm of feasibility for this study.

28Abeyasekra (2004, p.11) provides a good introduction of how PCA works:

“In PCA a new set of variables is created as linear combinations of the original set. The linear combination that explains the maximum amount of variation is called the first principal component. A second principal component (another linear combination) is then found, independent of the first, so that it explains as much as possible of the remaining variability. Further components are then created sequentially, each new component being independent of the previous ones. If the first few components, say the first 3, explain a substantial amount, say 90 per cent of the variability amongst the original set of 12 variables, then essentially, the number of variables to be analyzed has been reduced from 12 to 3.”
method of using PCA analysis in surveys or development is described by Abeyasekra (2004), Davis (2002), Filmer and Pritchett (2001). An example of this application in Tanzania is Gwatkin et al. (2000) and Gwatkin et al. (2007). Reig-Martínez et al. (2011) discuss its applicability in agriculture and Conte (2005) on food security. Although the method has received widespread appeal for interpreting the Demographic Health Surveys (DHS) (Rutstein and Johnson 2004), two major limitations exist: First, PCA works best on continuous data than discrete data. Second, since the analysis needs several components to reach a significant amount of explanatory power - as a fairly complex method - the first dimension often holds only limited explanatory power (Howe et al. 2008). This first component, however, is often strongly measuring long-run wealth (Vyas and Kumaranayake 2006), which is of primary interest in assessing poverty.

Critique of Functional Form In regards to the functional form, key critiques center around the substitutability assumptions of indicators, as well as the choices of weights (Lustig 2011, p.228). Since one of the biggest concerns lies in the feasibility and validity of aggregating data into a single index, a subsequent main critique is that the reduction of three dimensions into one stipulates that improvements in one area of the dimension (i.e. vulnerability) can off-set (or perfectly substitute) lower values in another (i.e. absolute income). This same problem plagued the HDI. One measure is to use a geometric mean for the aggregation of the dimensions, as opposed to its arithmetic counterpart.

Lustig (2011, p.228) describes the impact of this recent change for the HDI:

“The old HDI functional form implied perfect substitutability. A geometric mean implies an elasticity of substitution between capabilities or dimensions.

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29 The authority on the method itself is Jolliffe (2002).
30 Conte (2005) describes the use of PCA in second step to undertake cluster analysis to determine different household groups that exist. This was not done and is a further possible step for the future.
31 This measure is also applied in this dissertation for the Multidimensional Poverty index.
32 The arithmetic mean takes the form of summing up all the dimensions and calculating their mean. The geometric mean multiplies all of the dimensions and then takes the nth root.
equal to 1, thereby acknowledging the existence of diminishing marginal returns to increase one capability while keeping others constant. A distinctive advantage of the geometric mean, moreover, is that the rankings are invariant to the scale in which each variable is measured."

In summary, a review of the HDI, the most prominent and longest standing measurement of multidimensional poverty showed that critiques on the choice of variables can be tested via a PCA analysis, while critique on its functional form are remedied by using a geometric mean which reduces the possibility of perfect substitution. The other composite index reviewed next is the Multidimensional Poverty Index (MPI) which is a recent methodological advance that addresses some of these shortcomings and includes more than just the four indicators of the HDI.

**Example of Multidimensional Poverty Index**

The work by Alkire and Foster (2011a) stands out as offering a novel yet clear methodological approach towards creating a multidimensional poverty index (see Alkire and Santos 2010 for an application to the Millenium Development Goals and calculations to 104 developing country). It includes a focus on ten indicators of importance to the track the Millenium Development Goals using the three dimensions of the HDI: Education, health, and standard of living. While their application is focusing on the national level, they encourage its application across numerous levels, including the village, state, or national level. For this purpose, this research is one of the first to apply it to the regional level, by drawing on differences found across the six study villages. Their method (in the literature referred to the *AF method*; see also Alkire and Foster 2009 and 2011b) covers three main components that were relevant for unidimensional poverty measurements: identification, aggregation and decomposition.\(^{33}\) These are detailed in the beginning of Chapter 6. The benefit of applying their methods is that they are sensitive to changes below the poverty line (see earlier critique by Sen 1976) drawing on the FGT measurement (see Foster, Greer and Thorbecke 1984). It also

\(^{33}\)For ease of the description below, the vector language employed in their examples are removed. If interested, see their Section 4: The AF Method on p.295ff in Alkire and Foster (2011a).
can be applied to not only cardinal, continuous data, but rather ordinal data that is often included in measurements of non-monetary poverty (Alkire and Foster, 2011b). It furthermore is easy to interpret, although Ravallion (2011a) warns of the value of the creation of so-called *mashup indices*, as he sees greater value in the components rather than the aggregates. He nevertheless acknowledges that their work represents the “most well-developed and broadly applied MIP [multidimensional index of poverty] to date” (Ravallion 2011b, p.236).

### 2.1.4 Summary

The first section 2.1.1 reviewed the literature of the impact of agricultural development on poverty and inequality. It included a review of the role of agriculture in development with a specific focus on Africa. It was followed by a specific discussion of the impact of agricultural innovations in the context of organic agriculture. Since contract farming is one of the main avenues for development intervention via organic cotton, specific attention was paid to case studies. Besides the work by Eyhorn (2007), Eyhorn et al. (2005) and Bolwig et al. (2009), however, no studies exist that access the poverty and inequality from organic contract farming. Especially the latter has received limited attention, yet has key implications in regards to the ability for the development intervention to be *pro-poor*, especially when reviewed from a historical perspective given the impacts by previous agricultural revolutions.

The second section 2.1.2 provided a definition of organic agriculture, noting its holistic nature, which necessitates an attempt at using complex measurements to analyze its impact across the scales. Two key factors that stemmed from the review are the importance to refrain from simplifying organic agriculture as *de facto* organic, given that it is perceived to be an active practice, thus acknowledging the importance of certification. The section also included a review of the multitude of methods applied and their implications on sustainability. It connected with previous literature on sustainability and efficiency (i.e. Netting 1993), to highlight how small-scale farmers are believed to achieve higher or better sustainability levels. The review also showed that it however would be false to assume that organic agriculture by default is more sustainable, as
considerable diffusion of the methods can exist amongst farmers and significant varia-
tion within the farm groups themselves. For this purpose, previous attempts at not just
defining, but measuring agricultural sustainability are reviewed (i.e. Zhen and Routray
2003). Rigby et al. (2001) stand out from the literature for having operationalized an
organic scoring index, which aids in the actual assessment of differences, as well as the
use of visual elements to communicate the findings to inform relevant stakeholders.

The third section 2.1.3 reviewed the literature on Multidimensional Poverty. It
first included a review of its relationship to the other two literature sections: agricul-
tural development and sustainability. The literature showed that they are connected to
agricultural development by highlighting the importance of pro-poor growth being mea-
sured from a multidimensional perspective that includes non-monetary measurements
(Grosse et al. 2008, p.1021). It also showed how the work by Zhen and Routray (2003)
acknowledges important key non-monetary dimensions that need to be considered in
assessing the results of agricultural development on poverty and inequality.

Second, this section included a discussion of the move from a unidimensional poverty
- traditionally focused on monetary indicators, i.e. income per capita - towards mul-
tidimensional in the policy (i.e. IMF 2000, UN 2005, World Bank 2000) and research
fields (i.e. Grosse et al. 2008; Kakwani and Silber 2008). Key insights are that a
measure of poverty would need to be sensitive to changes amongst the poor. The FGT
measure (Alkire and Foster 2010) incorporates this. Furthermore, they should include
non-monetary poverty indicators (Kakwani and Silber 2008), including vulnerability
(Calvo 2008). Two examples of popular multidimensional measures are the HDI and
the MPI, with the latter being the most promising indicator and methodology devel-
oped. However, as they are developed for the national level, they have yet to be applied
to the local level (Alkire and Foster 2011a). For this purpose, this research is one of the
first to apply it to the regional level, by drawing on differences found across the study
area in order to answer the research questions outlined below.
2.2 Research Questions

From the review of the theoretical and empirical literature, several research gaps emerged in research related to organic agricultural production in general, and the impact of it on poverty and inequality in sub-Saharan Africa in particular. This section presents the research questions that aim at directly addressing these gaps. Although each of the three strands of literature are interrelated, they broadly correspond in order to the research questions outlined here and the subsequent chapters that answer them.

The first research question aims to address major research gaps in the agricultural development and inequalities literature in order to answer the overarching question of Who is an organic farmer? The second research question - Are organic farming practices more sustainable? - advances the literature on agricultural sustainability by providing an operationalization of an organic index that includes both organic and conventional farmers. The third research question measures the impact of organic agriculture on poverty and inequality from the perspective of multidimensional poverty.

The sections below list each research question, their hypotheses, and the theoretical and empirical gaps they address.

2.2.1 Research Question: Who is an organic farmer?

Based on Section 2.1.1 this question involves three hypotheses:

- **Hypothesis 1.1** Organic farmers are larger farmers that are also wealthier and better educated.

- **Hypothesis 1.2** Wealthier, larger and better educated farmers have a higher probability of joining bioRe, with early adopters increasing their wealth (assets) over time.

- **Hypothesis 1.3** Organic households have a significantly larger net income from cotton and total income per contributing household member.

Hypothesis 1.1 investigates whether or not the introduction and subsequent adoption of certified organic agriculture follows patterns of previous agricultural adoptions, where
the (early) adopters are larger, wealthier and better educated farmers as argued by Rogers (2003) compared to conventional non-adopters.

Hypothesis 1.2 builds on the previous Hypothesis 1.1 by modeling the probabilities for who is becoming an organic farmer, thus adding insights to the evidence (mainly limited to European countries; see Flaten et al. (2006) and Best (2008)) currently available as to who, out of all farmers in a low-input environment, takes advantage of organic agriculture (see Läpple and Van Rensburg 2011). A key aspect is to see whether or not they are self-selecting and if early adopters can increase their assets over time (Rogers 2003). Answering these important questions also allows for testing whether any wealth differences observed between organic and conventional farmers is due to the fact that only wealthy farmers become organic farmers in the first place.

Hypothesis 1.3 extends this analysis of wealth difference by answering, analogous to Bolwig et al. (2009) whether or not significantly larger net income from cotton and total income per contributing member are obtained in organic agriculture. This is important in order to lay a foundation for a more detailed analysis of the impact on poverty reduction and inequality that is undertaken in greater detail under Research Question 3. The overall aim of answering these hypotheses is to provide evidence towards the potential of organic agriculture as a pro-poor growth strategy.

2.2.2 Research Question: Are organic farming practices sustainable?

Based on Section 2.1.2 this question involves three hypotheses:

- **Hypothesis 2.1** Organic farmers as a group achieve higher sustainability scores than their conventional counterparts.

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34 The number of contributing household members were obtained by asking in the survey the household head to differentiate between contributing and non-contributing members (see Appendix A: Household Survey on first page). The benefit of not focusing on age as a delimiter of contributing versus non-contributing is that many children are considered by some households as key sources of labor. While this flexible definition of contributing household members introduces some variations in the potential interpretation of the term by each household member interviewed, it was considered superior given the integration of agricultural production (especially cotton) in the household’s daily lives.
• **Hypothesis 2.2** Given the knowledge- and labor-intensive nature of organic agriculture, even poorer conventional farmers achieve high sustainability scores without becoming certified organic - an indication that innovations trickle not just within, but down social strata.

• **Hypothesis 2.3** Given the knowledge- and labor-intensive nature of organic agriculture, early adopters or smaller farmers have higher sustainability scores, while smaller farmers also achieve higher productivity.

In response to the call by Kates et al. (2001 cited in Ness et al. 2007), a context-specific sustainability measure of organic production at the farm-level is developed to answer Hypothesis 2.1. It includes the adoption of understandings of sustainability, such as Izac and Swift (1994) and Rigby et al. (2001), to the local environment. Sustainability levels are then calculated and compared within and between organic and conventional farmers and existing patterns detected and explained with the aid of spider graphs and a multiple regression analysis. It aims to revive the debate launched by Rigby et al. (2001) whose index was designed to stir the debate of actual scoring and discussion of sustainability indicators.

Chapter 4 evaluated who becomes an organic farmer. Hypothesis 2.2. aims at strengthening our understanding of how organic farmers differ via their adoption of organic methods - positioned as an innovation - compared to their conventional counterparts. This is of particular interest given that the research takes place in a low-input environment, which is significantly different from the adoption and agricultural sustainability studies undertaken in a higher-input, heavily subsidized Western context. It also answers the questions raised earlier by Bolwig et al. (2009) in regards to which technologies are adopted and links back to Rogers (2003), who finds that innovations tend to diffuse within, rather than down social strata.

Since organic agriculture is a knowledge- and labor-intensive technology, learning-by-doing is an integral process that is expected to result in higher sustainability scores

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35 As discussed in Chapter 3, patterns of agricultural innovation adoptions analyzed here will also depend on the rich history of past interventions, thus negating our ability to speak of solely a *traditional* environment.
for early adopters that had more time to experiment with the various methods and implement them successfully. Looking at productivity - measured in net income per acre - the literature argues that smaller farmers (Netting 1993) tend to be more efficient (both economically and ecologically). This is in contrast to previous agricultural revolutions that were biased towards larger farmers due to enabling increasing economies of scales (see discussion by IAASTD 2009b on ‘global treadmill’). Hypothesis 2.3 tests both of these in the context of organic agricultural production in a sub-Saharan setting.

2.2.3 Research Question: What is the impact of organic agriculture on poverty and inequality?

Based on Section 2.1.3, this third research question involves three hypotheses:

- **Hypothesis 3.1.** Organic farmers as a group are less deprived and less poor compared to conventional farmers, as measured by a basic need level.

- **Hypothesis 3.2.** Organic farmers as a group experience lower poverty headcounts and breadths of poverty compared to conventional farmers as measured by a multidimensional poverty index.

- **Hypothesis 3.3.** Organic farmers as a group experience lower depths of poverty and inequalities compared to conventional farmers as measured by a multidimensional poverty index.

The hypotheses from this third research question build and expand onto the previous Hypothesis 1.3, which focused on larger net and total incomes being obtained by organic farmers. In order to answer any of the above hypotheses on the impact of cotton production on the dependent variables of poverty (and levels of inequality), they are expanded to draw on the rapidly growing research literature on multidimensional poverty analyses reviewed in Section 2.1.3. There are five broad levels of measuring poverty and inequality: deprivation in Hypothesis 3.1, headcounts and breadths of poverty - poverty gap - in Hypothesis 3.2, and depths of poverty - squared poverty gap- and inequalities in Hypothesis 3.3. These are all based on the work by Alkire and Foster (2011a, 2011b).
and Alkire and Santos (2010) reviewed in Section 2.1.3 and discussed in greater detail in Section 6.3.2 in Chapter 6.

Hypothesis 3.1 uses as a threshold the classical unidimensional poverty line of basic needs, which focuses on absolute, monetary terms. This differs from Hypothesis 1.3, that instead of just contrasting the incomes obtained by the two groups, it answers whether or not these income figures are large enough to sustain a level of basic need. As the only unidimensional measure of poverty, it includes an analysis of both the poverty headcount, as well as the poverty gap and the squared poverty gap.

Hypothesis 3.2 moves beyond this unidimensional poverty analysis by widening the analysis to include two more dimensions: a second dimension of non-monetary assets (see i.e. Grosse 2008) and a third dimension of vulnerability (see i.e. Calvo 2008). The addition of these second and third dimensions yields a multidimensional poverty index and allows for a relative approach to poverty analyses, including social capital or exclusion (Kakwani and Silber 2008), which is of interest for two main reasons. First, as reviewed in Section 2.1.1, innovations are hypothesized to travel across social strata (Rogers 2003). Second, social capital is believed to be important in the diffusion of organic agriculture, since organic agriculture is a knowledge-intensive innovation.

Hypothesis 3.3 uses the same multidimensional poverty figure, but focuses on the depth of poverty or inequalities using the FGT method outlined in Section 2.1.3. It completes our previous understanding of the difference existing between organic and conventional farming households by giving us a picture of the inequality and poverty. Based on the literature, it is hypothesized that organic farmers are not only having lower levels of poverty, but also lower levels of inequality. As such, it answers the call.

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36 It is defined in detail in Chapter 6.

37 The development of the multidimensional index takes place through the useful aggregation of these three dimensions into a single index. This differs from the simpler procedure of aggregation into a composite index undertaken for the Farm-Level Sustainability Index used to answer the second research question. With this novel methodological approach, the three hypothesis of the third research question are answered.

38 Social capital (or lack thereof) has been shown to have a large impact on one's ability to climb out of poverty, or even obtaining a safety net. Evidence from Tanzania (Cleaver 2005) and Côte d'Ivoire (Romani 2003) indicates that similarly to the introduction of innovations, increasing social capital in an area not only includes, but also excludes, often at the disadvantage of the most marginalized.
from Grosse et al. (2008) to take into account the multidimensional poverty indicators when evaluating the impact of pro-poor interventions.

2.3 Research Area

The three research questions outlined above are answered in the context of the most successful and longest standing organic cotton operation in sub-Saharan Africa: bioRe Tanzania. The first section 2.3.1 presents the study area. It provides a context for these research questions. Since the dissertation is based on a case study of an organic operation, the second section 2.3.2 provides background on this organic cotton operator, bioRe Tanzania. It includes a discussion of limitations. The goal is to provide an overview of the area in which these questions are analyzed, as well as highlight areas that are not addressed.

2.3.1 Study Area

The study area of Meatu district in Tanzania serves as an interesting case study for three reasons: First, at the crop-level, cotton is the main cash crop produced and also the largest income source for the majority of households. The introduction of organic cotton contracting is likely to have a large impact. This is accentuated by the fact that farmers are historically lacking other cash crop alternatives. Second, at the farm-level, farmers are limited in their access to improved inputs, especially fertilizers. Combined with the unusually large landholdings by households, organic agricultural methods that aim to improve soil fertility would be expected to have a significant impact. This application of organic farming is enhanced by the traditional cattle ownership. Third, at the regional-level, given its remote location and widespread poverty, agriculture is perceived to be the key sector towards creating pro-poor growth. As an intervention with the goal of alleviating poverty, organic contract farming consequently enters into one of the most challenging socio-economic environments.

39Traditional crops include sorghum, sweet potatoes, and peanuts
The chosen study area of Meatu is located in the Shinyanga region of Tanzania, East Africa. As depicted in Figure 2.3, it lies around 120 kilometers the east of the major cotton ginning hub of the city of Shinyanga. The district has a size of 8,871 square kilometers, with a varying altitude between 1,000 to 1,300 meters above sea level (United Republic of Tanzania, 2007; ICRA 2003). Located near the equator, Meatu exhibits a tropical climate dominated by a rainy season and a long dry season, with temperatures averaging around 25 degrees Celsius. The region is characterized by "broad and narrow valleys separated by rocky hills that consist mainly of granite rocks", including alluvial and lacustrine plains. (ICRA 2003, p.1). Meatu itself hosts three different soil types, with the soils in the north yielding the largest fertility. This
Sukuma catena is described by ICRA (2003) in Figure 2.4. It includes fine sand soil (Luseni) in which cotton or maize is usually planted. If rainfall allows, rice is planted on the lower slopes, while the mbuga soil serves for grazing. Farmers maintain their soil fertility traditionally by engaging in shifting cultivation, which is possible due to the large average landholdings of 80 acres. Given that farmers have no access to synthetic fertilizers, organic techniques are expected to have a large impact on improving soil fertility as seen in previous studies of organic agriculture.

![Figure 2.4: The Sukuma Cantena: General Shape and Sequence of Soil Types (Source: ICRA 2003, p.2)](image)

**Table:**

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky hilltop</td>
<td>Granite outcrops (tor or kopje) mixed with coarse sand</td>
</tr>
<tr>
<td>Luseni</td>
<td>Coarse to fine sands (Dystric Cambisols*, Eutric Regosols, petroferric phase)</td>
</tr>
<tr>
<td>Itongolo/ibambasi</td>
<td>Sandy clay with hardpan (Cambic Arensols) just below Luseni (especially on the relatively steep slopes), Calcaric Phaeozems with hardpan, sodic phase in lower position and on gentle slopes</td>
</tr>
<tr>
<td>Mbuga</td>
<td>Heavy cracking clay (Calcic Vertisols, sodic phase)</td>
</tr>
</tbody>
</table>

*FAO classification

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40 Farmers will occasionally risk planting cotton in the heavy clay as well.

41 See Jermann (2011) who cites qualitative studies by Schwaller (2004) and Schwank, North and Baettig (2001) as evidence that "soil fertility improves visibly after conversion to organic farming" (p.40)
Population

Not established as a district until 1980, Meatu contains a total of 71 villages with a population of 250'000 as of 2002.\textsuperscript{42} It is an overwhelming rural district, as only around 7,000 persons are classified as living in an urban environment, which amounts to a mere 3 percent, the lowest amongst all other districts in the region. It is marked by poor infrastructure, with the regional hub of Shinyanga located on average two hour drive away from the district center of Meatu, Mwanhuzi. Located in an area called Sukumaland, the dominant ethnic group is the Wasukuma. Traditionally cattle herders, the Wasukuma moved into the area in the early 20th century in search for grazing land. Under German and British rule, they were encouraged to shift towards agricultural export production, especially cotton. The history of these development interventions on cotton is discussed in greater detail in Chapter 3.

Out of all the neighboring districts, Meatu experiences higher levels of poverty.\textsuperscript{43} For example, 67 percent of the households experienced often or always food needs during 2003-04 (EDI 2005, p. 57). It also has the highest rate of households below the basic need line at 48 percent (ibid., p. 68), although in return the area is marked by a comparatively low consumption inequality\textsuperscript{44} given these low levels of income (ibid., p.69).

Poverty was also broken down by looking at asset ownership, including large differences between the poor and non-poor in house quality (ibid.).\textsuperscript{45} Research also shows

\textsuperscript{42}This population has grown at an estimated rate of 3.2 percent between 1988-2002, with the average household size above average estimated at 7 persons. Population density in the region - at around 55 person per square kilometer - however is estimated to be much lower than in other regions of Tanzania, such as neighboring Mwanza, where it averages at nearly 100 persons per square kilometer. (United Republic of Tanzania, 2007)

\textsuperscript{43}Although Tanzania had successive increases in terms of GDP per capita, reaching 1,426 US$ by 2010 (adjusted for purchasing power parity; UN 2011), ”the incidence of income poverty did not decline significantly” (United Republic of Tanzania, 2010, p.5). This was attributed to population growth, which averaged 2.9 percent, thus offsetting the annual growth of 4.5 percent in the agricultural sector - identified as a growth driver - that is key towards reducing rural poverty. In the rural areas where Meatu is located, the incidences of poverty consequently were the highest (twice as large than in Dar es Salaam, the economic hub), averaging 38.7 percent in 2000/01 and 37.6 percent in 2007 using a basic needs cutoff (United Republic of Tanzania, 2010, p.5).

\textsuperscript{44}The highest quintile’s consumption expenditures are only 1.5 times larger than the lowest quintile’s.

\textsuperscript{45}For example, while nearly 80 percent own a bed, only 65 percent of the classified poor households do so. Radio ownership was estimated at 47 percent, with only 25 percent of the poor owning one
that having an improved house, in addition to owning land, were valued as the most important by farmers in Meatu (Jermann 2011).

Economy

As shown in Figure 2.5, sale of cash crops in the Shinyanga Region currently is the largest income source for nearly 50 percent of all households. Due to the lack of rainfall, farmers are dependent upon cotton as their main cash crop, as rice production (possible in Shinyanga and Mwanza region) is not feasible. Even maize cultivation is problematic, with sorghum being more reliable (yet lacking a profitable market) (Ratter 2002; Ratter 2008; Bargawi 2008).

Agriculture still constitutes the backbone of the Tanzanian economy in general and Meatu district in particular. In 2000, 47 percent of export earnings in Tanzania came from this sector. While as high as 34 percent of the foreign exchange earnings came from cotton in 1995, by 2002 it fluctuated between 10 to 16 percent of gross foreign currency earnings (Kisonga 2004). More recent data showed that between 2005 to 2009, cotton earned the highest foreign exchange earnings, averaging 92 million US dollars per year, compared to 90 million by tobacco and 89 million by coffee (Tanzania versus 57 percent of the non-poor. Television, a rare asset given the need for access to electricity and satellite, are owned only by the non-poor (4.8 percent). Mobile phones, which have boomed in ownership since 2007, were recorded at a low 12 percent of total households. Only 3 percent of the poor and 16 percent of the wealthy households were said to have ownership of it. In regards to household amenities, iron sheets on roofs (as opposed to thatch) and cement walls (as opposed to mud) stands out as a strong differentiator between the poor and non-poor in the EDI survey (2007, p.69). 40 percent of all households have an iron sheet roof. Only 15 percent of the poor however are having one, compared to 50 percent of the non-poor. Even more directly, only 5 percent of all farmers have cement walls, with none of them being poor households. These assets are included in the survey.

Jermann (2011) undertook fieldwork interviewing 24 farmers during the 2009-10 season, creating rankings of the wellbeing indicators. Asking the question What does a good quality of life mean for you?, the participants of four focus groups made the following distinctions: Households with more than 100 acres are classified as wealthy, whereas the poor are lacking not only land, but also are engaging in casual labor for food. Regarding cattle, she finds that rich farmers tend to hold more than 75 cattle, whereas a poor farmer is lacking any. Similarly, houses with iron roofs, burnt bricks and a cement floor are considered indications of a wealthy household. Other assets discussed were differences in ownership of motorbikes - owned by the wealthy - versus bicycles owned by the poor. Two women’s groups pointed out that they value household assets, such as owning a sofa or a TV. Immaterial indicators discussed included education, employment, health, having good relationships, and being married.

Focus groups - discussed in detail in the following chapters - undertaken as part of this study revealed a similar pattern, with land and house being valued more than the traditional cattle. However, differences exist in regards to the thresholds set between rich and poor, as the focus group in Mwanyahina identified that there were three groups of wealth, average, and poor farming households. As such, they were different than the binaries produced in the earlier two research cited above.
Cotton Board 2010). It however remains a traditional export crop - with 70 percent of all cotton lint being exported. Furthermore, an estimated 90 percent of the income generated from cotton is obtained abroad, although strategies are drawn up to try to retain the added value within the country by spinning, weaving and processing the lint domestically (Tanzania Cotton Board 2010, p.v).

Meatu district is located within the Western Cotton Growing Area (WCGA), which spans the Mwanza, Mara, Shinyanga, Kagera, Tabora, Kigoma and Singida regions. Nearly all (95-99 percent) cotton comes from this area, with Shinyanga region contributing the largest share. The Eastern Cotton Growing Area (ECGA) which includes Mbeya, Morogoro, Coast, Tanga, Kilimanjaro, and Arusha only makes up the remaining 5 percent. This is due to numerous cotton insect pests and diseases, which make cotton growing more risky and expensive. ECGA also has better agro-climatic conditions, allowing farmers a wider range of crop availability, such as maize, coffee, sugar cane, beans, tea, and pyrethrum (Kisonga 2004, p.14-15). In the WCGA, cotton has a tremendous impact on the livelihoods of households. Nationally, it provides an estimated 40 percent of the population with a source of income or employment.
The largest challenge faced by the farmers in terms of productivity is their high dependence on rainfall (see SWOT analysis by Tanzanian Cotton Board 2010), which tends to average between 700 to 900 mm per year (Meertens et al. 1995, p.19). These bimodal rainfalls are important for cotton as they enable the growing of the crop in its early stages (from November to December) and allows for growth via the subsequent rainfall during March to April prior to the opening of the bolls. There tend to be large differences however across Meatu, with the southern region generally receiving less rain. Furthermore, rainfall can be erratic\footnote{Hankins (1973) finds that the rainfall is produced by convectional cells which are only a few kilometers apart in diameter (p.17). These convectional storms create sharp boundaries between areas that are receiving and not receiving rains. This results in high variability, as expressed in lack of correlations amongst neighboring weather stations. He gives the example of two stations that were only 17 km apart (in Mwanza and Nyegezi), where "rain occurred at only one of the two stations in 70 percent of all rain days, with a correlation coefficient for the daily falls of 0.06" (p.25). As a result, Hankins (1973) argues that the correct planting times of November and December, as proposed by government extensionists, are often inferior to the actual planting times by farmers later in the first and second week of January.} and exhibiting great variation:

"Rainfall may also be very patchy, heavy in one area and completely dry one kilometer away. Heavy, localized rainstorms separated by dry spells is a common pattern in Sukumaland. This pattern reduces the rainfall’s effectiveness, and causes the annual amount of rainfall to fluctuate considerably.”
(Meertens et al. 1995, p.20)

As a result of erratic rainfalls, threats remain of both too little rainfall (as only 2 out of 100 households are estimated to use irrigation practices in Shinyanga region) or water logging after intense rainfall periods (Bargawi 2008), especially in low-lying swampy areas (\textit{mbuga}). These challenges are unlikely to go away with increased variability due to global climate change (i.e. Binswanger 2009).

Another key challenge in the region is the low yields obtained, which are significantly lower than the other cotton exporters from West Africa. Bargawi (2008) reviews past yield estimates, which were set at 280 kg/ac by Ferrigno et al. (2005), 170 kg/ac by Poulton et al. (2004), and between 150 to 200 kg/ac by Ratter (2002). The latest statistics from the Tanzanian Cotton Board (2010) cite yield averages of around 300 kg/ac. Bargawi (2008) finds that the maximum yield reported for a village he studied
in Meatu was nearly 1000 kg/ac. Reasons for these large variations are different soil conditions, especially since few farmers are using external inputs. Post-liberalization, with the removal of input subsidies, synthetic applications have dropped significantly. While synthetic fertilizer levels have never been high, pesticide applications amongst conventional farmers are usually below 50 percent of all households and applied at sub-optimal levels (Bargawi 2008).

It is in this remote environment of poor soil fertility, low yields, low input-usage, and dependence on rainfall that bioRe Tanzania entered as a pioneer in organic agriculture in 1994.

### 2.3.2 Case Study: bioRe Tanzania

After the liberalization of the cotton sector in 1993 in Tanzania, bioRe Tanzania was founded by Remei AG, a Swiss cotton firm specializing in the production and marketing of organic textiles. While its sister operation of bioRe India is one of the few projects studied to analyze the impact on poverty of organic agriculture (Eyhorn 2005, Eyhorn et al. 2007), bioRe Tanzania has received limited attention. This was due to the fact that larger amounts of cotton were obtained from the Indian operation, as well as early management failure in the Tanzanian operation. However, with the introduction of genetically modified seeds in India, decertification of farmers are on the rise thus reducing output. Coupled with government export restrictions in India, seed (or lint) cotton in Tanzania have surpassed the Indian operation after the 2007/08 season (see Table 2.2).

bioRe Tanzania is operating in an integrated value chain with the Swiss company Remei as outlined in Figure 2.6. The key link exists between bioRe, which acts as the organic cotton operator in Tanzania and Remei, the cotton trading house in Switzerland. The latter guarantees to purchase all certified organic cotton from the former, while the former - bioRe - guarantees to purchase at least 80 percent of the estimated cotton from its farmers.

These organic producers receive unprecedented extension service (see Figure 2.7 for training session at Mwamishali headquarters), with each village which has an average of
Table 2.2: Comparison of Organic Production from India and Tanzania (Remei 2011)

<table>
<thead>
<tr>
<th></th>
<th>2007-08</th>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Farmers</td>
<td>2'374</td>
<td>2'372</td>
<td>1'983</td>
<td>2'665</td>
</tr>
<tr>
<td>Seed cotton (in tons)</td>
<td>4'644</td>
<td>7'980</td>
<td>4'120</td>
<td>3'720</td>
</tr>
<tr>
<td>Lint cotton (in tons)</td>
<td>1'620</td>
<td>2'796</td>
<td>1'448</td>
<td>1'284</td>
</tr>
<tr>
<td>Spun cotton (in percent)</td>
<td>6 %</td>
<td>39 %</td>
<td>31 %</td>
<td>50 %</td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Farmers</td>
<td>7'890</td>
<td>8'737</td>
<td>6'455</td>
<td>5'651</td>
</tr>
<tr>
<td>Seed cotton (in tons)</td>
<td>7'945</td>
<td>5'501</td>
<td>3'963</td>
<td>2'651</td>
</tr>
<tr>
<td>Lint cotton (in tons)</td>
<td>2'700</td>
<td>1'880</td>
<td>1'332</td>
<td>855</td>
</tr>
</tbody>
</table>

Despite this innovative integrated value chain, which contains numerous components of interest (see Heierli 2008), two stand out as contributing factors towards its success: the financing of the organic premium and the long-term partnership with Coop Switzerland. The organic premium of 15 percent is not paid by bioRe Tanzania but rather by Remei with its annual profits. What could appear as a mere accounting choice has a large impact as the extra payment is not added into the value chain. Since ginners and spinners in traditional commodity chains work with percentage margins on the value of the product, the removal of these costs and adding them at the end "avoids inflating the price of the product at each stage in the chain. That keeps the price of the final product two extension officers that visit each farmer monthly to provide advice. They also supply inputs and loans to farmers, with cotton sold (including a 15 percent premium) paid on the spot. Triodos Sustainable Trade Fund pre-finances the operation via a low-interest loan since 2004. While bioRe does not have its own ginner, it has an exclusive contract with the sole ginner operating out of Meatu, Bibiti. The most important change in recent years, especially in regards to increase foreign exchange earnings obtained within the country as outlined by the Tanzanian Cotton Board, is the expansion of domestic spinning and weaving of the cotton prior to exporting. This added value has increased dramatically over the last years, in an aim to diversify the risks for Remei that arose due to the export ban in India. The Tanzanian share of the total cotton spun - as listed in Table 2.2 - by Arusha-based Sunflag Tanzania consequently increased from a mere 6 percent in 2007-08 season to 50 percent by 2010-11 of all yarn traded by Remei (Remei 2011).

Although this innovative integrated value chain contains numerous components of interest (see Heierli 2008), two stand out as contributing factors towards its success: the financing of the organic premium and the long-term partnership with Coop Switzerland. The organic premium of 15 percent is not paid by bioRe Tanzania but rather by Remei with its annual profits. What could appear as a mere accounting choice has a large impact as the extra payment is not added into the value chain. Since ginners and spinners in traditional commodity chains work with percentage margins on the value of the product, the removal of these costs and adding them at the end "avoids inflating the price of the product at each stage in the chain. That keeps the price of the final product
low, making consumers more willing to buy.” (Pattni 2010, p.106). These consumers - around 70 percent of them - are found in the Swiss supermarket chain of Coop. Organic clothing, sold under the *Naturaline* label, is priced very competitively to conventional clothing (a t-shirt for example costs around 20 US$). Having Coop Switzerland as its long-term partner consequently creates the stability necessary for creating a sustainable enterprise as it provides the ability to transfer purchasing guarantees from Remei to bioRe and ultimately to the farmers.

Since bioRe Tanzania is the sole buyer of organic cotton in Meatu, it is positioned as a monopsonist. Defined as the ability for a buyer to become a price-maker with pricing discriminatory power, as opposed to price-taker in the market (see works by Jones 1988; Jones and Krummel 1987; Löfgren 1986, 1992), monopsony is in theory significant in shaping inequalities for three reasons: First, dealing with a monopsonist

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48Monopsony, as a form of industrial organization, has received special attention from agricultural researchers as it permits the sole buyer the ability to shape inequalities among villages (Dunn 1954; Jones 1988; Löfgren 1986, 1992; Lösch 1954; Palander 1935). This inequality-shaping force of monopsony plays a special role in creating imperfect competition and has received limited attention within Geography.
means that the organic cotton farmers in the Meatu District often have no other recourse but to sell at the prices offered by the organic cotton contractor if they are to obtain the price premium. Second, with the production chains in textiles becoming increasingly buyer-driven (Gibbon and Ponte 2005) and attaching equal importance to time and cost (Dicken, 2003), an ability to source guaranteed quantities and qualities of cotton from the farmers is key towards the success of a contract agent (see also Glaeser et al. 1992). Third, the monopsony status of bioRe – the organic cotton contract farming operation in Tanzania – is enhanced by its vertical integration, drawing on increasing economies of scope (Fafchamps et al. 2005), and increasing economies of scale in transportation (Merel et al. 2006). Although an analysis of monopsony is beyond the scope of this research, it is expected that in reality bioRe’s powers as a price-maker are limited for four reasons: increased side-selling; inspections; limits in pushing for intensification; and threat of GM cotton.

49 These include the controlling of grading, transportation, ginning, marketing, etc.
Limits to Monopsony: Side-Selling

bioRe sets the prices based on a daily average of all sellers in one of its 15 project villages in Meatu district. On average, bioRe purchases around 80 to 90 percent of all cotton of its farmers. In the 2008-09 season, this share however dropped to 44 percent purchased, with the 2009-10 season even lower at 41.50 percent. Three reasons exist for this side-selling: First, during years of high prices, the 15 percent premium - which is based on a five year average - assumes a lower share of the final price. Second, during high price years, competition is increased as many traders are searching for fulfilling their quotas. They consequently engage in questionable practices, which range from the benign picking up cotton at the farm directly and the more questionable practice, such as empty promises of ploughing fields with tractors at the start of next season. Third, given that bioRe has higher quality requirements, farmers are requested to clean their cotton upon delivery. Depending on the timing and communication of this request, farmers might just opt to sell the cotton without the premium, which can literally be next door from the godown.

Limits to Monopsony: Inspections

Although bioRe Tanzania is not gaining fair trade certification, it undergoes an annual social audit for its SA8000 certification, a social standard of Social Accountability International (Kompass Nachhaltigkeit 2010). It requires the adherence to nine criteria: no child labor; no forced and compulsory labor; a healthy and safe work place; freedom of association and right to collective bargaining; no discrimination; no disciplinary practices; regulations in working hours; remunerations according to living wage; and integration of these standards into their management systems (SAI 2011). Discussions with the staff and external auditor revealed that a key point of the inspection is to see whether or not farmers are aware of their rights according to the contract, but also

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50 The last season, 2010-11, showed an unexpected increase to nearly 90 percent, which was due to bioRe purchasing cotton as other traders were renegotiating lower prices.

51 Most harmful to farmers is most likely that the conventional traders often use manipulated weighing scales and don’t pay on the spot.
if bioRe is adhering itself to the terms outlined. As such, they serve as an important check on monopsony power in regards to contracting with (illiterate) farmers.52

Limits to Monopsony: Limits in Pushing for Intensification

The bioRe operation is exceptional due to its large investment in farmer training. This is exemplified by the unprecedented ratio of around two extensionists per 150 farmers. Besides the monthly visits, it includes a mapping of the farm plots, a demo farm, village campaigns, and farmer-to-farmer training at a village-based lead farmer. Even with this powerful system of monitoring and advising farmers, it however falls short at forcing farmers to adopt organic methods beyond those outlined in the contract as essential towards obtaining certification. One example is that bioRe has a long history of trying to stress the intensification of production. Methods include sowing cotton in row, weeding with oxen, and applying farm yard manure. However, all of these methods have very low levels of adoption (in the single digits).

Reasons for this pattern are discussed at greater length in Chapter 3 discussing the history of production and Chapter 5 measuring sustainability.

Limits to Monopsony: Threat of GM Cotton

Another limit to the monopsony power of bioRe comes from its dependence upon obtaining uncontaminated organic cotton. While it supplies its own untreated seeds to farmers (at a subsidized rate), the experience of its sister company in India has shown the threat that comes from the introduction of genetically modified (GM) cotton seeds into an organic environment. Two challenges in India are the securing of untreated seed supply in a setting where GM seed has grown from a few percentages five years ago to over 90 percent, as well as convincing farmers (in the face of aggressive GM marketing campaigns) that growing organic is in their long-term best interest. The struggles

52 Average adult literacy rate in Meatu is only 60 percent, which is by a few percentage points lower than its neighboring districts (EDI 2005, p.12). As far as current primary school enrollment rates go, children from Meatu are having a high enrollment rate with 81 percent yet a very low primary school satisfaction of 35 percent. Contrasting this high primary school enrollment rate is the very low secondary school rate, which is a mere 4 percent, the lowest of all neighboring districts (ibid., p.24).
Figure 2.8: Innovation in action: farmer ox-weeding in Ng’hiboko while using cellphone

faced by India put in question the feasibility of coexistence of both technologies (Novy et al. 2011), as it dramatically reveals the limited powers of an organic contractor. Since the Tanzanian Cotton Board has announced that it plans to introduce Bt (Bacillus thuringiensis) technology by 2014-15 via contracting farming routes, the threat of GM cotton has become real very quickly. The case study of another organic operator, Helvetas, in Burkina Faso where Bt cotton is already used (Coulter 2011), is of great interest in an investigation of potential impacts in future avenues.53

53 Especially the geography of it, as GM cotton production introduces spatial aspects in regards to contamination, buffer zone regulations, etc.
In summary, although a more detailed investigation of the monopsony and contracting power of bioRe is beyond the scope of this study, the four examples above highlight how their power as a price-maker and strong contractor are limited in key areas of its operations.

2.3.3 Limitations

Although the above sections have highlighted the benefits of undertaking a study of organic agriculture’s impact in a rural, sub-Saharan environment where farmers are heavily dependent on the crop of interest, two limitations exist.

First, studying organic agriculture’s impact in an African environment of low-input usage has the benefit of working in a location where a large room for agronomic improvements exist. However, this means that a comparison to conventional farmers is biased in that they are not having access to synthetic inputs. As such, it provides insights that are very different from a case study of India (i.e. Eyhorn 2005) or even Burkina Faso (i.e. Coulter 2011), where the supply infrastructure and subsequent application is more advanced.

Second, in regards to studying the impact of organic agriculture on poverty, the spread of wealth is low given the remote location and limited income opportunities. As a result, an analysis of the impact of organic cotton production on poverty and inequalities are different than if analyzed in a developed country context or one of high income inequalities (i.e. Latin America). Especially in regards to inequality, even if the introduction of organic agriculture would increase inequalities, it is (morally) debatable the extent this should be prioritized given the low levels of incomes to start with.

2.4 Data and Methodology

This section outlines the data and general methodology used in the dissertation. It introduces the primary data gathered, the secondary data that is available, including its shortcomings, and the broad methodologies embraced as a guiding framework for the study.
2.4.1 Primary Data

At the heart of answering the three research questions rests survey data on over 100 farmers gathered during fieldwork in Spring to Summer 2010. It was gathered with the aid of a field assistant - Emmanuel Paul Ngulujose - that served as a translator as most households spoke the local language of Kisukuma.

Household Surveys

The household surveys were designed specifically to address the research questions outlined above. They also were tested in an initial visit in 2009 and prior to the start of the research in a village outside the sample - Ng’hiboko - in 2010. Given the participatory econometric nature of the research (outlined in section 2.4.3), the survey was consequently revised and adjusted based on feedback from farmers and staff, as well as discoveries.\(^{54}\)

A copy of survey questionnaire, including the 34 questions in the survey, is provided in Appendix A.

Sampling Method and Size

The sampling method used for the research was a stratified random sample. Given that the diffusion and subsequent adoption of organic methods is believed to depend on the distance from the bioRe headquarter six out of the 15 project villages were chosen at random: 3 within 15 km from the headquarter, while 3 outside of it.\(^{55}\)

In each village, a random stratified sample of bioRe farmers and conventional farmers was taken. For bioRe farmers, the producer list was used and random numbers were generated, with 15 farmers selected. For conventional farmers, after a meeting with the village chairman or secretary, a list was produced of all cotton farmers.\(^{56}\) Out of

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\(^{54}\)Examples include the focus on access to ngiteli, a grazing reserve, the amount of cotton side-sold, or breaking down labor into finer categories.

\(^{55}\)Using the classification of Morganti (2010), there was at least one village in each zone. Sanga-Itinje and Minyanda are located in the north, Mwamishali, Kabondo, and Mwanyahina were located in the centre-west, while Mwamanongu was located in the south-east.

\(^{56}\)These were drawn either from village meetings or best from lists held by village officers on sales of
those lists, 15 conventional farmers were chosen at random with the assistance of the village council. Village maps were drawn subsequently to create approximate locations for each of the conventional farmers, while bioRe extension officers aided in placing their farmers. Out of these 30 farmers, on average at least 10 bioRe households were interviewed in each village, compared to an average of 9 conventional households per village as a control group (see Figure 2.9).

Since close attention was paid for a truly random spatial sample, which included visiting each farmer without the aid of either the village authority or an extension officer, the process of arranging interviews proved to be very laborious. As a result, in the village of Minyanda, for example, conventional farmers were located far away from the village center that was not accessible (which we found out painfully getting stuck in dried river beds) by even a four-wheel jeep. There were no farmers however that were avoided due to their distance wherever possible.

Figure 2.9: Sample Size by Village and Farm Type

Since close attention was paid for a truly random spatial sample, which included visiting each farmer without the aid of either the village authority or an extension officer, the process of arranging interviews proved to be very laborious. As a result, in the village of Minyanda, for example, conventional farmers were located far away from the village center that was not accessible (which we found out painfully getting stuck in dried river beds) by even a four-wheel jeep. There were no farmers however that were avoided due to their distance wherever possible.
2.4.2 Secondary Data

One of the benefits of working in the field of certified agriculture is the large accumulation of data available. This was the case with bioRe Tanzania, which established an internal inspection system that gathered all data electronically. Preliminary analysis of this data set provided important understandings of the situation on the ground in a visit in 2009.

In addition to the bioRe data, there is also data available for the region from the regular Household Budget Surveys, an agricultural census undertaken by the government, as well as a commissioned analysis undertaken by EDI (Economic Development Initiatives). All three survey questionnaires were used as a basis for creating the questionnaire listed in Appendix A. Key areas for example include the selection of assets used, especially house value, as the work by EDI (2005) identified key assets as poverty indicators. The agricultural census and the results by EDI (2005) was also used to create a better understanding of the region (see for example Figure 2.5 for the agricultural census and earlier discussion on poverty levels in the study area for EDI (2005)).

The wealth of secondary data available for the study area, however, lacks two main components needed for a multidimensional poverty and inequality analysis: First, either surveys have not been undertaken on conventional farmers, or they don’t distinguish between the two. Second, the secondary data available did not ask explicit questions regarding the third dimension of poverty, vulnerability. The design of the survey, as outlined above, specifically gathers data on these variables. Focusing on this form of analysis ultimately allows for achieving a broader, more comprehensive perspective of the actual state and inequalities in livelihoods both within and between organic and conventional farming households.

Another key strength of this research approach is that it takes advantage of having gathered survey data for each of these dimensions from the same households. This method, employed by Alkire and Foster (2011a) at the national level - briefly reviewed

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The work of the bioRe foundation uses this data to get a better understanding of the improvements taking place on the ground. Qualitative studies were also undertaken, the most recent being by Jermann (2011) using the sustainable livelihoods framework. Other (unpublished) studies included work on prices and a rapid appraisal by an outside consultant.
in Section 2.1.3 - can draw conclusions on the state of poverty, with the results being sensitive to the joint distributions of forms of deprivations. This differs from the more common marginal methods, which fail to “look across dimensions for the same person and cannot reflect the extent of association among deprivations” (ibid., p.303).

2.4.3 Participatory Econometrics

As coined by Rao (1998), this underutilized research method differs from other mixed methods in that “the econometric analysis is central to the exercise [and] has the participatory aim of making respondents important players in the analytical work” (Rao, 2002, p.1887). Besides the iterative use of advanced econometric methods, participatory econometrics improved my research in five key respects:

First, since regression analysis, for example, provides limited evidence on causality, undertaking qualitative fieldwork aids in improving our understanding of the directionality of these findings. Second, one of the largest areas of concern in quantitative research is the problem of outliers. This research method allows for demystifying measurement errors and bias that subsequently would be introduced in the sample, easing the decision of including or excluding data. Third, and most importantly, qualitative data allows for a context to not only cross-check the findings, but also stimulate new research questions or directions that previously were hidden from the view of the data analysis. Fourth, based on personal fieldwork experience and from an ethical standpoint, besides collecting new information, the sharing of findings in the research area is a prerequisite towards establishing a healthy and longstanding relationship that facilitates future time-series studies on poverty and inequality.59

For this purpose, two follow-up trips in January - February 2011 and September 2011 allowed for assessing changes on the ground after the survey. This is especially important as farmers benefited from unprecedented high commodity prices compared to the unusually low prices that existed during the year the survey was undertaken. This was the topic of discussion in the first return visit, which included three focus groups

59This was undertaken before departing via village meetings undertaken in each village in 2010.
and two semi-structured interviews with farmers on prices and research findings. The second research trip aimed at discussing the revised findings with bioRe staff.

The quantitative methods used include descriptive statistics and multivariate analyses, multilinear regression models, logit regressions, poisson regression, and Principal Component analysis (PCA). Descriptive statistics provide a sense of the poverty, inequality and sustainability levels within and between organic and conventional farming households. Multivariate statistics preliminarily analyze relationships amongst variables, especially relating socioeconomic variables to poverty, inequality and sustainability. Multilinear regression models, logit regressions and poisson regressions advance the multivariate analyses by understanding the importance of key variables in explaining differences amongst farmers. While logit and poisson regressions are mostly used to model differences between organic and conventional farmers, PCA increases our understanding of components contributing to poverty and inequality. As necessary, the details of the quantitative analyses are outlined in each chapter.60

Besides the focus groups and semi-structured interviews referenced above, the research also included archival research in order to better situate the introduction of organic agriculture in Meatu district. This research was undertaken for a week in 2010 and during a one month period in February 2011. The results are discussed in the next chapter.

2.4.4 Limitations

Although the research site was visited four times over a period of three years, the qualitative research arm was more limited than would be desirable for a critical ethnographic study. As such, this dissertation draws heavily on the quantitative data, with more detailed limitations and further avenues outlined in the concluding chapter. Furthermore,

60 For all quantitative analyses, the SAS 9.3 Base or Enterprise Guide (EG) software package was used. For the principal component analyses, Jolliffe (2002), O’Rourke et al. (2005), SAS Institute Inc (2008) and Suhr (2005) were used. For the logit and poisson regressions, Allison (1999) was the key reference. In addition, UCLA (2011) proved to be an invaluable resource. I’m exceptionally grateful also for the review, guidance and encouragement by Dr. Michael Lahr of all analyses run.
this lack of a continuous research period resulted in an ability to observe some key seasonal events. For example, with the fourth research trip nearly all events were observed. The selling season was however only witnessed at its beginning and ends, especially as most time was spent at headquarters.\textsuperscript{61}

In regards to participatory econometrics, a trade-off exists between focusing solely on either the participatory component (which demands small sample sizes studied individually) and the econometrics (which demands larger sample sizes that are evaluated in aggregate). In regards to the latter, econometric methods, the study could have benefited from larger sample sizes - especially at the village level - in order to draw more robust statistical conclusions. In regards to the former, participatory methods, observing more closely the struggles and successes of individual farming households would have provided even more insights into the inner workings of (organic) cotton production and its impact on levels of poverties and inequalities.\textsuperscript{62} These shortcomings, however, were addressed to some extent with the follow-up visits into the region and undertaking focus groups to include a larger number of farmers into the participatory process.

\textsuperscript{61}This shortcoming however was reduced by the fact that farmers don’t have much time during the selling period due to labor demands on harvesting etc.

\textsuperscript{62}Due to the combination of both methods under the umbrella of participatory econometrics, decertified farmers, for example, were not included as a specific group for inquiry since the sample size for these were too small for quantitative analyses.
Chapter 3
Agricultural Interventions in Tanzania

The goal of this chapter is to situate organic production within the long history of agricultural development in Sukumaland where Meatu District is located. This review is by no means encompassing, but rather the primarily aims to provide an introduction to the methods of production and livelihood strategies that existed prior to the arrival of bioRe in 1994. In addition, important links are drawn to build a deeper understanding of the current production systems and livelihood strategies that are the foci of the following Chapters 4, 5, and 6.

Given the combined usage of archival sources and qualitative data gathered via focus groups and semi-structured interviews, the chapter is organized around three major themes: cotton as a development intervention; the history of agricultural production methods; and the impact of these on poverty and inequality. Although each is interlinked, they were divided to best inform the three chapters to follow: For Chapter 4, understanding the origin of cotton production and its production is of greatest importance. For Chapter 5, the history of agricultural methods is of interest. Finally, for Chapter 6, the analysis of poverty and inequality benefits from understanding the impact of reforms (post-liberalization) and the Sukuma culture on farmers. Where feasible, these sections follow a historical path.

Section 3.1 on page 64 describes the rise of the white gold – cotton – from its precolonial origin to the major colonial and post-colonial development interventions that have resulted in its current status as the king of the cash crops. It includes section 3.1.1 which discusses the traditional origins and usages of cotton. In the following section 3.1.2, the motivations for the push by the Germans and the British in the cotton sector are outlined. In the final section 3.1.3, the postcolonial developments
in the cotton sector are presented, drawing the link from the past to the present era, including a discussion on the impact of it on the poverty and inequality of farming households. One key aspect focused on in this section is to situate the entering of bioRe into the sector. Another is to highlight the extent to which cotton farmers (in Meatu) are responding to changes in prices and diversify their production or taking advantage of new (export) opportunities.

Section 3.2 provides a brief introduction into the agricultural production methods that existed over the span of more than a century in order to discuss their diversity and situate the potential novelty of organic agriculture as an innovation. It includes four subsections: First, it reviews the traditional agricultural production system, which includes a discussion of intensification. This is followed by an investigation of the respective role of livestock, geography and culture.

Figure 3.1: Jubilant cotton trader in Mwamishali during purchasing season
3.1 Cotton as a Development Intervention

This section outlines the rise of cotton as the main cash crop and income source for the majority of farmers in Meatu District (see Figure 3.1 of cotton traders). As in other parts of Africa (e.g. Moseley and Gray 2008), cotton was coined the *white gold* (Pattini 2010). Yet not only has the gold lost some of its shine, so has its increase in importance been riddled with failures and conflicts. As such, this section aims at describing its non-linear rise to prominence by starting with the precolonial era and moving through colonial interventions to highlight the current outcome of what is conventional and organic cotton production on the ground.

3.1.1 Traditional Usage of Cotton

![Figure 3.2: Pre-Colonial Cotton Usage Depicted in Koponen (1988, p.265)](image)

There exists some confusion in the literature in regards to the introduction or existence of cotton production. While cotton production is usually attributed to the Germans’ goal of sourcing cotton around the mid-1890s, an archival review of early

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1Koponen (1995) cites 1893 as the first year German production was noted.
explorers’ written accounts reveals that pre-colonial cotton production existed.\textsuperscript{2} Cloth-making took the form of either bark fabrics or cotton-weaving.\textsuperscript{3}

In the study area of Sukumaland, Shinyanga is mentioned as a location where “major concentrations of cotton growing and weaving were reported” (Koponen, 1988, p.265). Explorers noting the production were Burton, Götzen, Stanley, as well as Willis (see footnote 165 in Koponen, 1988, p.265). Supf (1908) also reports that indigenous cotton varieties were planted and processed in several regions of Tanzania (p.11). Reading the diaries of Stanley’s explorations and travels through Sukumaland, it however bears mentioning that European cloth was readily traded for restocking his caravan with grain (Stanley, 1961, p.55).

As depicted in Figure 3.2 published by Burton, the coarse cotton was spun and weaved into a simple dress via the use of a primitive loom. The type of cotton grown, according to Koponen, was “most probably the [earlier mentioned] bush-like \textit{Gossypium herbaciacum} which was planted when the field was first taken into cultivation and the[n] left to grow” (p.265). This appears to indicate that the perennial crop was not uprooted, a practice that nowadays is prohibited by the authorities to increase yield, quality and reduce pest incidences.\textsuperscript{4}

\subsection*{3.1.2 German and British Push for Production}

In this section, the German and British interventions are discussed, with a focus on their motivations in order to situate organic cotton contracting.

\textsuperscript{2}Although Africa is home to one original species of cotton (\textit{Gossypium herbaceum}) and the Nubian kingdom was found using an improved South Asian species (\textit{Gossypium arboreum}) around 2000 B.C.E. (Chowdhury and Buth 2008), it was not until the arrival of the Europeans that large-scale production using the dominant species (\textit{Gossypium hirsutum}) took place. The word ‘using’ is chosen on purpose, as Chowdhury and Buth (2008) claim that the Nubians actually did not make textiles, but rather used seed cotton towards feeding their animals.

\textsuperscript{3}Kisonga (2004) also mentions mattresses as a product in which cotton was used.

\textsuperscript{4}Koponen (1988) states that non-food crops, e.g. tobacco and cotton grown for cash, “became ‘men’s crops’ in the sense that they were planted and tended by men. This was the general picture, admittedly with some variation, in places where grain growing played a major role in the economy.” (p.283) Cotton was also regarded as a tradable commodity amongst neighboring tribes (Koponen, 1988, p.105).
Motivation and Cotton Production under German Rule

Fuchs (1907), who was undertaking an expedition to study the feasibility of building a railroad, published his notes and offers one of the first accounts of German desires for planting cotton. For the Sukumaland area, he notes that the clay soil seemed well suited for cotton, although he expressed worries regarding the observed rainfall irregularities. On his further travels through the steppe, he remarked that the soils would be excellently suited for cotton cultivation via plantations. Due to the more even terrain, he argued that nearly everywhere one could combine the more advanced steam plough with readily-available workers. To make up for any rainfall shortages, he suggested the addition of irrigation capacities, remarking (with less confidence) potential locations to create dams.5

The vision of a modernized cotton production in the German colony, as outlined by Fuchs (1907), was echoed by Chancellor Bismarck, who saw the merits in extending plantation projects into the interior. His motivation was to cultivate “tropical produce which we cannot produce at home” (Koponen, 1995, p.167) - cotton, coffee, tobacco, cocoa, spices, and vanilla - which at the time Germany imported 500 million marks' worth (ibid.). Cotton specifically was situated as responsible for many political and economic changes in world history, thus justifying the move towards expanding German production. Supf - acting as the major spokesperson for a lobbying group - compiled and published a book containing notes about the development of cotton production in Deutsch-Ostafrika between 1900 and 1908. In it, he posits that:

“‘King Cotton’ (ed: not translated) has become one of the mightiest rulers. He has cut deeply into the social relationships, to some extent completely transformed them. He has granted an existence, wealth and prestige for thousands over thousands. He has spread a new culture, technology and science across a whole hemisphere (or continent), just to be carried even higher by them in return. Certainly he has also given rise to the shame of

5While his accounts reflect the German aspirations of increasing productivity via the latest technologies and plantations, the German enthusiasm was not contained to cotton alone. Other Germans started an ostrich farm or even a zebra farm. (Fuchs, 1907)
humanity - slavery. [...] History teaches us, to keep a watchful eye on the ‘cotton-question’ (Baumwollfrage), which [Bismarck] praised, by declaring to German farmers cotton production in German colonies as a desirable goal” (Supf, 1908, p.4).

After the cotton crash in 1869, where 703 spinners in Europe went bankrupt, Germany emerged with the largest textile industry in continental Europe. Calculating the ratio from his valuation of German production of lint cotton compared to consumption by its industries, it amounted to a miniscule 0.00022 (Supf, 1908). Expressed in percent, this amounts to about 1/50th of 1 percent. Given the importance of the industry, which contained millions of dollars of investments and was estimated to support over 1 million working families, according to Supf, “it is clear that a crisis, which could break out in the present cotton industry, would carry with itself such social dangers, whose consequences would seem unpredictable” (ibid., p.7). In summary, Supf’s sense of urgency was to spur independence and “secure and strengthen the national and societal wealth [in Germany]” (1908, p.8).

However, early attempts at cotton production, which began as early as 1886-88 (Supf 1907) in Deutsch-Ostafrika seemed doomed. Koponen (1995) describes these early failed attempts by the new colonizing power as half-hearted. Both the cultivation sites and the plants were often suboptimal to their new environments. According to him, during this period of “years of colonial apprenticeship”, the exploitation (german: Raubwirtschaft) of extracting readily available goods exceeded any gains from the plantations (p.168).

In 1902/03, the production efforts were renewed. German industries, the state

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6Supf also argued that, due to high transportation costs, primary processing of the commodity (Verarbeitung und Veredlung) should be undertaken in the colonies themselves. (1908, p.7)

7He produced a fascinating graph, based on data from Watkins (1895), which illustrates the dramatic vulnerability, as in 1860-62, prices increased by 900 percent. Supf (1908) argued that this same volatility had returned in the market due to increased consumption (and reduced production) in the US. He also highlighted, reminiscent of 21st century market trends, that “wild speculation has taken control of the cotton market”. This resulted in a dramatic increase in prices, costing the German textile industry losses of 60 million Mark, which - converted to the US currency also on the Gold standard - translated into around 15 million US$. (p.3 in Bericht II: Deutsch-Koloniale Baumwoll-Unternehmungen).

8By 1902, Dr. Stuhlmann reports in the journal Der Tropenpflanzer that four different cotton pests were sent for inspection to Germany. While they were able to identify some, the advice received appeared to be less promising: “Out of the methods known for the crop protection and eradication
and other interest groups\textsuperscript{9} argued for a renewed push for cotton cultivation, with “the main thrust in the early years of the century was clearly directed to the advancement of cotton cultivation by Africans” (Koponen, 1995, p.227). Mwanza and Lake Victoria region - part of Sukumaland - were mentioned as hopeful locations, as plentiful cattle was available and the transport of the cotton to Germany could be achieved via Dhow to Kenya and from there via the Ugandan railway to the port in Mombasa (Supf 1908, p.7).

In the following year, cotton production improved\textsuperscript{10} and the operation was expanded via the hire of a German-American cotton farmer (from Texas) as inspector. In a newly opened extension school designed for 50 (!) students, the agricultural methods taught were similar to organic methods, given the lack of synthetically available inputs. The long list of methods included:

- the improvement of soil structures via erosion controls and irrigation combined with the use of hoe, plough, and harrow
- the use of draft animals and breaking in of oxen
- proper planting of cotton and treatment of cotton until harvest
- teaching of the main cotton pests and methods to combat them
- proper harvesting of cotton, including ginning
- and the breeding and crossbreeding of cultivars. (Supf 1908, p.7-8)

\textsuperscript{9}One example was the German Colonial Economic Committee KWK founded by Supf.

\textsuperscript{10}By 1903/04, Supf (1908) reported favorable trends in production, as both small-scale production by the Sukuma and plantations were considered, with the latter preferred in Tanzania. Since the population was spread out and living away from the road at the coastal areas, resettlement was suggested for people from the interior into the coastal areas for planation production.

of the pest, the best method appears to be that by widespread occurrences all plants of the affected field be burned” (p.200). Given these rudimentary methods, keen interest continued in development of cotton. Within the same year, \textit{Der Tropenpflanzer} published the analysis of over 30 samples of cotton lint from German-East Africa. They included 13 samples of Gossypium barbadense, 11 samples of Gossypium peruvianum, 4 samples of Gossypium herbaceum and 2 samples of Gossypium hirsutum. Judged by the Bremer Cotton Exchange, the Gossypium hirsutum was estimated to be of highest quality (Tropenpflanzer 1902, p.309ff).
In addition to these new coordinated developments, Wieland - a German - made contracts with the local chief - Mteni Masana - and 145 Manquas of the region Nera, located close to Mwanza - in one of the earliest forms of private contract farming. He promised to supply them with seeds and tools, as well as organize transport, while guaranteeing to pay 4 pesa per pound. The resulting net profit was to be shared in “equal parts” between all parties involved (Supf 1908, p.12). Furthermore, he also offered a school for teaching “rational cotton production and on harvest preparation” (ibid., p.12).

Additional investments were undertaken by two German textile companies to plant 60,000 ha and 20,000 ha respectively in the region, with attempts at improving cotton quality via planting Egyptian cotton. Throughout the first decade of the 20th century, Supf (1908) in his reports highlights the volatility existing in the world market and their dependence on it. The Germans tried to counteract these volatilities by offering price guarantees (p.26). Officials however warned of the perils of their limited knowledge of local pests and soils, even contrasting it to superior knowledge of local farmers.

In summary, the Germans’ endeavor to generate revenues took place under the umbrella of a resource exploitation model, which relies on generating growth by increasing production in areas perceived as holding a distinct comparative advantage vis-à-vis other production areas (Hayami and Ruttan 1985). Their original attempts at increasing economies of scale by introducing both mechanized large-scale and increasing smallholder cotton cultivation however failed due to inappropriate soil and climate conditions (Hydén 1980) or inadequate understandings of it. In regards to organic methods, even in the first intervention, basic techniques such as combating soil erosion, using oxen in the fields, crop rotation, and other post-planting techniques were emphasized. In contrast to the current operation, given the top-down approach and the limited resources to engage with the farmers, these failed to be taken up outside of a few (German) model farms. Finally, although hardly altruistic, the section has shown

11“A renewed rape of the cotton market by American speculators has resulted in a speed up of the European cotton movement, led by Germany” (Supf 1908, p.3).

12Koponen (1995, p.418-9) cites the German Governor of Tanganyika, Rechenberg, who stated that the locals had developed knowledge and skills to properly use the soil.
how a clear concern for providing a secure income via purchasing and price guarantees, as well as subsidized inputs, was already present in a global yet highly volatile cotton market.

**Motivations and Cotton Production under British Rule**

Inheriting Tanganyika from the German under a League of Nations Mandate in 1919, previous production was initially undertaken either via plantation methods or by European farmers themselves. Drawing on Schuknecht (2010), there are four main motivating factors that reveal the interests at hand in pushing for increased cotton production during the inter-war period, not among plantation owners, but rather smallholders.

First, from an agronomic perspective, it was perceived that cotton was a “comparatively drought-resistant and profitable annual crop” compared to other available options (Schuknecht, 2010, p.52). This was especially true in the context that it was already successfully planted in the area after the Germans undertook several failed trials in many other regions.

Second, similar to the Germans motivations, there was intense lobbying efforts to reduce dependence on cotton from the US. A major British textile manufacturing lobbying group - the Empire Cotton Growing Corporation - visited the area in the early 1920s. Its representative argued that “cotton can be established as the leading economic crop in Tanganyika” (Hastings Horne, 1922, p.5-6, as cited in Schuknecht, p.52).

Third, not only was increased cotton production aiming at reducing dependence upon American imports, it also was desirable as to increase consumption of British products abroad. A fourth and final motivating factor was the need to increase revenue within the colony itself since the ‘unwritten rule’ was fiscal independence or self-sufficiency. Cotton exports would be taxed, exported for a fee via the railroad lines, stimulating imports and purchases of British goods.\(^\text{13}\) (Schuknecht, 2010, p.50ff)

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\(^{13}\)Although plans existed to also undertake European-owned ginning, the profit margins were minuscule and subsequently left to the Asian entrepreneurs.
In summary, the motivations for British production followed in the German footsteps. The push for establishing cotton as the primary cash crop\(^{14}\) consequently intensified, shifting from plantations and contract farming towards small-holder production.\(^{15}\) This move was successful, as within five years of taking on the League of Nations Mandate, Tanganyika already exceeded the German production. In the Mwanza Province north of the Shinyanga region, it reached nearly 1.8 million pounds in 1923 and peaking at 4.3 million pounds in 1926 (Austen, 1968, p.271, as cited in Schuknecht, 2010), before decreasing in the late 1920s and reaching 18 million pounds by 1936 (McLoughlin 1995, p.85, footnote 10; as cited in Schuknecht, 2010, p.59). This increased production, however, coincided with a perceived rapid increase in cattle and human population, raising fears that Sukumaland was steering towards an environmental crisis, culminating in the Sukuma Development Plan.

Similar to the market volatility experienced by the Germans in the early 20th century, the Great Depression revealed vulnerabilities all too common place in the modern era. While it took a full ten years from 1929 to 1939 for the export earnings to recover to the previous levels, the British expressed their fears that cotton producers might retreat from the production due to these vulnerabilities. A report to the League of Nations in 1939 (as quoted by Schuknecht, 2010, p.56) highlights this worry:

“The reaction of the African to price fluctuations differs fundamentally from that of the European on account of the fact that the African is not usually dependent on a cash economy. Unless he receives constant encouragement the African is apt to become discouraged by a fall in price and to reduce rather than to increase his plantings for the following season. This may

\(^{14}\)In the 1920s, cotton however remained of lesser importance than cash crops in other areas (such as coffee in the Bukoba or Kilimanjaro region). Schuknecht consequently describes Sukumaland during that period as still a “subsistence economy with limited production of crops for the market and a pastoralist element.” (p.55) Besides cotton and coffee, Tanganyika’s economy was heavily dependent upon sisal as its main source of export earnings. Together they made up more than 70 percent, with cotton around 15 percent, and sisal nearly 45 percent (Havinden and Meredith, 1993, p.183, as cited in Schuknecht, 2010, p.55).

\(^{15}\)The Sukuma mostly grew cotton to pay for taxes, as well as to avoid wage labour on plantations. Large scale cotton planting was limited to a few chiefs. Recalling their ability to command labor with the strengthening of their powers, Iliffe (1979, p.291; as cited in Schuknecht, 2010, p.54) found that 76 percent of the cotton in the Shinyanga District was grown by chiefs using tributary labor in 1923.
well be the correct reaction in order to improve the price by reducing production and thereby increasing demand but unfortunately other primary producers elsewhere do not follow his example and the sole result may well be that his cash returns are so far reduced that he is not able to purchase necessities such as clothes and hoes.” (p.31-32)

Schuknecht interprets this fear as “[resulting] less from their concern about the material well-being of ‘natives’ [...] but rather from the fact, that any reduction of production of export crops would have a negative impact on the revenue prospects of the colonial state.” (2010, p.56) The perceived solution, consequently, was the improvement and subsequent stabilization of the marketing system by cutting the middlemen and attempting to increase producer prices. This was undertaken by “granting buying monopolies\textsuperscript{16} in certain areas to large firms which were involved in their primary processing and export. Another effort of increasing production in the face of price volatility was to directly target the farmers themselves via increased presence of extension agents.\textsuperscript{17} These interventions display how already prior to the arrival of bioRe, obtaining a steady supply of cotton was a key concern, with price controls and extension services acting as key instruments.\textsuperscript{18}

The nature of these top-down interventions, including compulsion coupled with unintended consequences of actually reducing cotton prices, resulted in resistance. Katama (2005) cites a popular Kisukuma song from the 1940s that illustrates how people were contesting and resisting the push for (intensive) cotton cultivation under the British by sharing a story recounted in Ukiriguru, Kwimba District, on how the local chief

\textsuperscript{16}It was believed that this would lead to the stabilization of producer prices, thus providing a constant incentive for producers to maintain production.” (p.56-7). The plan however backfired, as prices actually decreased due to the elimination of competitors.

\textsuperscript{17}Developed by the Director of Agriculture, Ernest Harrison, and dubbed a ‘Plant-More-Crops’ campaign, it stressed that “the level of production could be easily raised by exerting more pressure on the native cultivator whom they regarded as notoriously lazy and underemployed.” (Schuknecht, 2010, p.57). Beyond propagating increased production via an additional 160 extension officers, it also included the exertion of pressure through the local chiefs and the usage of propaganda and education efforts.

\textsuperscript{18}Although the parallels are strong to the efforts of bioRe and organic contract farming, the limited qualitative research undertaken highlights how few farmers would be expected to make these historical associations.
Ng’wandu cooked cotton seeds for lunch for the visiting British agricultural officer.\textsuperscript{19} Other active practices of resisting the push for cotton cultivation included the boiling of cotton seeds prior to planting so they would fail to germinate.\textsuperscript{20} Focus groups, which included a semi-structured interview with an elder, revealed additional stories of resistance. The most popular surrounds the usage of farm yard manure. Section 3.2 discusses the usage at much greater length. What is worth noting is that prior to the arrival of the Europeans, especially the British, no recollection existed regarding usage of farm yard manure. Having witnessed it personally under British rule, one participant explained that people were instructed to put a stick in four corners of the plot. The length of the plot should be 70 by 70 meters (or steps), or approximately one acre. Manure had to be filled up to the level of the stick, which could be as high as 3 feet. One form of resistance was to move the sticks closer together.\textsuperscript{21} According to the elder, “people were not interested with cultivating”, which was why they were reducing the size (Focus Group Mwamishali 2011). This form of resistance was confirmed in another focus group in Mwamanongu.\textsuperscript{22}

\textsuperscript{19}The shared story was captured by Kamata (2005, p.76):
- Nchilu Bulačka alitudanganya abanhu waluha / Nchlu Bulacka is cheating and causing us trouble
- Kupwjiwa kumalugulu kuja kunsilili / we are chased from the hill top to the slopes
- kulima maduta, kulima buluba / to cultivate ridges and grow cotton
- mungu twambilijage (x2) / help us god
- Bengeleja bashoke gukaya / send the British back home
- Kuhadikijiwa kufumila mabuluba / to be compelled to grow cotton
- ng’weji gwa miili / the month of december
- utemi ng’waya ng’wana ng’wandu, Chief Ng’waya ng’wana ng’wandu
- Ubagema ba wana shamba kubalisha mabuluba / tried to feed extension officers with cotton seeds
- akatulwa nho (x2) / he was severely beaten
- akaliwa ma faini / and was heavily fined
- akoya na koya / he never dared again.

\textsuperscript{20}Katama (2005) also cites a more recent example of a Regional Commission from Mwanza, who admitted on BBC Swahili in 2002 that “they had to ‘force’ every household to grow two acres of cotton” (Katama, 2005, p.162).

\textsuperscript{21}This point of discussion caused a lot of laughter amongst the group, which included besides the elder four younger farmers.

\textsuperscript{22}Another method was to take the sticks and put them more into the ground so as to lower the
Similar to current organic operations, improvements in extension services rarely translated directly onto the ground. Saylor (1970) studied the effectiveness of yield increased due to the creation of an extension service during the main period of the Sukumaland Development project, which ran from 1946 to 1959 and cost more than a half a million pounds over this duration (Saylor, 1970, p.15). Although reliable data availability was scarce,\textsuperscript{23} he finds both cotton yield and output to have increased significantly (see Figure 4.2).\textsuperscript{24}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{cotton_production.png}
\caption{Cotton Production Statistics Based on Saylor (1970)}
\end{figure}

The main methods - enforced via legislative order - were on “ridging, planting of cassava, intercropping of food crops and cotton, manuring, plowing, soil conservation, and forestry”. In addition, the scheme included “large scale mechanization trials, ran demonstration plots and farmers drilled boreholes, improved roads, set up stock multiplication units, etc.” (ibid., p.15). Although the interventions were diverse, increasing

\textsuperscript{23}He states that the only reliable yield estimates would be from 1950 (310 pounds per acre) and 1964 (500 pounds per acre) when a random sample of 1 % of the farmers was undertaken. In other years, the yields were simply evaluated by observing the fields and guesstimating a yield.

\textsuperscript{24}Although he estimates that extension services impact these yields with a lag of around five years, exact lengths (or linkages) are more difficult to calculate.
cotton played a central role in the “ultimate aim” of relocating people to open up new areas and increase the acreage under production (extensification), while soil fertility was to be enhanced in the older areas (intensification) (ibid., p.15).

Schuknecht (2010) however points out that although the outcome might have been desirable, the methods and means were based on unplanned developments.

As a whole, efforts at intensifying production were rarely successful, which are similar to the challenges outlined of bioRe. Cotton production nearly tripled in the early 1950s in the Lake Province due to extensification of production, with farmers responding to price signals, but also to the formation of marketing and producers’ cooperatives.

“[...], a detailed analysis of the causes of the boom reveals a more complex picture. It is argued that increased production was mainly due to the initiatives of Sukuma cultivators who responded quickly to improved market conditions and that ‘development’ often occurred on different lines than anticipated and desired by colonial developers. Rather than increasing output per acre through the adoption of labour-intensive farming methods, Sukuma peasants opened up new land, integrated new mechanical implements - most notably ox-drawn ploughs - on a large scale into their ‘traditional’ system of agriculture, increasingly employed labourers against wages or drew more extensively on already established forms of communal labour. Thus, Sukumaland witnessed a remarkable process of agricultural expansion which was to a large extent due to African rather than colonial ‘development’ initiatives and confronted colonial experts and administrators with a major dilemma as it vividly illustrated that it was impossible to achieve and enforce soil conservation and increased production at the same time” (Schuknecht (2010), p.40).

The Lake Province in Tanzania compromises the five administrative districts of Shinyanga, Maswa, Mwanza, Kwimba and Geita. Based on estimations from Malcolm (1953), about one million of the population were Sukuma (Schuknecht 2010, p.44). The Meatu district from the research area was not denoted on the map as one of the 49 existing chiefdoms, which were joined post-WW II by the British to form a federation in order to more easily manage the area via indirect rule (p.45).

In the post-WWII setting, the state-controlled marketing was relaxed by the British. Schuknecht however notes that “the creation of cotton cooperatives in Sukumaland was not due to colonial development programmes but rather to the aspirations of a newly emerging African commercial elite that sought to eliminate Asian traders from the market and managed to mobilise parts of the peasantry for their scheme” (2010, p.41). While the state was initially suspicious of the rapid rise of these cooperatives, it aided in their fusion into the Victoria Federation of Cooperative Unions in 1955, which “monopolised cotton buying within the Lake Province and even started to challenge the dominant position of Asian entrepreneurs in the ginning sector” (ibid., p.41). This cooperative became the largest in the whole of Africa (Hydén 1980, p.59). By 1959, the cooperative reached monopoly status over a period of only six years, partly due to the perceived high levels of economic exploitation through the taxation (by the British) and marketing of cotton (by Asian traders).
3.1.3 Postcolonial Developments in the Agricultural Sector

Post-independence is broadly structured into the period of *ujamaa* under Nyerere’s rule, and the subsequent period of economic liberalization after leadership changed under then-President Mwinyi. While prior to liberalization, farmers were pushed towards producing cotton under an inefficient subsidized production regime, after liberalization the share of prices obtained by producers increased, with farmers diversifying production away from cotton depending on changes in price and taking advantage of other opportunities.

**Cotton under Ujamaa**

Under *ujamaa*, the villagization campaign was created by Tanzania’s first president, Julius Nyerere, in his attempt to foster rural development based on local traditions of respect, common property and an obligation to work (Hydén 1980, p.98). By creating clusters of production (which later were forcefully created via resettlements (Scott 1998)), the goal was to increase economies of scale for higher production (Hydén 1980, p.101). This included the establishment of a domestic industry to foster the export of processed rather than just raw goods (Bates 2005, p.23). Potential benefits of *ujamaa* villages included that farmers had better access to advice by agricultural extension officers (who wouldn’t have to walk that far), with less labor spent on grazing, as animals are taken care of by few men and their children. Furthermore, farmers would have access to ox ploughs or even tractors, thus enabling improved production (Ntulo 1977).

While the *ujamaa* policy is widely regarded as a failure\(^{29}\), Nassor (1996) provides specific evidence looking at cotton as he studied the impact of villagization in the 70s (and recovery programs in the 80s) on cotton production between 1950-1994. The analysis is done via the creation of a dummy variable for the villagization policy and the economic recovery programs, where the total quantity of cotton supplied by farmers

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\(^{29}\)Although around 50 percent of the entire population was displaced onto new lands that were either too removed from essential needs (firewood and water) or promised free services (education, health care), the attempt at creating (communal) clusters of development failed (Ponte 2002, p.45ff).
in a given year is modeled.\textsuperscript{30} Nassor (1996) finds both dummy variables significant: on average, the positive impact of the economic recovery program was 110,823 tonnes per year, whereas the supply of cotton during the years of \textit{ujamaa} was on average reduced by 63,000 tonnes per year (Nassor, 1996).

What is illustrative from the findings is the importance to understand the alternatives to cotton production. Katama (2005) cites work by Limbu who showed that “whenever rice production increased it negatively affected the production of cotton” (Limbu, 1997, p.11, as cited in Kamata 2005). Although rice was historically produced in areas that were not suitable for cotton production, post-independence the lines between these two commodities became more blurred. Kamata (2005) gives the example from 1968, where ministers expressed worries that rice (paddy) harvests increased by 49 percent, while cotton decreased by 28 percent.\textsuperscript{32}

Another goal of the \textit{ujamaa} policy was to strengthen the processing industry. For cotton, this involved building up a domestic textile industry. By the end of 1970s to early 1980s, this industry made up the “largest manufacturing sector in Tanzania in terms of employment and second largest by gross value of production. It employed

\textsuperscript{30}The independent variables considered are the producer price for cotton in that year (as well as the price of rice, a competing cash crop in Northern Sukumaland) as well as the average rainfall in that year (which was not significant). To capture year to year change, the quantity of cotton supplied in the previous year was included (and significant), in addition to a time trend variable which should capture such variables like “technological development and increase in population engaged in cotton production” (Nassor, 1996, p.14). This latter variable was also significant, as year over year, cotton did increase by 6,300 tonnes. Not entirely surprising, cotton price of this year does not impact cotton quantity sold, which is expected given that farmers plant well in advance. The difference in the change between the cotton and rice price however does matter (Nassor 1996). This is confirmed by Kisonga (2004) who finds cotton production to be positively influenced by own producer price as well as the competing producer price.\textsuperscript{31} This significant interaction between cotton and rice, although not applicable to our study (given that only one out of the 6 villages has limited rice cultivation), does highlight the interplay between the price of mungbean and cotton in our case.

\textsuperscript{32}Similarly, between 1991/92 to 1997/98, rice production increased even in Shinyanga from 63,500 tonnes to 190,500 tonnes, while in Mwanza no increase was recorded (Kamata 2005). In a telling experience, on the way to a meeting of organic advocates at Oxfam headquarters in Dar es Salaam, we walked across a poster in the lobby that portrayed rice as the ‘white gold’ in Shinyanga. Looking at the Oxfam UK homepage, we see that in Shinyanga, this is the main focus: \url{http://www.oxfam.org.uk/shinyanga/}. The statement itself is provocative, emphasizing a crisis where no or few viable alternative income sources exist, while making reference to the traditional cash crop of cotton. Also, there might be unintended consequences of increasing rice production in Shinyanga. Since it is important to note that this conflict exists less in Meatu, it however does have an impact, as seen in the 2010/11 purchasing season, where the total cotton output in Tanzania was significantly lower, thus resulting in increasing pressure by buyers to enter Meatu and search for the cotton there. This caused significant difficulties for organic operators to get their farmers not to side-sell their coton. However, conversations with BioRe staff indicated that this does not seem to be a problem from their experience.
about 25 percent of the manufacturing labour force and contributed about 25 percent of the GDP by the manufacturing sector” (Kisonga, 2004, p.24). By the 1980s, prior to liberalization, there were more than 30 mills - 80 percent of which were state-owned - with a capacity to spin 50,000 tons of yarn (Kisonga, 2004). The apparent success of these mills, however, was mostly based on government interventions (subsidies and protections), with the industry running into a rapid demise.

**Cotton under Liberalization**

Emerging into the 1980s with an unsustainable debt load, a weak export sector and increasing inability to obtain oil or further credit, Tanzania (under the new leadership of President Mwinyi) consequently agreed to implement a sequence of structural adjustment programs (Ponte 2002). These reforms included: radical privatizing of government services (especially parastatals); eliminating market barriers to imports (Shivji 2006); creating improved fiscal policies for (agricultural) exports (Ponte 2002); and increasing attractiveness for outside investors by freeing capital flows (Schroeder 2008b). As a whole, these structural adjustment policies have (at least in the short run) satisfied the desires of the international finance and donor communities and improved Tanzania’s economic growth figures and statistics,33 with Tanzania having become a recent darling for international investment (see example of South African investors in Schroeder 2008b).

Post-liberalization, the radical privatizing of parastatals resulted in all but three textile mills continuing to exist after 1994/95.34 Based on Maro (2000 cited in Kisonga 2004), we can identify three reasons for the decline include: First, having not enough supply of lint to run the mills profitably, as post-liberalization the cotton no longer had be processed domestically. Second, there was a sharp increase in competition from (second-hand clothing) imports. Third, even if wanting to run at full capacity, production was undermined by constant power cuts and interruptions, which proved

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33Inflation, one of the main ‘goals’ of neoliberal policies was reduced to single-digits from a high of over 30 percent in the beginning of 1990 (Cooskey 2004).

34The managing director of bioRe Tanzania was a former manager of the largest textile mill in Tanga, Tanzania, prior to his start with bioRe in 1995.
too costly (especially when having to invest in and maintain generators).\textsuperscript{35}

Another consequence of liberalization was that the cooperative societies and unions that held a monopsony until the late 1980s, marketing 100 percent of the cotton, came under considerable pressure. By 2001/02, this percentage has dropped to 10 percent. However, regional unions are still owners of several ginneries, although many of them being over 30 years old and in need for a much-needed repair. The reason for the demise to four cooperative unions included the high operational costs, weak management, lack of savings, and rapidly declining support amongst the community (Malosha 2008). To fill the void, private sector buyers have increased dramatically from 10 in 1994/95 to 54 by 06/07, gaining a market share from 9 to 95 percent (Malosha 2008, p.13).

Figure 3.4 depicts the gains in cotton production since 1985. It has changed considerably, with the only clear trend in the increasing grower price per kilogram of seed cotton.

\textsuperscript{35}An issue that still is plaguing the economy to this date.
Figure 3.4: Production Figures since 1985 of Cotton in Tanzania (Tschirely et al. 2009)
For a while, cotton production was the exception. In 1984 the ban on cooperatives was lifted. Farmers began receiving again input support and production (including yield) reached record levels (see Figure 3.4). However, the same inefficiencies and mismanagement that plagued cooperatives earlier continued to create havoc and it was only a matter of time before they would fail to obtain credit to finance their losses (Gergely and Poulton 2009). By 1994, consequently, the government began large-scale liberalization and allowed private traders to enter the cotton market. On a whole, as of 2000, 258 parastatal organizations were (successfully) dissolved (Ellis and Mdoe 2003).

Interestingly, a recent World Bank publication argues that Tanzania – out of all major cotton sector in sub-Saharan Africa – is not only the most competitive, but also marked by too much competition (Poulton et al. 2004; Tschirley et al. 2009; see Figure 3.5 on page 82). After liberalization in 1994/95, an astonishing 28 cotton buyers surged into the free market, spurred by high international cotton prices (Poulton et al. 2004; see also the upper-right hand side of Figure 3.4). While this resulted in an initial boom in production due to higher producer prices, the overcapacity in ginning and fierce competition amongst traders led to the collapse of early input-supply schemes (due to problems of free riding or side-selling associated with a lack of monopsony power; see

36 As shown in the lower left-hand graph in Figure 3.4, total lint production, after increasing from 45,000 tons in 1984 to a peak of 80,000 tons by 1987, declined again to old levels by 1990.

37 The story is fairly complex, as not only government attitudes within Tanzania have shifted against further liberalization (Cooksey 2003), but also inequality itself has increased in the aftermath of the dissolving of the parastatals, with former land assets being acquired by powerful officials, who often times found employment within the same (although privatized) business (Ellis and Mdoe 2003).

38 After liberalization of the cotton sector in 1994/5, Gibbon (1998) undertook a survey in its 4th year to find its impact on the seed cotton marketing season of 1997/8. He finds that in the immediate year after liberalization, cotton production (as measured in cultivated area under cotton) increased substantially. With the monetization of pesticide and fertilizer inputs, production yields however failed to increase in subsequent years. This he attributes to a “failure to shift toward more optimal farming methods, and a significant decline in non-labor input use.” (ibid., p.1). Somewhat surprisingly, although private traders are offering higher prices, primary cooperative societies continue to have a large market share, “partly based on their retention of effective monopolies in certain geographical areas” and loyalty (ibid., p.1). Foreshadowing, he was cautious about their future viability: “Their ability to retain market share seems likely to weaken as the years pass, since with credit-based input supply no longer being undertaken, loyalty will lose most of its rationale. In addition, cooperatives may experience falling purchases as a result of failures of liquidity and a further decline in price competitiveness.” (ibid., p.1) . Kisonga (2004) found that farmers are responsive to changes in cotton prices in terms of their planting strategies.
The intense competition also sped up a deterioration in purchasing standards, thus leading to a painful quality decline of Tanzanian cotton overall. The historic premiums that cotton received on the international market have subsequently been forfeited. It is within this context that greater coordination, as opposed to competition seems in order, especially if one is adamant about stimulating stable production volumes through the provisioning of inputs, extension service and especially research into improved seed development (Tschirley et al. 2009).

In summary, with an estimated 80 percent of Tanzanians continuing to depend on agriculture for their livelihoods, recent reform efforts have tried to increase their share of the producer price through increasing competition and liberalization. Although more politically sensitive sectors have not gone as far, liberalization in the cotton sector might have gone beyond healthy levels of competition, as the status and yield of the cotton has slowly been degraded over the last decade (see the lower-right graph in Figure 3.4 for yield). It is within this context that many development policymakers as well as private businesses continue to look for a pathway towards increasing output and reducing poverty in Tanzania.

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39 Beyond the cotton sector, Dorward et al. (2004) find that a key element of future pro-poor agricultural policies include a “rejection of simplistic presumptions that pure competition is always the most satisfactory form of market development” (p.89).

40 The volatility within the sector in terms of total production seems especially large, given that farmers are relying on extensification and tend to plant less cotton in years of expected low market prices.
Agriculture after Liberalization

In the agricultural sector, as depicted earlier, the picture is uneven. According to Cooksey (2003), the initial reforms after 1985/6 resulted in improved farm gate prices for producers due to the devaluation of the currency (thus making exports more attractive) and the removal of the parastatals’ and marketing boards’ monopoly on crop marketing. The Tanzanian consumers, furthermore, had readily available access to basic consumer goods thanks to import liberalization, and between US$5 to US$15 million taxpayer money was saved annually with the ending of fertilizer subsidies (Cooskey 2003; Shivji 2006). From a crop perspective, maize was perceived as a success story as output has grown parallel to demand at 2.4 percent annually (Cooskey 2003, p.71). Furthermore, while the removal of the input subsidies had a negative impact on farmers in other crops, due to the fact that they previously tended to just reach the larger farmers in the first place, it failed to have a strong negative impact on small-scale farmers (ibid.).

At the national level, neoliberal policies however are believed to have enlarged existing inequalities and vulnerabilities (Ellis 2006; Ellis and Mdoe 2003), and introduced insecurities into both input (Cooksey 2003; Ellis and Mdoe 2003) and land markets (Schroeder 2008a; Schroeder 2008b). The argument is that although the policies ‘got the price right’ (as seen in the improvement of cotton prices), it resulted in ‘getting just about everything else wrong’ as qualities and yields have deteriorated and a lack of agricultural research and credit provisioning systems have become bluntly apparent.

After the implementation of the first structural adjustment packet in the mid-1980s, agricultural production (as measured in net per capita production) declined markedly (see Figure 3.6). This fall of agricultural production is associated with the radical restructuring that took place under the first wave of liberalization.

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41 This is especially more worrisome given the recent global food crises and continued decline in international, non-proprietary agricultural research funding (i.e. CIGAR) that have been the main source for improved agricultural innovation in developing countries.
Figure 3.6: Decline in Agricultural Productivity per Capita from 1960 - 2007
Ponte (2002) argues that in the first years following the structural adjustments in the early 1990s, farmers spent more on cultivating their crops, risking more in marketing their crops, while earning less from their sales. This was confirmed by Havenik (1993 cited in Ponte 2002), which showed that contrary to the objectives of structural adjustment, the increase in crop producer prices has not kept up with the increase in prices of consumer goods and agricultural inputs. The liberalization resulted in an increasing commercialization of rural life: people need cash inflows at several times throughout the year. They consequently did not switch from food to export crops, as was expected by the World Bank, amongst others, but rather away from what he terms ‘slow’ crops to ‘fast’ crops.

These fast crops, which include tomatoes, beans and bananas ensure repeated and faster returns to investments in capital and labor throughout the agricultural season. Ponte (2002) however cautions that even farmers who sell these crops do not have higher net earnings per se. Another form of diversification is to work off-farm, although this ability is limited in rural, peripheral areas. It has allowed rural households to spread their risk and access alternate sources of income or savings. It also counter-balances the risk involved in ‘fast crop’ cultivation due to the high perishability and price volatility of the crops involved (Ponte 2002). In Meatu, these diversification options however are historically limited, given the low level of rainfall observed. In neighboring Kagera district, a study by de Weerdt (2010) showed that farmers who diversified away from traditional crops and were able to obtain income outside of farm activities fared the best.

Regarding inequality, Ponte (2002) finds that due to tightening labor markets resulting in difficulties to secure labor, social structures are increasingly deteriorating and the most marginalized are placed in a weaker position. In summary, he finds that

42 Fieldwork has shown that it are farmers with access to irrigation equipment that can take advantage of these opportunities, such as tomato.

43 In the words of Ponte (2002)

“Commercialization of rural life entails a gradual but steady passage from social networks to contracts, from reciprocity and redistribution to market mechanisms, and from public to private resources of well-being. Substituting social negotiations with contracts prompts a further round of commercialization, which breaks down more social ties. Weakened
rural households that have strong economic ties and access to major markets were more likely to be successful in improving their livelihoods through diversification than their more isolated counterparts (Ponte 2002).

This section has revealed that farmers are benefiting from higher producer prices, yet possibly are more exposed (due to deteriorating social networks or greater dependency on markets) to market volatilities. While in Meatu district, due to the lack of rainfall, diversification in cash crops is limited, a key focus of the research has to be on investigating which crops exist that farmers are able to take advantage of in addition to who those types of farmers are. An interesting question to observe, consequently, is to see whether or not farmers are responding to the higher or lower cotton prices in their production decisions, which would indicate reduced dependencies compared to the pre-liberalization period.

3.2 History of Agricultural Production

One of the key findings from the previous section is that although German, British and Tanzanian interventions aimed at increasing productivity via improved production methods, they largely failed as improvements were undertaken mostly via extensification - increasing planting area. This section illustrates the history of agricultural production in general, with a focus on traditional agricultural methods in a comparative context of organic agriculture. The key argument is that although farmers in Tanzania were mostly practicing slash and burn methods, traditional agricultural practices did include intensification methods similar to organic agriculture. Section 3.2.1 first provides an overview of the type of agricultural production that took place outside of cotton, before

social networks and more difficult access to public provision of social service mean weaker safety nets. Therefore poorer households are likely to become more vulnerable to natural disasters and economic shock.” (p.164)

44 Koponen argues that although the agricultural system did change over time, it can be described as a traditional African agricultural system since it was only “marginally affected by long-distance trade” (p.236).
engaging in a review of intensification prior and after the colonial experience.\(^{45}\) The goal of this section is to also highlight the diversity of agricultural goods produced in the area, as well as the limitations. Section 3.2.3 deals explicitly with cattle and their role in agricultural production and Sukuma society. The research is completed by paying explicit attention to the role of geography in section 3.2.4 and culture in section 3.2.5.

### 3.2.1 Traditional Agricultural Production

Pre-colonial production mostly focused on the planting of a variety of grains of African origin, such as millets or sorghum. It was towards the turn of the 19th century, that maize (which yielded more under good growing conditions) was becoming more widespread (Koponen, 1988, p.225). Introduced via Zanzibar-based long-distance trade that increased in mid-19th century, other non-African crops included rice, cassava, sweet potatoes or other legumes, such as peas and beans. In many parts of Sukumaland, groundnut was a major crop (ibid., p.226). These crops were mostly intercropped, which according to Koponen (1988) can be “regarded as one of the major inventions in African agricultural methods” (p.227).\(^{46}\) Precolonial agricultural production in the area seemed to be thriving.\(^{47}\)

\(^{45}\)Koponen (1988) makes an interesting distinction from Schuknecht (2010) on the classification of the production methods of the Sukuma people. While Schuknecht (2010) is describing their production as mixed agriculture, implying an integration of cattle with agricultural practices, Koponen (1988) classifies them as agropastoralists. By this, he means that in their “economy both cattle and agriculture were essential but not closely integrated” (Koponen 1988, p.245).

\(^{46}\)He cites Paul Richards who asserts “intercropping as ‘one of the great glories of African science’ that was ‘to African agriculture as polyrhythmic drumming is to African music and carving to African art.’” (Koponen, 1988, p.227). The benefits listed by Koponen include the creation of shade, which limits exposure to the sun and rain, thus reducing erosion. Furthermore, lacking pesticides, the occurrence and spread of pests and disease was limited as neighboring plants were not the same. The different requirements for soil nutrients by the plants resulted also in a more balanced use of soils. (p.227)

\(^{47}\)According to Stanley’s report on February 11th of a stop he took at Mombiti in Sukumaland, “visitors from all parts of this populous neighbourhood came to Mombiti with millet, small potatoes, sesame, tobacco, pot herbs, goats, honey, et cetera, for sale where they found a ready market with our half-starved people” (Stanley, 1961, p.55). On his entry on February 19th, he described with great enthusiasm the scene observed in Wandu, which is in Sukumaland:

“We soon came in view of the beautiful and picturesque plateau which now replaces the low hot plains through which we lately travelled. Thickly dotted with massive granite blocks piled up in rugged knolls and hills, or rose up in rounded clumps [sic] while between and all around were well cultivated fields, herds of cattle grazing on the short sweet grass - it was a scene of scope and beauty such as we had not met with before, and it made a vivid impression on us all for its novelty and beauty. […] Villages were numerous, and
Cory (1970) describes their agricultural methods as “extensive rather than intensive, [with] population pressure being met by emigration to sparsely populated areas.” (p.4) He however adds - in what appears to contradict later British policies - that the “peasant has always had a good name as a cultivator of the soil” (p.4). From the work by Rounce (1949) on “The Agriculture of the Cultivation Steppe of the Lake, Western and Central Provinces”, he quotes at length:

“At certain seasons of the year they will work very hard indeed in order to obtain little more than a subsistence, when with careful planning and forethought they could obtain much greater returns. There is however such a wealth of sound knowledge and power of good judgment of agricultural matters held by the average native of the cultivation steppe, that if he was once given the lead, and his extreme conservatism broken down, the possibilities of his development would be very considerable.” (as quoted on p.4 by Cory 1970).

3.2.2 Intensification

One example of intensification is ridging. It was reportedly widespread in fields across Sukumaland.48 The best known intensive cultivation system in the whole of Tanzania existed at the northern edge of Sukumaland’s extent on the small island of Ukara in Lake Victoria (Koponen 1988, p.235). Their system was intensively studied by colonial scientists and visitors and became a model for a subsequent push for intensification across the southern plains. The Wakara people who inhabited the island combined “green and

all surrounded by milkweed hedges leaving lanes to which clung the sweet breath of the cattle whose route to graze lay between them.” (Stanley 1961, p.58)

On February 22nd, at a halt at Abbadi, Usukuma, he describes that the “[h]erds are numerous, the wide, open, green plateau is whitened by their immense number. The villages are clusters of cone-huts surrounded by manifold hedges of milkweed [. . .]” (ibid., p.59)

48According to observations by British colonial officer, “ridges made it possible to aerate and weed the light tropical soil without stirring it too much or resorting to the arduous process of digging. The ridge served equally well as a drain under waterlogged conditions, and as a water retainer under dry conditions. And it was a handy method of green manuring, i.e. returning the organic matter from weeds and legumes into the soil” (Koponen 1988, p.224; drawing on Rounce 1949). The practice also was integrated well into an interannual cycle, with the ridges turned over into trenches after each year.
dung manuring, irrigation, intercropping, crop rotation and proper terracing” (ibid., p.235). All this intensification was taking place without recourse to improved seed varieties (mostly bulrush millet and groundnuts), nor improved iron tools (i.e. ploughs) (ibid., p.235-6), and included irrigation and tree nurseries.

According to the history collected with two elders and in three focus groups in Meatu, the application of farm yard manure, as an example, was said to have been unknown to them prior to the arrival of the colonizers. An elder from a lineage of Sukuma chiefs stated that back in late 19th century, the land was so fertile that nobody was taking advantage of it. He attributed it also to the beginning of English colonialism specifically mentioning the year 1919, which was the first year under British rule: “The origin is the whites”. According to him, there were few incentives in engaging due to the shifting cultivation, as the land was good (plentiful) and Meatu consisted of a “big forest at that time” (Interview with Elder, Sanga-Itinje).

In summary, although intensification methods, such as ridging or even applications of farm yard manure are known in areas north of Meatu, no traditional knowledge of it appears to have survived. The push for organic methods focusing on increasing soil productivity via the application of farm yard manure, consequently, needs to be put in a context where farmers - if the historical knowledge exists - view it as an extension of previous top-down interventions. Lack of adoption also should be viewed in the

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49 This system was able to sustain a dense population of 300 people per square kilometer and even produced a surplus that could be marketed beyond the island. As remarked by a German visitors, “the whole area of the island is utilized, nowhere is fallow land (Koponen 1988, p.235)

50 In the village of Mwamanongu, farmers stated upon asked whether or not they ever used farm yard manure, that they were “told from elders that formally they were not using FYM. Because even when [inaudible] the white man came and the man took those things and gave the Sukuma something [knowledge on FYM].”

51 Specifically asked in regards to Meatu, he recalled the death of Bagome in 1949, who was the local leader and how the whites instructed to use it.

52 This last point was a question asked by a focus group member to an elder participant in Mwamishali. He was wondering why the knowledge of farm yard manure and how to apply it was not passed on to the next generations by the elders who have experienced it during British colonialism and later ujamaa. His response was that it was tiresome work. He later also added regarding the idea to push for FYM usage in the village plots that “[h]e saw it with open eyes [that] there was one older man who was practicing it.” When asked what the people’s reactions were, he responded that “he got good yield, but they were thinking it was degrading, troublesome work.” Another farmer added that “[that man] was wasting his time.” (Mwamishali).
relatively low pressures on land compared to the Wakara people.\textsuperscript{53}

### 3.2.3 Role of Livestock

Besides farm yard manure, other practices that were first introduced to them under the extension system implemented by the German and the British, were the integrated use of cattle and ox plough.\textsuperscript{54} Cattle often times was referred to as being the equivalent of a bank account in the focus groups and the interviews, as well as surveys (see also Dercon 1998 and Jermann 2011). Since the introduction of a formal banking system, the question was asked in Mwanyahina Focus Group, whether or not there was a difference in its usage. Farmers argued that with cattle, it is also a status symbol, “because anyone can know and [...] see.” This contrasts with a bank account: although “even [a] bank account you can know [if a neighbor has it], but we can not know how many shillings or your account number.”\textsuperscript{55}

Although increased cattle ownership naturally would result in greater availability of farm yard manure and likelihood of intensification, often the reverse is the case. This is due to the large amount of cattle held and the lack of keeping them in a kraal. Rather, due to shortage in grazing lands, they are often sent far away for herding and can even delay cotton planting in case of a late return. Consequently, their primary role, as opposed to the case of bioRe India (Eyhorn 2005) is as an income source, bank account and a status symbol. These findings are integrated into the analyses to follow.

### 3.2.4 Role of Geography

Cattle also played a key role in the spatial relationships in the area. For example, a common theme throughout the pre-colonial literature on the Sukuma people is their

\textsuperscript{53}This Boserupian logic of adoptions to high land pressure is confirmed by Meertens et al. (1995).

\textsuperscript{54}As stated in Mwamanongu, “[t]hey were told even for ploughing [on how to use it] and that they didn’t even eat cattle when it died, because they were thinking it was like a man.”

\textsuperscript{55}This transparency in wealth, although having clear benefits in terms of especially social capital, also has its limitations. As stated by a younger farmer “[...] if I got 4 million [Tsh] from cotton, I can’t sleep with the money because somebody will know” (emphasis added, Focus Group Mwanahina). For a more differentiated discussion, see Chapter 7 and the decomposition of the multidimensional poverty index, which integrates more findings from the focus group in Mwanonongu.
relationship with the neighboring Maasai. Koponen (1988), in his authoritative work on the socio-economic landscape prior to the arrival of German colonialists, states that amongst the Sukuma, pre-19th century conflicts mostly existed surrounding Maasai cattle raids (p.143). Besides the Maasai, intertribal warfare existed according to early explorer accounts, including both German (i.e. Junker) and British (i.e. Stanley) explorers’ depiction of encounters with a chief called Mirambo.

Intertribal warfare, where it existed, was furthermore interlinked with the occurrence of famines. As a result, geographical patterns of settlements were clustered in its early stages, thus increasing land pressures and incentives to develop, adapt and adopt intensive agricultural methods. The two semi-structured interviews with the elders in Mwamishali and Sanga-Itinje confirmed the accounts that cattle raids were common from the Maasai. But even warfare or raids between the different Sukuma chiefs would

According to Koponen, “[t]he relationship between the Maasai and their neighbours depended essentially on the amount of cattle among the latter: the less cattle they had, the more prone Maasai were to establish peaceful, trade-based relations instead of cattle-raiding.” (p.105)

Kamata (2005) cites work by Welsh (1974, p.164), who mentions that two ‘chiefs’ were dethroned after drought affected their areas. Comparing whether or not famines were more often the cause for war or vice versa, Koponen (1988, p.171-2) finds that “war is more often given, or at least implied as a major cause of famine.” Coinciding with war was an increase in the spread of diseases.

Koponen (1988) acknowledges that it is difficult to determine the ‘original’ settlement pattern, voicing uncertainty regarding the extent of its dispersion. He however does find “a trend from more scattered settlements or smaller villages towards more nucleated settlement and larger villages in the latter part of the 19th century and this trend must be attributed mainly to war” (p.172). This is confirmed by Cory, who argues that people lived close together for defensive reasons where cattle raids by the Maasai were often (Cory 1970, p.3). Koponen specifically mentions Sukumaland, where stockades or hedges were erected to protect from slavers or neighboring tribes. He cites another researcher, Bumann, who “even met old people in Unyamwezi who remembered that the art of building stockage-like tembes began: at the same time that firearms were introduced into the country.” (p.172-3) While they kept potential intruders out, they are believed to have kept infectious diseases in, resulting in increased vulnerability to their spread. Cory (1970) cites Malcolm, who argues that:

“[b]esides considerations of soil, rainfall and water supply which influenced the location of the earlier settlements, it is easy to forget that as recently as 60 years ago, the distribution of population was still controlled to a considerable extent by considerations of security [. . .] The traditional Sukuma village was usually situated on high ground if not actually under the shadow of a granite tor. It was roughly circular in shape and protected by euphorbia hedges. Within these fortifications lived the whole village community with their stock, and the present organization of collective labour is a natural result of conditions in which it would have been dangerous to hoe alone. The arable and pasture lands of the village were in its immediate vicinity and often limited to the area in which the alarm could be heard.” (as cited in p.116).
be possible\textsuperscript{59}, although this was “very rare” (Sanga Itinje Interview).\textsuperscript{60} Land pressure however was a large motivator for migrating from the Mwanza region in the North to Meatu District. The Sanga-Itinje’s elder’s great-grandfather – who himself owned 270 cattle – migrated in search for grazing area. He was elected chief in the area when they had problems with cattle theft.\textsuperscript{61} It was with this movement into an unpopulated area that the settlements became more scattered as intertribal warfare was reduced.\textsuperscript{62} This shift away from clustered settlements and intensive practices towards scattered settlements and extensification was said to have been influenced by the arrival of the German Administration who pacified the area. \textsuperscript{63}

In summary, the spatial pattern of production seems to have had an impact on the agricultural practices engaged in. While outside threats, especially of both inter-tribal war and fear of Maasai cattle raids, were omnipresent, the settlements were clustered thus inducing intensive agricultural methods. However, as farmers shifted into formerly uninhabited areas, such as Meatu, in search for grazing land, they began to settle in scattered patterns. This reduced the incentive to apply intensification methods, as long as a security network existed to aid in case of need from wild animals attack or

\textsuperscript{59}“If there isn’t rain, they tend to disagree on the area that was ruled. So they will start to fight between the chiefs over the area”.

\textsuperscript{60}The elder in Mwamishali mentioned that he did not see it “with his open eyes”, but he gave a similar account in regards to conflicts potentially existing due to droughts and disputes over land access (Mwamishali Interview).

\textsuperscript{61}He described how they would apply secret ingredients around the kraal or the house, so no Maasai could enter.

\textsuperscript{62}He confirmed that settlements included around 10 scattered households spread over a large area. The greatest fear was an attack from a wild animal, especially lions, in which case a warning noise was made.

\textsuperscript{63}Cory argues that a shift took place from intensive towards extensive agricultural planting. Citing Malcom (1970, p.116),

“German authorities are said to have prohibited the system of land sales and individuals anxious to obtain good land began to move further afield and clear new areas. The spread appears to have been rapid and in a period of about 20 years the occupied area must have been very considerably extended. This process of expansion also removed the necessity for manuring [...]”

Doubt however remains on the potential for Germans to successfully ‘pacify’ the area as discussed during their reign, especially in more remote, less populated regions, such as Shinyanga, whose district according to Stanley did not exceed 2000 people by 1889 (Stanley, p.560). Focus groups and semi-structured interviews with elders did not reveal that the Germans would have pacified the area. Rather they would have motivated migration due to their restrictions on land sales, although the only reason mentioned was seeking more grazing pasture for cattle as mentioned earlier.
occasional Maasai raids.

3.2.5 Role of Culture

Given the previously outlined traditional importance of cattle ownership as an asset but also social capital, this section provides a better understanding of the role of Wasukuma traditions and cultures in order to explore their impact on shaping inequalities and poverty.

Koponen (1988) argues that most traditional societies in Tanzania exhibited social hierarchies. According to him

“all societies were divided at least into leaders and led, i.e. chiefly lineages, or ‘aristocracy’, and free peasant lineages. But there were also differences within these two categories; sources often refer to ‘poorer’ or ‘more well-to-do’ people. In addition, slavery and pawnship were widespread not only in the ‘new’ plantation form but within the African societies themselves” (p.377).

While social inequalities were minimal in societies based on matrilineal inheritance, he specifically mentions Sukumaland as an area where this increased differentiation took place, as “the introduction of cattle as movable wealth seems to have been a powerful differentiating factor.” (p.378) According to the focus group in Mwamishali, these hierarchies continue to exist, although the time has improved “compare[d] with the era of the chief, every person now can eat.” (Mwamishali FG).67

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64 According to Cory, the Sukuma people opposed to other tribes were not impacted by the slave trade (Cory 1970). They were often employed as porters to the coast until the construction of the railroad.

65 Although this work is not able to elaborate on gender issues, Cory did discuss that “quite a number of women have their own holdings” (p.133). While she can get access after a death or divorce, there appears “no prohibition of her acquiring land from the authority by allocation” (ibid., p.133). Nevertheless, when in a marriage, according to Cory, “[a] husband is the sole owner of all crops grown on his holding and has the right to dispose of them” (p.133). In regards to growing organic cotton and gender issues, the reader is referred to the work by Christa Suter-Schwaller on organic cotton in India and Romina Jermann on organic cotton in Tanzania.

66 This view is supported by Schneider (1979), who discusses how the Sukuma were shifting from a matrilineal, to a patrilineal heritage with the introduction of cattle.

67 The village elder pointed out that Nyerere and all that followed, were children from family of chiefs.
Outside of cattle, access to land was of essential importance for agropastoralists and according to focus groups has increased in importance, even surpassing cattle. There were several - for Africa typical - social norms in place that governed this access and counteract potential rises in inequalities. For example, there existed an overarching usufructuary right of occupancy, in which “[…] a man owns his land so long as he occupies it effectively and he therefore cannot sell, pledge, or otherwise dispose of it.” (Cory 1970, p.111). By the 1950s, land was inherited along patrilineal lines (ibid., p.111). Violations of the usufructuary right are contingent upon several agricultural practices that were designed to keep a farmer from owning land beyond his ability to use them.68

While according to Cory, no lack of insecurities in land tenure seemed to exist, as he witnessed “at present little or no land hunger” (ibid., p.111), land shortages are more common as reflected in the increase in rent payments for one acre in recent years. Furthermore, there is an increasing shortage of land for grazing, as common access to it was reduced. Finally, after ujamaa, many farmers lost access to their land holdings according to him, when the chief had a need for something previously, “he comes at my place and just takes it. For example goats. If you have a lot of cattle, it was instructed that you had to reduce the number. And it will be reduced that number and cattle would be sold. There was a limit to the number that you could have.” Asked regarding the purpose of that limit or the reasoning given, he responded by saying that “[i]t was a secret to the chief. But it was happening you have to reduce the large number of cattle […] at that time the chief was collaborating with the whites, so it was difficult to understand why we would reduce the number of cattle.” In regards whether or not these continue in the present, he stated that “because of environmental destruction, the government is advising [to reduce the number of cattle].” For a discussion of the management and development interventions by the British see the excellent work by Schuliknecht. Regarding the more recent component of government intervention, see the thesis by Ng’wanza Kamata on Environmental Change and the Politics of Control and Marginalization in Tanzania: The case of Sukumaland, which highlights the push for agroforestry by the government in a revival of a traditional grazing reserves, ngitelis. Another work for example is Schneider (1979) who talks about the Range Development and Management Act of 1964, which was first introduced for the Maasai and then extended to Sukumaland in 1967-8. “Its purpose was to convert pastoralists to a ‘cash economy’ and bring capital and management to the underpopulated range, thereby shifting pastoralism into ‘full production’. The act proposed model ranches based on government capitalization of water, rangers, etc. In short a variety of ujamaa applied to ranching.” (p.248)

68These for example include leaving extensive areas of land follow, cultivating only small areas in the plots or allowing informal access to other applicants (ibid., p.115). Two specific rules existed in regards to the cultivation methods with either labor or machinery. Regarding labor, the employment of paid laborers beyond a customary form of in-kind payment was regulated: "If, under certain circumstances, a man needs paid laborers for the cultivation of his holdings, he must ask permission of the authority before he can employ them." (ibid., p.115). Regarding machinery, “[i]f a man wishes to cultivate fields outside his effectively occupied holding with machinery, he must first be allotted the land by the authority.” (ibid., p.115)
and were limited in ownership. After the coming into power of Nyerere and his post-independence villagization scheme, not only were traditional customs weakened (with the abolition of traditional chiefs and the forming of formal political hierarchies), so was land access redistributed. The son of a former Sukuma chief interviewed for this study described how they owned a lot of land in 1962, yet lost it under *ujamaa*. However, since his landholdings were beyond the village center area where the *ujamaa* village was founded, he was able to retain some land, which they split amongst the extended family. This consequently introduces spatial inequalities felt until contemporary times, as he confirmed that “those who are a bit further have remained with their land” (Sanga Itinje Interview).

Just as informal land ownership tenures survived *ujamaa*, so did other traditional customs. One tradition that according to the elder has become more important were

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69 With the arrival of *ujamaa* (villagization) and the shift from customary to tenurial rules, few people could continue to manage or maintain their ngitelis, as people had to give up their possessions and ‘rights’ over their customary land (Kamata 2005). The 1992 presidential commission, which investigated land matters revealed continued conflicts dating back, noting that “one of the implications of the movements of people to villages was an unequal access to land.” (ibid., p.90). This factor plays a significant role as noted in our regression results, showing increasing distance away from the village center has a positive result on income per acre. This was contrary to what Nyerere emphasized in a visit to Shinyanga in 1975, where he called on people to reduce their livestock numbers, increase their tree plants, as well as cotton production, while warning against the substituting of sorghum or other drought-resistant crops with maize in this semi-arid environment (ibid.). This call for planting drought-resistant crops came a year after the food shortage in the region, which Nyerere blamed on environmental issues. According to Kamata (2005), it rather was explained by Nyerere’s forced resettlement under “opersheni vijiji”. Many people were rushed to abandon their own fields. In the words of one elder: “There was a drought that year but this was not the main problem, my family could not farm in a meaningful way, because everything that we had was destroyed in the forced villagization campaign, we were also allocated a “sabini” which was not big enough to grow anything to meet household needs. The hoe and much of what we needed for farming were also destroyed in the move” (cited in Kamata, 2005, p.159-160).

70 Given that the customary rules of land ownership still existed within the community and everybody knew who was the owner, the lack of a formal land title was not a hindrance to him. As a matter of fact, according to him, the village authority is nowadays never involved in land sales or renting agreements, as it is an informal transaction that takes place with the neighbors of the land as witnesses.

71 These include secret societies such as the *Balasi* which is a group hunting with elephants and other wild (illegally in the reserves) (interview Sanga-Itinje). Traditional dance societies were also mentioned. These include informal groups to aid in the fieldwork amongst members. According to Cory, these include the Buyeye and Bugoyangi (a society of snake-charmers); Bununguli (society of porcupine hunters); Bugumha and Bugika (dance societies); and the Buyege (older society for hunting elephants with bows and arrows) (1970, p.120). Formally, other social institutions existed for doing in-kind labor at the village level. Out of those, the bukombakomba, which seems closest to the *bafunya*, is widely still used. Examples cited by Cory include the *isalenge* - “the village organization for mutual help" - which is under the leadership of the *basumba batale*. Another group is the *bafunya*, where “a group of family members invited by one member to help in the cultivation of the field” or the *ngida*, which exists to aid newcomers set up his new home (ibid., p.120).
traditional healers. As discussed in the focus group in Mwamishali, people still seek them out, for example for identifying the best time for planting cotton.  

The flipside of the traditional healer is the increasing importance of witchcraft. Meatu district rests in the heart of one of the most active witchcraft regions in Tanzania (Tanner 1970), as sadly witnessed in the rise of albino killings over the last years due to the belief of their magical power. Witchcraft influences the society in multiple ways, with a specific focus here on agricultural practices. Although only one household member surveyed explicitly referenced witchcraft when describing backlashes against his business success, multiple stories were shared during fieldwork. One of the most memorable one was shared by a bioRe manager, who recounted the story of a visit by a regional politician to an organic farmer. The politician was impressed by the farmer’s operation, yet was wondering why he was not using more farm yard manure. While the farmer noted that he did not have enough available himself, the suggestion to expand by seeking manure from the neighbors was met with resistance due to the fear of the neighbor’s manure being bewitched (or ‘poisoned’).  

In summary, a review of the Wasukuma culture shows that it has an important impact on the agricultural practices chosen and poverty and inequality in general. For example, the lack of farm yard manure applications is potentially influenced by fears of witchcraft. It is also likely to impact some households’ decision making process in regards to maximizing profits, thus reducing inequalities. Furthermore, although usufructuary rights traditionally kept land inequalities low, these increased in the aftermath of the forced resettlement under ujamaa. This process was explained to have created inequalities in land holdings, as farmers who had no customary right to land  

73“You have to cultivate in certain months and if you do differently, you can be hurt. Even here there are people who can look at moon to plant.” Failure to follow these instructions, if sought out, will result in suffering. The question whether or not a traditional healer ever recommended using FYM was met with a lot of laughter.  

74According to the interview with the elder in Sanga-Itinje, when asked if witchcraft was still existing, he replied that “they are still existing ... [laughing]... Many!”. The reason for why they continued to be present (or even increasing) was “because it is a belief on that. Maybe somebody if he ignores, he can get problems. Because it is there, he must make sure that it is proceeding. [...] He can’t ignore it until he dies.” It is passed on often down the family, with very strict conditions set on who is allowed to become trained in witchcraft. 75 Reasons given include failures to follow through on promises, but also jealousy, which according to him could be accentuated in times of stress, as found by Miguel (2005) in his leading research on witchcraft in the Shinyanga region.
outside the village were left with only their land holdings in the village. Furthermore, overall land shortages - reflected in increased cost of renting agricultural and grazing land - reinforced these inequalities. Finally, cattle and a shift towards a patrilineal society were the origins of unevenness. Acting not only as an income source, but also as a status symbol, their importance however appears to have declined, as reflected in the prioritizing of land over cattle.

3.3 Summary

The first section 3.1 located cotton production by highlighting how it already was a crop planted for traditional usage. The first development intervention by the Germans resulted in it being pushed for export production. While attempting to increase economies of scale via plantation and mechanization as well as diffusing agricultural methods (i.e. combating soil erosion, crop rotation) that are similar to organic agriculture, most of the increase of production came via exploitation of resources and extensification. The second intervention by the British shifted towards small-scale agriculture, as cotton output grew. Although a concerted effort was made towards the diffusion of intensive agriculture, the appetite for increasing output in order to stimulate the economies of the colony and the homeland took precedence. Both German and British interventions also took place during times of high market volatilities, with efforts put into place analogous to organic farming - via a price premium and subsidized inputs - to provide for a stable supply of cotton yet also guarantee a fair price. Post-independence under ujamaa, cotton production actually was less successful, as it was marked by failures to stimulate production. While domestic processing capacities were created via a textile milling sector, that also collapsed after liberalization. The review however showed that farmers were eager to shift their production, if able, according to the fluctuations (and higher shares) of the producer prices obtained. This exposure to world market prices however has come at a cost as some farmers failed to diversify their production. This is likely to be the case in Meatu, where limited capacities, due to agroecological conditions, have historically existed for diversification.

The second section 3.2 reviewed the history of agricultural production. It revealed
that although limited local knowledge remains, with increased population densities, farmers to the north of Meatu have been known to practice intensive agriculture. As a result, emphasis on intensive agriculture – for example via farm yard manure applications – at least in some segments of the population is related to the previously failed three interventions outlined in section 3.1. It also is related to the change in settlement patterns, which moved from being clustered towards more scattered as availability of land increased. Cattle, which play a large role in Wasukuma culture, are traditionally viewed as a source of income, source of savings, but also prestige. In regards to agriculture, however, as opposed to resulting in intensive production, they often have a negative impact due to grazing shortages and delayed planting. These cattle are traditionally a source of inequality or differentiation within the community, land ownership has increased in desirability given the increasing shortage for both agricultural and grazing purposes. This indicates a shift from previous era, with land becoming a source of unevenness, accelerated by the failure of ujamaa and subsequent loss in land ownership. On the other hand, traditional customs, such as the consulting of healers or practice of witchcraft, have been on the rise and are likely to impact production decisions of farmers.\textsuperscript{76} These impacts of course are difficult to measure without undertaking an ethnographic research approach, which is beyond this dissertation.
Chapter 4

Who is an Organic Farmer? Adoption of an Organic Innovation

Before answering the second research question in regards to the sustainability levels of organic and conventional farming households, it is important to establish a clearer picture of who exactly is an organic or conventional farmer. This chapter is organized sequentially in three parts. The first Subsection 4.1 focuses on the key socioeconomic difference existing between the two groups. This section tests the first hypothesis outlined in Section 2.2.1, whether or not organic farmers are owners of larger farms and are also wealthier and better educated. The second Subsection 4.2, building on these findings, models who becomes an organic farmer in the first place, which tests the second hypothesis outlined in Section 2.2.1. These models include a logit model to calculate the probabilities of becoming an organic farmer. A count model is created in Section 4.2.2 in order to answer the second part of Hypothesis 1.2 on changes in assets over time. This count model tests for the possibility that only wealthy farmers become bioRe farmers.\(^1\) Drawing on a probit and count model allows testing the hypothesis that organic farmers are self-selecting.

The third Subsection 4.3 answers the final Hypothesis 1.3 in Section 2.2.1 by providing a snapshot of the difference in income obtained as analyzed through the metrics of net income per acre and total income per contributing household member. It lays the groundwork for analyses undertaken in Subsection 6.2 on unidimensional poverty and is a key component for the multidimensional poverty analyses undertaken in Chapter

\(^1\)The model thus aims at reducing issues of endogeneity. A further calculation could involve a spatial probit model, which aims at analyzing these patterns of joining (or not joining) bioRe by explicitly taking spatial location into account. Examples include works by Smith and Song (2004) and Holloway et al. (2002).
Table 4.1: Definition of Variables Chosen

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Household head finished primary school or better&lt;br&gt;Age of household head as proxy for learning-by-doing</td>
</tr>
<tr>
<td>Size</td>
<td>Household members&lt;br&gt;Contributing household members&lt;br&gt;Acres owned&lt;br&gt;Ox Ploughs&lt;br&gt;Ox Carts</td>
</tr>
<tr>
<td>Wealth</td>
<td>Number of wives&lt;br&gt;Cattle&lt;br&gt;Rented Land (in percent)</td>
</tr>
</tbody>
</table>

6. Its aim is to contribute to the literature by providing preliminary evidence of the strength and validity of organic agriculture as a pro-poor growth strategy, which is analyzed in greater detail in Chapter 6.

4.1 Socio-Economic Differences of Farming Households

This section answers the hypothesis whether or not organic farmers own larger farms and are also wealthier and better educated. It uses the survey data to contrast organic and conventional farmers via an analysis of statistically significant differences of the means. Table 4.1 lists the socio-economic indicators chosen to measure education, size and wealth. For education, these include using both older age (as informal education and learning-by-doing on the farm) and formal education as a measurement. The size of the farm is defined by the number of household members (both total and contributing), the number of acres owned, as well as the availability of two key farm tools - ox ploughs and ox carts. The wealth of a farming household is recorded using the variables of number of wives, cattle, and percentage of land rented.\(^2\)

Using these ten indicators, an independent sample t-test compares the difference in the means between the two farmer types with a hypothesized value of 0. The sample size was reduced to 49 conventional and 63 organic farmers, respectively, since some

\(^2\)The motivation for using percentage of land rented as opposed to using absolute number of acres rented indicates the dependency (and expenditures) a farmer has on rented land, with larger percentages indicating lower wealth.
Table 4.2: Comparisons of Socio-Economic Indicators Means Across Farmer Types

| Socio-Economic Indicators       | bioRe Mean | Conventional Mean | Pr>|t| |
|---------------------------------|------------|-------------------|------|
| Age                             | 46.78      | 45.18             | 0.52*|
| Finished Primary School or Better| 0.60       | 0.69              | 0.32 |
| Household members                | 11.03      | 8.78              | 0.01 |
| Contributing household members   | 5.00       | 4.20              | 0.07 |
| Acres owned (acres)              | 81.71      | 32.37             | <0.01*|
| Ox Ploughs                       | 1.65       | 0.80              | <0.01|
| Ox Carts                         | 0.56       | 0.31              | 0.02 |
| Number of wives                  | 1.41       | 1.04              | 0.01*|
| Cattle                           | 34.38      | 12.61             | <0.01*|
| Rented Land (in percent)         | 5.83       | 39.81             | <0.01*|

* indicates that the variance between the two groups failed homoscedasticity (at 0.05) and thus the Satterthwaite test for unequal variance was chosen instead of the usual pooled one.

Farmers had data points missing. Assuming equal variance - homoscedasticity - the t-statistic for comparing the two means - \( \bar{x} \) - is,

\[
t = \frac{\bar{x}_1 - \bar{x}_2}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \tag{4.1}
\]

with the standard deviation - s - calculated as

\[
s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \tag{4.2}
\]

(Rogerson 2001, p.49ff)

Drawing on the t-test, we can determine whether the observed difference between the two groups is significant, or just a chance occurrence.

The results are presented in Table 4.2. With the exception of age, education (i.e. whether or not a farmer finished primary school or better)\(^3\) and to a lesser extent contributing household members, all the means are significantly different between the two groups looking at differences in wealth and size of the farm. The strongest differences

\(^3\) There are two reasons why 67 percent of conventional farmers yet only 58 percent of bioRe farmers seem to have finished primary school. First, bioRe farming household heads were slightly older (although not significantly). Thus they were unable to obtain education during the British colonial periods and consequently fail to reach the Standard 7 primary school of the current system. A second reason is that non-bioRe farmers obtain lesser shares of income from cotton. While this by itself should not have an impact on education, the fact that some of the non-bioRe farmers were actually (successful) shopowners explains some of the difference.
were found between farmers and their land ownership: *acres owned* and *rented land*. In addition, this difference appears to expand into agricultural assets in the case of ox ploughs. Two reasons account for why we are finding a larger difference amongst ox ploughs than ox carts: First, ox carts are often held in smaller quantities, with one being sufficient for the majority of farmers, thus resulting in less existing variation. Second, derived from the agricultural land findings, we see that the drastic lower numbers in ox ploughs are most likely connected with the lower amount of land available to be prepared in the first place. Combined with the more than twice as large average of cattle heads held by bioRe farmer, it also becomes evident that many farmers lack the cattle to operate an ox plough; out of the 26 farmers who do not own any ox plough, 14 conventional and one bioRe farmer don’t possess any cattle.\footnote{Although cattle can be loaned or rented for such purposes.}

Observing difference in demographics, we see that bioRe farmers also have a statistically significantly higher number of wives than their conventional counterparts. This indicator is often used as measures of wealth within a polygamous community.\footnote{One bioRe employee noted upon my third return to the field site in 2011 that investments were not undertaken in cattle, nor in iron roofs, as postulated by me, but rather in paying dowry and building a new house for a second or third wife. This was in the aftermath of historic record cotton prices at the beginning of the 2011-12 purchasing season.} Observing the lack of a strong significant difference in contributing household members, we can conclude that bioRe farmers can support more *non-contributing* household members. In terms of age, however, no significant difference appears to exist at the level of the household head, highlighting that at least at the level of the household head, it is not necessarily older household heads’ whose families are more likely to become certified organic farmers and adopters of organic methods (although see earlier footnote on education and age).

In summary, answering Hypothesis 1.1, we find that organic households, compared to conventional, are statistically significant wealthier and larger. However, using both age and having finished primary school as indicators of education, no significant difference exists. These are the same findings as observed by Bolwig et al. (2009), where
differences in both education and age were not significant between organic and non-organic farmers.

One important shortcoming from the analysis is that one is just looking at a snapshot in time. Consequently, it is important to highlight the inability using just a difference in means test to conclude if this wealth difference existed *ex ante* or as a result of benefiting from organic cotton production.⁶ The following section addresses this gap.

### 4.2 Modeling who Becomes an Organic Farmer

Given the limitations of the comparison of means, this section identifies the factors that determine the probability of a farmer joining bioRe using the same socio-economic indicators from Table 4.1. It thus answers Hypothesis 1.2 by using a logit regression model that is commonly used to assess likelihoods with a dependent binary variable, such as whether or not a farmer is a bioRe member as of the 2008/09 season. This statistical analysis allows for the characteristics distinguishing organic farmers from conventional ones to emerge from the above data set. The results identify not only which out of the 10 variables in Table 4.1 are the most significant (and thus what differentiates the two groups significantly), they also provide a better understanding of whether size, wealth or education is a driving factor and if farmers are truly self-selecting, as argued by Rogers (2003). In a second step, using a count model, the analysis is refined by assessing if early adopters - farmers who have been with bioRe for a longer time - have increased their assets over time. This analysis in Section 4.2.2 uses no longer a binary dependent variable, but rather years of membership as the dependent variable, thus allowing for temporal differentiation that did not exist in the earlier section.

⁶Research on investments amongst organic cotton farmers also shows that farmers who have been with bioRe for a longer period do *not* have higher investment levels in cattle, house construction or small business than those that joined just recently. Measured across two years, however, the farmers who have been with bioRe the longest had less variability in their incomes (bioRe 2010).
4.2.1 Logit Model

The logit model in Table 4.3 tests the null hypothesis that all explanatory variables have coefficients with a value of zero. In other words, it tests that households with more or less wealth, size, or education, have a higher probability of becoming bioRe farmers. As seen in the two chi-square tests for model significance we can reject the null hypothesis: out of the ten independent variables used in our model, at least one has a coefficient that is significant and not zero (Allison 1999).7 The fit of the model is illustrated by comparing the Akaike’s information criterion8 - AIC - or the Schwartz criterion9 - SC - which is also known as the Bayesian information criterion - BIC. Generally lower values of these statistics correspond to more desirable levels. The Schwartz criterion punishes more for overestimating with insignificant parameters. Consequently, even before analyzing individual indicators’ significance, the fit statistics show that potential remains for reducing the Covariates in Table 4.3 for our model by reducing the number of variables.

Taking a look at the variables used in the logit model in Table 4.3, we see that only a wealth indicator - percentage of land rented by a farmer - is significant10 and strongly negative (at p-value of 0.002).11 Percentage of land rented is a strong wealth indicator as it indicates that a farmer is lacking stable ownership of land and has to continuously rent additional plots if wanting to plant (more) crops. This indicates that neither size nor education, but rather wealth, is an important indicator of the probabilities for a farming household joining bioRe.

---

7According to Allison (1999, p.20), the log-likelihood chi-square is calculated by comparing “the log-likelihood for the fitted model with the log-likelihood for the fitted model with no explanatory variables. It is calculated by taking twice the positive difference in the two log-likelihoods. [...] The score statistic is a function (a quadratic form) of the first and second derivatives of the log-likelihood function under the null hypothesis.” There is no clear preference for either method, although “[i]n small samples or samples with extreme data patterns, there is some evidence that the likelihood ratio chi-square is superior.”

8Calculated as -2 * log-likelihood + 2 k, where k is the number of estimated parameters.

9-2 * log-likelihood + k*log (n), where n is the sample size.

10The significance is calculated similar to linear regression models by estimating a Wald Chi-Square: squaring the result of the division of the coefficient estimate by its standard error (Allison 1999).

11However when rerunning it without percentage of land rented, we see continued significance, with ox ploughs being the most individually significant.
Table 4.3: Logit Model of Who is an Organic Farmer

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.13</td>
<td>0.01</td>
<td>0.928</td>
</tr>
<tr>
<td>Age</td>
<td>-0.003</td>
<td>0.01</td>
<td>0.910</td>
</tr>
<tr>
<td>Finished Primary School or Better</td>
<td>0.21</td>
<td>0.11</td>
<td>0.738</td>
</tr>
<tr>
<td>Number of HH Members</td>
<td>0.02</td>
<td>0.06</td>
<td>0.810</td>
</tr>
<tr>
<td>Number of Contributing HH Members</td>
<td>-0.08</td>
<td>0.29</td>
<td>0.593</td>
</tr>
<tr>
<td>Acres owned (in acres)</td>
<td>-0.003</td>
<td>0.28</td>
<td>0.596</td>
</tr>
<tr>
<td>Number of Ox Plough</td>
<td>0.47</td>
<td>1.25</td>
<td>0.264</td>
</tr>
<tr>
<td>Number of Ox Cart</td>
<td>-0.08</td>
<td>0.02</td>
<td>0.891</td>
</tr>
<tr>
<td>Number of Wives</td>
<td>0.29</td>
<td>0.69</td>
<td>0.408</td>
</tr>
<tr>
<td>Number of Cattle</td>
<td>0.01</td>
<td>0.61</td>
<td>0.434</td>
</tr>
<tr>
<td>Rented Land (in %)</td>
<td>-0.04</td>
<td>10.06</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Model Fit

<table>
<thead>
<tr>
<th>Model and Coefficients</th>
<th>Intercept</th>
<th>Likelihood Ratio</th>
<th>Model Significance</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>134.94</td>
<td></td>
<td></td>
<td>40.56</td>
</tr>
<tr>
<td>SC</td>
<td>164.85</td>
<td></td>
<td></td>
<td>34.45</td>
</tr>
</tbody>
</table>

Pr: .01
Table 4.4: Correlation Across Variables

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>No. Wives</th>
<th>HH Members</th>
<th>Contr Members</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.00</td>
<td>0.066</td>
<td>0.292</td>
<td>0.368</td>
<td>-0.573</td>
</tr>
<tr>
<td>No. Wives</td>
<td>0.066</td>
<td>1.00</td>
<td>0.351</td>
<td>0.224</td>
<td>-0.067</td>
</tr>
<tr>
<td>HH Members</td>
<td>0.292</td>
<td>0.351</td>
<td>1.00</td>
<td>0.718</td>
<td>-0.260</td>
</tr>
<tr>
<td>Contr Members</td>
<td>0.368</td>
<td>0.224</td>
<td>0.718</td>
<td>1.00</td>
<td>-0.292</td>
</tr>
<tr>
<td>Education</td>
<td>-0.573</td>
<td>-0.067</td>
<td>-0.260</td>
<td>-0.292</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Acres</th>
<th>% Rented</th>
<th>Cattle</th>
<th>Oxplough</th>
<th>Oxcart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres</td>
<td>1.00</td>
<td>-0.393</td>
<td>0.721</td>
<td>0.547</td>
<td>0.532</td>
</tr>
<tr>
<td>% Rented</td>
<td>-0.393</td>
<td>1.00</td>
<td>-0.297</td>
<td>-0.463</td>
<td>-0.260</td>
</tr>
<tr>
<td>Cattle</td>
<td>0.721</td>
<td>-0.297</td>
<td>1.00</td>
<td>0.557</td>
<td>0.435</td>
</tr>
<tr>
<td>Oxplough</td>
<td>0.547</td>
<td>-0.463</td>
<td>0.557</td>
<td>1.00</td>
<td>0.672</td>
</tr>
<tr>
<td>Oxcart</td>
<td>0.532</td>
<td>-0.260</td>
<td>0.435</td>
<td>0.672</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The fact that the overall model is significant yet only one variable is individually significant indicates the existence of multicollinearity. As explored in Table 4.4, the collinearity is strongest between similar categories. For example, the number of household members and those contributing is very significantly correlated at 0.718. Similarly, oxploughs and oxcarts are correlated at 0.672. On the other hand, cattle is significantly correlated with measures of farm size, such as the number of acres owned (0.721) or oxploughs (0.557) or oxcarts (0.672).

A solution is to remove insignificant variables that measure the same. In a first step, the model is reduced by removing household members and age (leaving in contributing household members and education) as well as oxcarts. In a second step, either cattle or acres owned are left in the model. These steps assure that we still have one indicator for each of the three categories of wealth, size and education.

The results from these two improved models are reported in Table 4.5 (for cattle) and Table 4.6 (for acres owned). As we can see from the findings, the models improved significantly in terms of their overall fit (with lower values for intercept and coefficients for the AIC and SC preferable). Furthermore the most important variable, percentage of land rented, has not changed in either its significance (it has slightly improved in both models), nor its coefficient estimate (which has largely remained the same). In Table 4.6, number of ox ploughs, however, was approaching strong statistical significance at 0.08 and the new estimate of 0.56 is higher than our previous coefficient estimate of
Table 4.5: Revised Logit Model of Who is an Organic Farmer (with cattle)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.006</td>
<td>0.0001</td>
<td>0.994</td>
</tr>
<tr>
<td>Education</td>
<td>0.26</td>
<td>0.27</td>
<td>0.602</td>
</tr>
<tr>
<td>Number of Contributing HH Members</td>
<td>-0.063</td>
<td>0.30</td>
<td>0.584</td>
</tr>
<tr>
<td>Number of Ox Plough</td>
<td>0.45</td>
<td>1.59</td>
<td>0.207</td>
</tr>
<tr>
<td>Number of Wives</td>
<td>0.29</td>
<td>0.64</td>
<td>0.424</td>
</tr>
<tr>
<td>Cattle</td>
<td>0.007</td>
<td>0.37</td>
<td>0.541</td>
</tr>
<tr>
<td>Rented Land (in %)</td>
<td>-0.04</td>
<td>10.96</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Model Fit

<table>
<thead>
<tr>
<th>Model Fit</th>
<th>Intercept and Coefficients</th>
<th>Model Significance</th>
<th>Chi-Sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>127.37</td>
<td>Likelihood Ratio</td>
<td>40.15 Pr &lt;.01</td>
</tr>
<tr>
<td>SC</td>
<td>146.40</td>
<td>Score</td>
<td>34.23 Pr &lt;.01</td>
</tr>
</tbody>
</table>

0.40.\textsuperscript{12}

Combined with number of wives and its continued insignificance (yet slightly smaller coefficient estimate in Table 4.6), we understand that ox ploughs has a greater weight as per its coefficient estimate due to the change in the intercept from its positive to negative value in both models. In sum, although the variable of number of wives could be removed to improve the model further - in addition to variables on number of contributing household members, cattle, acres owned, and education - these two models allow for a strong estimation of who becomes an organic farmer.

Discussion

Although the overall model is significant, the coefficients’ significances in Table 4.3 reveal that organic farmers rent a lower proportion of their entire land used in agriculture

\textsuperscript{12}This differs from Table 4.5, where the number of ox ploughs is actually not significant (at 0.207). Recalling the collinearities in Table 4.4, one reason could be that ox ploughs are slightly more correlated with cattle (at 0.557) than acres (at 0.547), thus causing errors at attributing individual significances. Given how minute this factor is, it might be magnified by the fact that cattle is also less correlated with percentage of land rented, thus increasing the explanatory power of that variable (as indicated in the higher chi-square score at 10.96 for the model with cattle, as opposed to 10.48 for the model with acres owned).
Table 4.6: Revised Logit Model of Who is an Organic Farmer (with acres owned)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.086</td>
<td>0.011</td>
<td>0.916</td>
</tr>
<tr>
<td>Education</td>
<td>0.27</td>
<td>0.30</td>
<td>0.587</td>
</tr>
<tr>
<td>Number of Contributing HH Members</td>
<td>-0.46</td>
<td>0.16</td>
<td>0.690</td>
</tr>
<tr>
<td>Acres (owned)</td>
<td>0.0002</td>
<td>0.002</td>
<td>0.962</td>
</tr>
<tr>
<td>Number of Ox Plough</td>
<td>0.56</td>
<td>3.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Number of Wives</td>
<td>0.280</td>
<td>0.58</td>
<td>0.446</td>
</tr>
<tr>
<td>Rented Land (in %)</td>
<td>-0.04</td>
<td>10.48</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Model Fit and Coefficients

- Intercept and Coefficients: AIC = 127.84, SC = 146.87
- Likelihood Ratio Chi-Square: 39.67, Pr < .01
- Score Chi-Square: 33.86, Pr < .01

than conventional farmers. As a measure of wealth it appears as the only consistent factor that significantly increases the probability of joining bioRe. Given that organic farmers by contract have to own at least three acres of land in order to be allowed to join bioRe, this strong significance also represents a lower threshold for farm size. Farm size itself is not significant, as conventional farmers on average owned 32 acres (see Table 4.2 on page 101). Another contributing factor is that bioRe farming households rent less land since they are constrained to only use land that is organic from fellow certified farmers. Addressing the Hypothesis 1.2, these models reveal that this selection by organic production requirements stands in contrast to the self-selection of early adopters described by Rogers (2003) in previous agricultural innovations.

Given that the overall model is significant, yet most variables appear insignificant, it is important to compare the same findings from the logit model with the findings from the t-tests of the socio-economic indicators averages across the two farming types in Section 4.1. Nearly all of the socio-economic indicators are significant when comparing

13 The magnitude of the land ownership is not significant by itself (see insignificant variable in Table 4.6) nor is it necessarily strongly correlated with the percentage of land someone is renting (see Table 4.4).
their mean levels, yet in the logit model only *rented land* and *ox ploughs* were individually significant. Since we are unable to draw any conclusions beyond *rented land* or to a lesser extent *ox ploughs* from the logit model, it shows that farmers that join bioRe are not necessarily wealthier, but own their own land. Other measures of farm size, such as household members, were not significant, nor was education. Answering Hypothesis 1.2, we find that neither higher education nor larger farm size determine significantly the probabilities of a farmer joining bioRe. Large percentages of land rented - as an indicator of wealth and formal selection criteria of bioRe farmers - however is statistically significant. bioRe farmers consequently do not appear to be self-selecting entirely, as the minimum criteria for joining organic agriculture come into play.

In regards to education, we see that in all the models it is not individually significant. As such, it does not appear that adopters of organic agriculture were better educated farmers, at least as measured in regards to the household head (and discussed earlier in Footnote 3 on page 101). A breakdown of key assets across farming household heads that either finished primary education or those that didn’t is shown in Table 4.7. It reveals that on key assets, such as land ownership and agricultural assets, the farmers with less education actually have statistically significantly higher means. It provides some indication that education levels might be less essential towards becoming an organic farmer than previously hypothesized in Section 2.2.1 on page 36. Since they differ from a Western setting, these results are encouraging as they provide some evidence that organic agriculture - which is a knowledge-intensive technique - is not limited by lower human capital (investment) levels.

In summary, the above logit models identified that only percentage of rented land was strongly and consistently significant. As an indicator of wealth, it appears that neither farm size nor education significantly increased the likelihoods of joining bioRe. A potential conclusion drawn from this is that having fewer cattle or no ox ploughs does not mean that a farmer is less likely to be able to join bioRe *a priori*. This would reveal important implications in regards to organic agriculture’s impact - as an innovation - on poverty reduction and inequality. Compared to input-intensive agriculture, it consequently would appear that beyond land ownership, capital is not a limiting factor.
Table 4.7: Comparisons of Socio-Economic Indicators Means across Education of Household Heads

| Socio-Economic Indicators | Mean for More than Primary Education | Mean for less than Primary Education | Pr>|t| |
|---------------------------|--------------------------------------|--------------------------------------|------|
| Acres Owned               | 84.61                                | 45.43                                | 0.02 |
| Rented Land (in percent)  | 10.57                                | 26.78                                | <0.01*|
| Number of wives           | 1.31                                 | 1.21                                 | 0.53*|
| Cattle                    | 31.98                                | 20.59                                | 0.14 |
| Sheeps and Goats          | 33.05                                | 22.06                                | 0.15 |
| Ox Ploughs                | 1.67                                 | 0.91                                 | <0.01*|
| Ox Carts                  | 0.62                                 | 0.34                                 | 0.02*|

*: indicates that the variance between the two groups failed homoscedasticity (at 0.05) and thus the Satterthwaite test for unequal variance was chosen instead of the usual pooled one.

4.2.2 Count Model

One remaining question - articulated in the second part of Hypothesis 1.2 - however is whether or not early adopters of organic agriculture are able to increase their wealth over time, thus resulting in increased inequalities. This question is addressed with the aid of a count model in this section. Instead of using the binary indicator for whether a household was a bioRe member or not, a count model uses the number of years a household was with bioRe. This achieves two tasks. First, it helps test the second part of Hypothesis 1.2, which states that early adopters are increasing their wealth (assets) over time. The second advantage is that so far, both comparison of means tests and logit models failed to discriminate whether or not bioRe farmers were wealthy prior to joining bioRe. In order to improve the ability to distinguish the problem of endogeneity, which hampers our ability to distinguish between the influence of being bioRe farmer on wealth and vice-versa, the count model tests if the wealth changed over the years. If only wealthy farmers would join bioRe, we would expect to see no significant change in asset ownership over the years. This outcome would also fail to support Hypothesis 1.2 that early adopters are increasing their assets over time.

For this purpose, three models were tested. The first model re-runs the data as in Table 4.6 but with years since joining bioRe as the dependent variable. The second

\[14\] Although a cumulative logit model could be run, as the data is ordinal (as well as cardinal), some years have only one or two observations. Allison (1999) recommends as a rough rule of thumb that
Table 4.8: Adjusted Poisson Model Predicting Years with bioRe

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.559</td>
<td>19.22</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of Wives</td>
<td>0.070</td>
<td>0.37</td>
<td>0.5405</td>
</tr>
<tr>
<td>Number of Contributing HH Members</td>
<td>-0.109</td>
<td>3.39</td>
<td>0.0656</td>
</tr>
<tr>
<td>Education</td>
<td>-0.088</td>
<td>0.16</td>
<td>0.6904</td>
</tr>
<tr>
<td>Rented Land (in %)</td>
<td>-0.030</td>
<td>12.99</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of Ox Plough Acres (owned)</td>
<td>0.132</td>
<td>1.04</td>
<td>0.3071</td>
</tr>
<tr>
<td>Model Fit and Coefficients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>515.29</td>
<td>Likelihood Ratio</td>
<td>-250.65</td>
</tr>
</tbody>
</table>

As seen in the first adjusted model in Table 4.8, the model using socio-economic indicators is a good fit. All variables have the same sign as seen in Table 4.6, with the exception of education, which changed from positive to negative. This change - although individually not significant - is explained by the observed decreasing of each category should have at least 10 observations. Consequently, a poisson regression is run instead. The first two models (see Appendix for Table E.4, Table E.5 and Table E.6) are plagued by overdispersion - the relationship was 3.35 in Model 1, 3.63 in Model 2. Model 3, on the other hand, has a 0.909 value. Although this difference between 1 was minimal, it also was adjusted - as the deviance is larger than the degrees of freedom, which are not reported here. While the coefficients are not biased, it underestimates standard errors and results in overestimated chi-square statistics. The validity of the significance of the individual variables is consequently put into question. As a result, they would benefit from an adjustments for overdispersion, or a regular regression would be preferred. This adjustment was undertaken as proposed by Allison (1999). The adjustment involves taking “the ratio of the goodness-of-fit chi-square to its degrees of freedom, and call the result C. Divide the chi-square statistic for each coefficient by C. Multiply the standard error of each coefficient by the square root of C.” (Allison, 1999, p.223) To use the Pearson chi-square, in SAS the GENMOD procedure is modified by using the PSSCALE option.

---

15 The first two models are plagued by overdispersion - the relationship was 3.35 in Model 1, 3.63 in Model 2. Model 3, on the other hand, has a 0.909 value. Although this difference between 1 was minimal, it also was adjusted - as the deviance is larger than the degrees of freedom, which are not reported here. While the coefficients are not biased, it underestimates standard errors and results in overestimated chi-square statistics. The validity of the significance of the individual variables is consequently put into question. As a result, they would benefit from an adjustments for overdispersion, or a regular regression would be preferred. This adjustment was undertaken as proposed by Allison (1999). The adjustment involves taking “the ratio of the goodness-of-fit chi-square to its degrees of freedom, and call the result C. Divide the chi-square statistic for each coefficient by C. Multiply the standard error of each coefficient by the square root of C.” (Allison, 1999, p.223) To use the Pearson chi-square, in SAS the GENMOD procedure is modified by using the PSSCALE option.
schooling with increased age of older household heads. The strongest significance is still observed in percent of land rented. Instead of ox ploughs, which was approaching significance previously, we now see that the number of contributing household members is negative and significant.\textsuperscript{16} This indicates that long-term bioRe members do not actually have more contributing household members per se. Acres and ox ploughs owned have a positive sign, indicating that they increase with years of membership, yet are individually insignificant. This seems overall to indicate that the same main differences exist between bioRe and non-bioRe, as well as amongst bioRe members when looking at the length of their membership.\textsuperscript{17} In summary, using the six variables chosen, there is no significant evidence that older bioRe farmers increase the size of their land holdings, reduce their amount of land rented over time, with an added effect that longer bioRe members also have fewer contributing household labor (which could be an age effect).

The first model used a range of socio-economic indicators. We are mostly interested in wealth, however. Thus, the second model uses the standard wealth variable of cattle, as well as land owned and seven additional household assets as proxies for long-run wealth.\textsuperscript{18}

Table 4.9 reports the poisson regression results using the nine measures of long-run wealth for all farmers, including non-bioRe. The model overall is a good fit, although slightly worse compared to Table 4.8 as seen in the similar yet larger AIC and likelihood ratio.

Looking at the assets, a very interesting pattern exists. The amount of land owned is the most statistically significant,\textsuperscript{19} with a household owning 10 more acres increasing

\begin{equation}
100 \times (e^{\beta} - 1)
\end{equation}

\textsuperscript{16}Since the dependent variable is logged, the coefficients can be interpreted by calculating:

\textsuperscript{17}Since members often joined the first year a village was added to the project, a spatial probit would make sense to observe if the earlier member village are significantly different from the later.

\textsuperscript{18}This was determined using the PCA analysis in Chapter 6. The reader is referred to there for a more in-depth discussions.

\textsuperscript{19}After the removal of rented land (in \%) due to the fact that the variable is not an asset, but a calculation using land ownership as its basis.
Table 4.9: Poisson Model Predicting Years with bioRe and Assets (all farmers)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.9425</td>
<td>21.92</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Acres (owned)</td>
<td>0.005</td>
<td>7.40</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Bed</td>
<td>-0.003</td>
<td>0.00</td>
<td>0.996</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.003</td>
<td>0.00</td>
<td>0.996</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.230</td>
<td>3.21</td>
<td>0.073</td>
</tr>
<tr>
<td>Cellphone</td>
<td>-0.194</td>
<td>1.45</td>
<td>0.229</td>
</tr>
<tr>
<td>Radio</td>
<td>-0.356</td>
<td>3.93</td>
<td>0.047</td>
</tr>
<tr>
<td>Television</td>
<td>1.348</td>
<td>2.95</td>
<td>0.086</td>
</tr>
<tr>
<td>Cattle</td>
<td>-0.006</td>
<td>1.43</td>
<td>0.232</td>
</tr>
<tr>
<td>Bank Account</td>
<td>-0.441</td>
<td>0.87</td>
<td>0.352</td>
</tr>
</tbody>
</table>

Model Fit

<table>
<thead>
<tr>
<th>Intercept and Coefficients</th>
<th>Model Significance</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>575.24</td>
<td>-277.62</td>
</tr>
</tbody>
</table>

the years of being a longer member with bioRe by 5 percent. Similarly, bicycle and television are statistically significant, although both only approaching conventional 0.1 cutoff. Besides television, which should be considered a luxury item given that only few households owned one, bank account and cellphone are statistically insignificant and negative. In addition, radio was also negative, although statistically significant.

As discussed in focus groups, farmers who own a radio can not be considered rich or poor as it depends on the quality of the radio. Furthermore, there is a decreasing utility to owning more than one radio. Similarly, farmers mentioned that usually one cellphone suffices, although the female members present were indicating that especially if a household had a cellphone for the household head and his wife, that would be an indication of a wealthier household. Combined with the fact that negative odds are observed of being a longer bioRe farmer with more contributing household members, one reason older members might not own more cellphones is that they have fewer contributing household members that would need such a device. This contrasts from bicycles, which can be used by all household members, although usually two or three per household also suffice. Bicycle ownership is associated with more years but certainly doesn’t cause it. While beds are very weakly negative, they are also highly insignificant. Furthermore, although cattle is slightly less insignificant, the magnitude is low similar
Table 4.10: Poisson Model Predicting Years with bioRe and Assets (bioRe farmers only)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.6674</td>
<td>216.84</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Acres (owned)</td>
<td>0.002</td>
<td>3.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Bed</td>
<td>0.052</td>
<td>2.31</td>
<td>0.128</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>-0.362</td>
<td>1.07</td>
<td>0.301</td>
</tr>
<tr>
<td>Bicycle</td>
<td>-0.037</td>
<td>0.24</td>
<td>0.623</td>
</tr>
<tr>
<td>Cellphone</td>
<td>-0.014</td>
<td>0.02</td>
<td>0.879</td>
</tr>
<tr>
<td>Radio</td>
<td>-0.225</td>
<td>7.03</td>
<td>0.008</td>
</tr>
<tr>
<td>Television</td>
<td>1.364</td>
<td>5.69</td>
<td>0.017</td>
</tr>
<tr>
<td>Cattle</td>
<td>-0.002</td>
<td>0.50</td>
<td>0.478</td>
</tr>
<tr>
<td>Bank Account</td>
<td>-0.551</td>
<td>4.67</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Model Fit

<table>
<thead>
<tr>
<th>Intercept and Coefficients</th>
<th>Likelihood Ratio</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>267.70</td>
<td>-123.85</td>
</tr>
</tbody>
</table>

In sum, out of the three variables that are approaching statistical significance of 0.05, acres owned has a positive influence on the number of years with bioRe, as does the number of bicycles owned. On the other hand, owning more radios would indicate lower likelihoods of being a long-term bioRe member, with each additional radio resulting in 30 percent less years with bioRe. Answering the hypothesis using data that includes conventional farmers, we find that early adopters appear to have larger land (and bicycle) ownership, with radio being negatively related with longer membership.

In order to understand these patterns better, Table 4.10 describes the result form the poisson regression with the same variables by focusing not on the 107 households used in Table 4.9, but solely the 60 bioRe farming households for which all data was available. This step is expected to increase the ability to differentiate solely between

---

20 Since both acres and cattle owned are in the model, not statistically significant but pointing in opposite directions, it could be an indication that longer bioRe members are more invested in their agricultural production versus livestock herding, or at least that no clear direction exists. This would differ from the standard assumption that reigned previously that wealthier farmers would invest their profits into cattle.

21 By removing the zero years, we are observing a more normal distribution, as opposed to a classic Poisson distribution. Given that this reduces a problem of overdispersion, this method still applies, although other methods, such as a ordinary least square regression, might be equally or even more appropriate.
early- and late-adopters of organic agriculture, as it excludes the laggards or non-adopters completely.

The model fit is dramatically improved from the previous two models, as seen in the smaller AIC and the likelihood ratio. While before only three variables were approaching statistical significance, in this model three are within 0.05 with acres owned being within 0.1, and beds approaching 0.1.\textsuperscript{22}

The key difference between the second and third poisson model focusing on the long-run wealth assets is the latter’s improved ability to predict long-term membership. Again, if all bioRe members were considered \textit{wealthy} prior to joining bioRe, we would not expect to find a significant pattern to account for the differences in years with assets. Land, measured as acres owned or percentage of land rented, was (highly) significant in each of the three models. This suggests that farmers are able to expand their ownership of land over the years,\textsuperscript{25} potentially in a shift towards having more secure access to land versus ownership of cattle.\textsuperscript{26} Even moving beyond a specific interpretation on the increases or decreases in odds of being a long-term bioRe member by asset ownership, the mere significance of the individual variables indicates that variations exist in wealth and early adopters are not the same as late adopters. So far, however, all models used indicators of wealth that were accumulated over time. The next section focuses on looking at actual income data obtained during the 2008-09 season from cotton and total income in order to understand current differences in actual income obtained.

\textsuperscript{22}Starting with the intercept, it is larger given the removal of the non-bioRe farmers (which had zero years) and the subsequent increase in the mean. While bicycles are no longer significant (and now negative), bank account now is significant, with ownership increasing the percentage of years of membership by 42 percent.\textsuperscript{23} On the other hand, the \textit{luxury} equivalent of the bank account – televisions – is even more strongly significant as ownership triples the duration of membership\textsuperscript{24}. Cattle is still insignificant, although its coefficient exhibits little change. As a very positive sign, land ownership is still significant (at 0.01) and positive, although at slightly lower magnitude of 2 percent longer membership per 10 acres. This reduction in magnitude, compared to the previous model with the conventional farmers, indicates that bioRe farmers, on average, are always larger than conventional ones. Beds, which previously was highly insignificant, is now approaching significance, also having a positive impact on being a longer bioRe member, with each additional bed increasing years by 5 percent. Radio is still negative, although weaker at minus 20 percent per radio.

\textsuperscript{23}The impact however was weaker in the third model as observed earlier.

\textsuperscript{24}Although the small possibility remains that the first villages chosen by bioRe to open up for organic farming might have been those where larger farm sizes existed compared to other villages. This could be especially true given the lack of self-selection observed using the logit models.
4.3 Differences in Incomes of Farmers

One of the key questions in organic agriculture surrounds its impact measured in terms of increased income obtained from the certified crop. The potential benefit can be measured either at the level of the commodity itself - in this case net income from cotton - or at the household level - in this case total income (see also Bolwig et al. 2009 and Eyhorn et al. (2005)). With this data at hand, the goal is to test Hypothesis 1.3, that organic households have a significantly larger net income from cotton and total income per contributing household member.27

Calculation of Income and Labor

In this research, the income data is ideally derived from the information on the sale of cotton (Q. 14.1), other crops (Q. 14.2-14.9), sales of livestock (Q.18) and all other incomes (Q. 22-24) obtained outside of agriculture. Ideally, only net income would be reported. This was feasible for cotton, where the net cotton income was calculated using the expenditure data available (Q.25). In Appendix A, all cotton expenditures are explained, including the decision making process on calculating gross income from cotton and yields. These include expenditures on the cost of labor, seeds, pesticides, renting land and transportation expenditures.28

The total income was calculated by aggregating all the income items that were available. There are seven unique sources of income reported: cotton, mungbeans, other income from crops, livestock, small business, labor, remittances, and other income. Appendix B outlines the details of the calculations.

Drawing on participatory econometrics, one other element that was adjusted after consultations and early trials of the survey, was the labor category. In the final survey version, it was subdivided into three categories: bukombakomba; luganda; and hired

27 The division by household members is done to ease comparison between households that are not of the same size.

28 The major omission here is expenditures on preparing land which was not explicitly included in the survey unless provided by the farmer himself. These include expenditures on hiring labor, but also possibly a plough (or even a tractor in a few odd cases). Also, as described later, household labor costs were not enumerated explicitly, although they were taken into account when assessing costs for purchasing food for bukombakomba for example.
labor. They are ordered according to their costs and social capital, with *bukombakomba* being the cheapest yet most social capital-intensive form, while hired labor is the most expensive, yet necessitates the least social capital. Furthermore, the order is also representative of the amount each labor type was drawn upon by the households. Appendix D provides a more detailed description of these three labor types and their shares drawn upon by organic and conventional households respectively.

Deducting all the costs, the net cotton income calculated amounts to more than 50 percent of the total income obtained by farmers. Given the low year (in terms of price), its average share was 41 percent for non-bioRe farmers and 60 percent for bioRe farmers respectively. Comparing it to organic and non-organic coffee production in Uganda, the averages are considerably higher. For organic coffee farmers, it amounted to around 35 percent of total income. For non-certified farmers, it was merely 15 percent (Bolwig et al. 2009, p. 1096). Even before analyzing specific income differences in order to answer Hypothesis 1.3, it already is clear that cotton producers in the Meatu District obtain a higher share of their total income from cotton: a finding that is not surprising given the history of production described in the previous Chapter 3. However this statistic fails to provide us with information on the absolute income obtained. Dercon (1998) finds that the poor in the Shinyanga Region often gain more income from safer off-farm activities (employment), which traps them in a situation where they are not able to invest in cattle, which are a high-return lump sum investment. To test this and account for all sources of income when comparing the economic situation of households, two metrics were chosen for measuring the households: Net income from cotton and total income.

### 4.3.1 Net income from Cotton at the Household-Level

The descriptive statistics on net income from cotton for all farmers are listed in Table 4.11 and in the top histogram in Figure 4.1. The mean income per household from cotton alone is 815,064 Tsh, with the median being significantly lower, at 582,900 Tsh. Based on the range, which spans from a net loss of -375,420 Tsh to an earning of 4,165,000 Tsh, we can see that some farmers had negative net income from cotton.

Also, using the available data, it is projected that at least 95 percent of the farmers
Table 4.11: Descriptive Statistics on Net Income from Cotton

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>815,064</td>
<td>822,227</td>
<td>-375,420</td>
<td>4,165,000</td>
<td>4,540,420</td>
<td>662,486 to 967,641</td>
</tr>
<tr>
<td>5th Pctl</td>
<td>28,000</td>
<td>195,100</td>
<td>582,900</td>
<td>1,149,700</td>
<td>2,678,000</td>
<td>( n: 114 )</td>
</tr>
<tr>
<td>25th Pctl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td></td>
<td></td>
<td>75th Pctl</td>
<td>95th Pctl</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,149,700</td>
<td>2,678,000</td>
<td></td>
</tr>
</tbody>
</table>

are earning positive incomes from cotton, even during the low price year.\(^{29}\) Five farmers obtained a loss, or 4.4 percent of the 114 farmers. Two of them were bioRe farmers, while three were conventional producers. The farmer with the minimum value of \(-375,420\) was a tragic case, as all of his cotton (planted on rented land) was stolen at harvest time, except for one sheet that he was able to carry home the night of the harvest. Since he did not own an ox cart, he had to leave the cotton on the plot to wait for a hired ox cart to bring it to the selling post. The two bioRe farmers had well-below average yields, at 79 and 64.5 kg per acre respectively. This caused them to make an unexpected loss, especially since one also had expenditures on rented land, while the other had considerable expenditures for \textit{bukombakomba}.

\(^{29}\)This calculation of course would change considerably, if the household’s labor was enumerated for example per work day at minimum wage. However, as noted earlier, this appears to be not feasible nor necessary, given that many of the goods produced on the farms are actually sustaining their own livelihoods.
Figure 4.1: Histograms of Net Income from Cotton
Table 4.12: Descriptive Statistics on Organic Net Income from Cotton

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,053,339</td>
<td>843,281</td>
<td>-198,499</td>
<td>3,737,750</td>
<td>3,936,249</td>
<td>844,384 to 1,262,294</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
<th>n: 65</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28,000</td>
<td>195,100</td>
<td>582,900</td>
<td>1,149,700</td>
<td>2,678,000</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.13: Descriptive Statistics on Conventional Net Income from Cotton

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>498,985</td>
<td>681,699</td>
<td>-375,420</td>
<td>4,165,000</td>
<td>4,540,420</td>
<td>303,179 to 694,793</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
<th>n: 49</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-28,200</td>
<td>134,900</td>
<td>368,300</td>
<td>578,000</td>
<td>1,518,000</td>
<td></td>
</tr>
</tbody>
</table>

As indicated by the standard deviation being larger than the mean, with the median being smaller than the mean, the distribution experiences significant positive skew. This is not entirely surprising, given that income data is usually adjusted via log-transformation to approximate normality.

In order to test Hypothesis 1.3 on higher incomes for organic farmers, the analysis is broken down into organic and conventional farmers. Using the same descriptive statistics outlined above, Table 4.12 and Table 4.13 were created. Organic farmers earn on average just above one million Tsh, at 1,053,339 Tsh, with a median value of 582,900 Tsh. Conventional farmers, on the other hand, earned on average from cotton 498,985 Tsh at a median of 368,300 Tsh.

These results provide strong evidence for accepting Hypothesis 1.3 that organic farmers have higher net income from cotton: Not only are organic net incomes higher (as shown in the mean and median in Table 4.12), there is a consistent pattern that they are also less variance. This is well-established in the *Distribution of Net Income from Cotton by Farm Type*, as outlined in Figure 4.1. They exhibit a smaller range, as both the previously highest and lowest value from the previous Table 4.11 are two conventional farmers. Also, the standard deviation for organic farmers in Table 4.12 is smaller than the mean, whereas the standard deviation in Table 4.13 for conventional farmers is larger than the mean. The differences in mean is furthermore significant.

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30This figure is very similar to 1.1 million Tsh obtained of a sample of only bioRe households using primary data gathered by bioRe staff for a long-term survey of purchasing power.
when looking at the 95 percent confidence limits for the two means, which do not overlap.\textsuperscript{31} This difference in net income of cotton between organic and conventional farmer is statistically significant when undertaking a formal t-test at 0.0002.\textsuperscript{32}

\textsuperscript{31}Even though the maximum net income from cotton was obtained by a conventional farmer, all percentiles, even the 95th, are larger for organic farmers.

\textsuperscript{32}It is also significant at the level of net income per acre, and net income per contributing household members. It fails significance at the comparison of costs, where bioRe farmers are having slightly lower costs.
Figure 4.2: Histograms of Net Income from Cotton per Contributing Household Member
4.3.2 Net Income from Cotton per Contributing Household Member

In order to study the economic efficiency, but also to assess household levels of poverty, it is important to divide these net income figures by a measure of household members. The calculations using this new measure of net income of cotton per contributing household member confirms the previous findings and similar results as in the analyses of only net income of cotton listed in Table 4.14 and Table 4.15.

Hypothesis 1.3 is confirmed using net income from cotton adjusted by contributing household member. The average contributing organic household member generates statistically significant larger net income from cotton than the conventional counterpart. The 95 percent confidence interval for the contributing household member in organic farming lies between 177,682 to 268,655 Tsh, which is outside the upper limit for the conventional contributing household member at 168,511 Tsh. The median income, at 179,440 Tsh for organic household members, is nearly twice as large as the median income from cotton for conventional farmers at 92,400 Tsh. They are similarly distributed.\(^{33}\)

\(^{33}\)As depicted in Figure 4.2, the farming incomes are more normally distributed in organic farming than in conventional households. While the former’s standard deviation is smaller than its mean, the latter has a standard deviation that is larger than its mean, thus indicating greater comparative dispersion.
Table 4.16: Descriptive Statistics on Total Income

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,730,420</td>
<td>1,427,931</td>
<td>-123,499</td>
<td>6,900,600</td>
<td>7,024,099</td>
<td>1,465,460 to 1,995,379</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
<th>n: 114</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>184,800</td>
<td>659,000</td>
<td>1,336,270</td>
<td>2,289,000</td>
<td>4,625,340</td>
<td></td>
</tr>
</tbody>
</table>

4.3.3 Total Income at the Household-Level

In order to answer Hypothesis 1.3 on total income, the same calculations were undertaken as for net income from cotton. It involved the two steps of evaluating them along the lines of organic and conventional farmers, but also in regards to total income and total income adjusted per contributing household member.\(^{34}\)

The mean total income captured in Table 4.16 for all households was 1.7 million Tsh, which is double (112 percent) the income from cotton alone. The median total income, at 1.3 million Tsh is also 129 percent higher than the median cotton income. With 95 percent confidence, the mean total income rests somewhere between 1.5 to 2.0 million Tsh.\(^{35}\)

Comparing the conventional and organic histograms of total income in Figure 4.3 reveals two trends. First, organic farmers again are much more evenly spread out, approximating a normal distribution. On the other hand, conventional farmers are positively skewed, yet have a minor ‘hump’ at the positive end. This indicates that the income extremes of very poor or very wealthy are represented by non-bioRe farmers.

\(^{34}\)A minor caveat is that the contributing household members were technically used as a basis for assessing the number of people assisting in cotton production. No separate number of household members was gathered in the survey for this total income figure.

\(^{35}\)While a single (bioRe) farmer still has negative income, even with his additional earnings from mungbeans, the 5th percentile is more than 5 times larger for total income at 184,800 Tsh than the 28,000 Tsh estimated for net income from cotton. This increase however was less pronounced as we move upwards towards the 95th percentile: At 4.6 million Tsh it was only 73 percent higher than the net income from cotton.
Figure 4.3: Histograms of Total Income
Table 4.17: Descriptive Statistics on Organic Household Total Income

<table>
<thead>
<tr>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,914,870</td>
<td>1,176,584</td>
<td>-123,499</td>
<td>5,334,760</td>
<td>5,458,259</td>
<td>1,623,326 to 2,206,413</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
<th>n: 65</th>
</tr>
</thead>
<tbody>
<tr>
<td>418,120</td>
<td>1,016,500</td>
<td>1,871,060</td>
<td>2,784,200</td>
<td>3,936,680</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.18: Descriptive Statistics on Conventional Household Total Income

<table>
<thead>
<tr>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,485,740</td>
<td>1,687,343</td>
<td>63,900</td>
<td>6,900,600</td>
<td>6,836,700</td>
<td>1,001,079 to 1,970,402</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
<th>n: 49</th>
</tr>
</thead>
<tbody>
<tr>
<td>158,580</td>
<td>359,900</td>
<td>1,013,000</td>
<td>1,775,000</td>
<td>6,311,200</td>
<td></td>
</tr>
</tbody>
</table>

Breaking the analysis down between organic and conventional households, one expects to find that the range is larger for the latter. As a matter of fact, the range for conventional households reported in Table 4.18 is 6,836,700 Tsh, which is 25 percent larger than the range among organic farmers.\(^{36}\)

In regards to their means, there is a significant difference between the income from cotton and total income as the confidence intervals now overlap. For organic farmers, we are 95 percent confident that the mean lies between 1.6 to 2.2 million Tsh. For conventional farmers, while the lower limit is 1 million Tsh, the upper limit of 2.0 million Tsh is nearly equal to the mean for organic households, thus indicating significant overlap. This overlap results in the t-test for a statistical difference in means failing at 0.13. As a result, the evidence using total household income is not as strong in regards to there being a difference between organic and conventional farmers.

**Total Income by Source**

Given the lack of statistical significance between the total means, it was broken down into its subcomponents in order to best identify which were the ones where conventional farmers earned a higher income in. For each of the seven sources of income, a t-test for the difference of means was undertaken and reported in Table 4.19. Beyond cotton

\(^{36}\) We still observe the same patterns when comparing the size of their respective means and standard deviations as described above: Organic households have an average of 1.9 million Tsh that is larger than its standard deviation of 1.2 million Tsh. This indicates a less dispersed distribution. On the other hand, conventional households have a mean that is not only 22 percent lower - at 1.5 million Tsh - but also has a larger standard deviation - at 1.6 million Tsh.
Table 4.19: Comparisons of Income Means Across Farmer Types

| Income Category   | bioRe Mean | Conventional Mean | Pr>|t| |
|-------------------|------------|-------------------|-----|
| Total Income      | 1,914,870  | 1,485,741         | 0.1317* |
| Other Crops       | 59,223     | 21,980            | 0.1599* |
| Mungbeans         | 82,308     | 78,316            | 0.8830 |
| Remittances       | 15,384     | 490               | 0.3368* |
| Small Business    | 121,723    | 367,000           | 0.1165* |
| Labor             | 19,692     | 116,694           | 0.2005* |
| Other Income      | 46,892     | 172,122           | 0.1940* |
| Livestock         | 516,308    | 230,153           | 0.0120* |

*: indicates that the variance between the two groups failed homoscedasticity (at 0.05) and thus the Satterthwaite test for unequal variance was chosen instead of the usual pooled one.

Income and total income, which were described above, income from livestock sales is the only other additional metric for which organic farmers have significantly higher incomes. Organic households had more than twice as many sales - at 516,308 Tsh - than their conventional farmers - at 230,153 Tsh. This difference was statistically significant at 0.01 level and expected based on the findings from Dercon (1998) that poorer households lack access to cattle.

Even more interesting are the mean comparison where conventional households actually achieved a higher income. These income categories are noticeably from outside of agriculture: income from small business, labor and other income. The largest difference exists in labor, where the average income of 116,694 for conventional farmers was nearly five times larger than the 19,962 Tsh earned on average for organic farmers. This appears to corresponds with the findings from Dercon (1998) that poorer farmers have higher labor incomes, although it includes a large conventional household as an outlier.

The two other sub-categories of income where organic farmers were noticeably higher than conventional was in remittances (at 15,384 Tsh versus 490 Tsh on average) and the sales of other crops (excluding mungbeans) with 59,223 Tsh earned compared to 21,980 Tsh. Neither differences however are statistically significant, since in remittances for example only a single farmer from each group had any income. Even in the other income from crops, there were only a total of 15 farmers out of the 114 that earned additional income, which is too small a number to draw statistical conclusions on the whole sample.

The outlier is a retired military officer, who not only earns a significant pension but whose wife is also a teacher and consequently earns a large income. The 3.6 million Tsh earned by this household is more than 6 times larger than the next largest labor income at 510,000 Tsh, which was earned by a family where several household members engage in mostly agricultural labor.
Income Outside of Agriculture

In regards to income from small business, conventional farming households on average earned 367,000 Tsh, which is two times larger than the 121,723 Tsh for organic farmers. Compared to the difference in labor means, which was large yet not statistically significant, this latter measure is approaching statistical significant at the low 0.1 value.

Beyond statistical difference, both measures highlight two different socio-economic aspects of this conventional farming group. First, labor income is obtained by 20 households total, out of which 11 were conventional. These eleven households earned a below average income from cotton, at 334,725 Tsh. Similar pattern exists for organic farmers, who only earned 741,917 Tsh from cotton. This indicates that labor income was often earned by poorer households when compared to their cotton income. For example, the farmer described earlier that lost all of his cotton harvest due to theft (except for one sheet of cotton) earns some money as a bicycle repair man.

A special sub-category of households with cotton income are those that are also shop owners. This group was captured by wealthy conventional farming households\(^\text{39}\) that were depicted in the right side of the histograms in Figure 4.3.\(^\text{40}\) To strengthen this picture even more, these households were also (as those earning labor income) earning below the average income from cotton at 394,534 Tsh per household. This indicates that they clearly have different (yet successful) livelihood strategies that do not depend as much on cotton production (see Figure 4.4 of interviewed conventional farmer earning income selling water).

\(^{39}\) Of course this puts into question the farming categorization as they earn most of their income outside of agriculture.

\(^{40}\) As we will see in the comparison to the basic need line in Chapter 6, 13 out of the 14 conventional farmers were above the basic need line if they obtained income from a small shop. These 93 percent is dramatically higher than the corresponding figure of below 35 percent for all conventional farmers. For the farmers who earn labor income, they are only marginally above this average at 55 percent. On the other hand, for bioRe farmers, if they earned labor income, they were actually below the average at the basic need line. Out of the 9 farmers, only 4 were above, amounting to 44 percent.
Figure 4.4: Conventional farmer earning additional income selling water in Sanga-Itinje
Income from Other Crops

Out of all the income subcategories listed in Table 4.19, the one where the least difference exists in means is in the sale from mungbeans. Mungbeans, discussed further in Chapter 5, has a special role in reducing absolute incidences of poverty by increasing the earning potential of farmers.\footnote{It was discovered early on in trials of the survey to be of great importance and conversations on the ground resulted in changing the survey to give it a more prominent role.} It also reduces inequalities that exist between small and large farmers, bioRe and conventional farmers, as well as wealthier and poorer households. This occurs as the crop can be sown on a relatively small area, with limited additional labor efforts nor expenses. Out of the 54 farmers that had income from mungbeans, 38 were above the basic need line. This 70 percent is significantly higher than the averages for all households.\footnote{For conventional farmers the figure lies at 50 percent of farmers with choroko income above the basic need line.} This number would fall to 33 farming households if they didn’t earn any income from mungbeans. The full potential of its equalizing power however is not realized until the next year, as so far only 20 conventional farmers were gaining income from mungbeans in the 2008-09 season, although 38 planted mungbeans in the 2009-10 season.

![Figure 4.5: Future Decisions on Mungbean by Conventional Farmers](image)

As shown in Figure 4.5, nearly all conventional farmers indicated that they would increase their production for the 2010-11 season stimulated by the high price: This
price increased from around 250 Tsh/kg in the 2007-08 season to nearly 2,000 Tsh per kg by the 2010/11 season. In the 2008-09 season for which this survey was done, it was at around 1,250 Tsh to 1,500 Tsh per kg. Out of the conventional farmers, 36 said that they would plant more mungbeans, whereas only 2 said that it would remain the same. No farmers said that they would plant less mungbeans, while five said that they do not know. In addition to increasing the mungbeans yields even more, 20 farmers said that they would increase the production by planting it by itself.

Although similar numbers exist for organic farmers, a key difference is that the conventional farmers are planning on increasing their mungbeans planting while decreasing their cotton production. This appears to indicate a momentous shift, considering the history of cotton as the sole cash crop in production in Meatu District described in Chapter 3. As seen in Figure 4.6, 19 non-bioRe farmers out of 51 farmers - equaling 37 percent - responded that they would decrease their cotton acreage. For bioRe farmers, only 17 out of 63 farmers - 27 percent - responded that they would do the same. BioRe farmers in general were much less certain about their production decision, with 19 out of 63 - 30 percent - indicating that they do not yet know (and will have to wait with making their decision). This figure was significantly lower with 11 out of 51 conventional farmers - 22 percent - indicating that they have yet to make their decision.

The main motivation for these decision making processes was based on the low cotton price received in the prior year compared to the high mungbean price. As a result, considerable flexibility remains based on price signals. For example, many farmers decided to still increase their cotton production in the aftermath of the very high prices they observed (yet failed to receive due to early selling) in the 2009-10 season.

4.3.4 Total Income per Contributing Household Member

The previous analysis focused on total income, where we found no statistically significant difference between organic and conventional farmers. However, as for net income from cotton, in order to answer Hypothesis 1.3 on larger total income, an adjustment
Figure 4.6: Future Decisions on Cotton by Farm Type

is necessary by contributing household members. The analysis of net income from cotton per contributing household member showed statistically significant differences in the distributions, with the mean being significantly larger for organic farmers. The same pattern fails to exist when observing differences in total income per contributing household members (see Figure 4.7).\textsuperscript{43}

\textsuperscript{43}As a matter of fact, a reversed picture emerges, where the organic farmers are exhibiting a positively skewed distribution. The conventional farmers’ histogram, on the other hand, approaches normality.
Figure 4.7: Histograms of Total Income per Contributing Household Member
Table 4.20: Descriptive Statistics on Total Income per Contributing Organic Household Member

<table>
<thead>
<tr>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>423,958</td>
<td>309,544</td>
<td>-41,166</td>
<td>1,627,000</td>
<td>1,668,166</td>
<td>347,257 to 500,660</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
</tr>
</thead>
<tbody>
<tr>
<td>130,216</td>
<td>238,063</td>
<td>336,114</td>
<td>535,600</td>
<td>1,066,952</td>
</tr>
</tbody>
</table>

n: 65

Table 4.21: Descriptive Statistics on Total Income per Contributing Conventional Household Member

<table>
<thead>
<tr>
<th>Mean</th>
<th>Std Dev</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>95 percent CL for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>432,546</td>
<td>529,040</td>
<td>31,950</td>
<td>2,300,200</td>
<td>2,268,250</td>
<td>280,587 to 584,504</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5th Pctl</th>
<th>25th Pctl</th>
<th>Median</th>
<th>75th Pctl</th>
<th>95th Pctl</th>
</tr>
</thead>
<tbody>
<tr>
<td>45,917</td>
<td>107,890</td>
<td>204,286</td>
<td>623,571</td>
<td>1,705,500</td>
</tr>
</tbody>
</table>

n: 49

The mean for the total income per contributing organic household member - at 423,958 Tsh - is nearly identical to the mean for the conventional households - at 432,546 Tsh. Although the median is nearly 60 percent larger - 336,114 Tsh for organic contributing household members - compared to 204,286 Tsh for conventional ones, the difference fails to be significant. This is due to wealthy conventional households which are reflected in the larger range and standard deviation (above the mean). ⁴⁴

Similar to the earlier observation on absolute total income, this distributions is explained by the two household types: those that are too poor to join bioRe and those that are less interested in earning the majority of their income via cotton production, obtaining it instead via the service sector (i.e. shop owners, teachers). ⁴⁵ This is confirmed furthermore when looking at the confidence limits for the mean. Not only is the lower limit of 280,587 Tsh for conventional farmers below the 347,257 Tsh lower limit for organic farmers. The upper limit of 584,504 Tsh is also above the 500,660 Tsh for organic farmers.

In summary, while the analysis reveals clear significantly larger net income from cotton per contributing household member for organic farming households, this difference

⁴⁴Furthermore, the distribution estimations show that contributing conventional household members are estimated to have higher incomes at both the 75th and the 95th percentile, while being lower at the 5th, 25th and the median.

⁴⁵Note that every single household actually planted cotton.
is not statistically significant when looking at the total income per contributing household member. The main explanation is that conventional households are not solely compromised of the poor, land-less class, but also of a class of shop-owners and other small entrepreneurs that place less value in cotton production overall.

4.4 Summary and Discussion

The first section analyzed the socio-economic differences of farming households. The results proved that organic farmers on average own larger farms and are also wealthier compared to their conventional counterparts. However, opposed to Hypothesis 1.1. and theory postulated by Rogers (2003), they are not better educated. This is a promising finding, given that organic agriculture is more knowledge- and labor-intensive, than capital-intensive compared to previous agricultural innovations.

The second section investigated who becomes an organic farmer using a logit and count model. It found that only percentage of land rented - as a measure of wealth - was consistently significant in explaining membership with bioRe. Since a minimum threshold exists of 3 acres for joining bioRe, this indicates that farmers are not self-selecting per se, but rather are selected using the above criteria. Furthermore, when replacing the binary of bioRe membership with a new dependent variable of years of membership, the results indicate that early adopters of organic agriculture have increased wealth and assets, although only increased land ownership and access was a strong indicator of longer membership consistently. In summary, answering Hypothesis 1.2, we consequently find that neither education of the household head nor farm size determines significantly the probabilities of a household joining bioRe. Wealthier farmers - as measured in fewer percentage of land rented - however have a consistently higher probability of joining bioRe. Furthermore, early adopters of bioRe are estimated to have higher assets, especially in terms of land ownership.

The third section investigated whether or not organic farmers are significantly wealthier in terms of net income and total income gained during the 2008-09 season.
The results confirm the hypothesis for net income from cotton per contributing household member, yet fail to show the same for total income. Even though cotton makes up around 50 percent of the average total income, the sample includes successful conventional households for whom agricultural income constitutes a less important income source.

One key finding consequently from testing the last Hypothesis 1.3 is that two groups of conventional farmers appear to exist that are located at opposite spectrum of a wealth strata. While the poor conventional households clearly are not able to join bioRe due to their lack of land ownership or access, the later shopowner-class opts out of organics by choice. This new finding consequently adds another dimension to the findings regarding self-selection in Hypothesis 1.2. It appears that while the selection for the majority of farmers is not based on self-selection, as land ownership seems to be the limiting factor, there clearly are a group of conventional farmers that are choosing not to become organic farmers due to the perceived lower profit to be obtained in cotton production overall.

In regards to inequality, the chapter produced interesting insights derived from the historic rise of mungbeans as a rival cash crop to cotton. Given its high price and low labor and land demands, it is postulated that it can act as a source of reducing income inequality, since it is planted with great enthusiasm by conventional farmers. The crop itself was at first introduced by bioRe as an organic method to take advantage of its nitrogen-fixing properties with the aim of improving soil fertility via intercropping it in cotton or planting it by itself. While the boom in mungbean price was unprecedented and fortuitous, the development highlights the fluidity in the ability for both certified organic and conventional farmers to benefit from the organic methods introduced in the region. Given that the study takes place in an environment of low input intensity, the following Chapter 5 investigates what differences exist when focusing not on ecological, as opposed to economic sustainability.
Chapter 5
Measuring Sustainability of Organic Agriculture

Organic agriculture, as a development strategy, often finds itself juxtaposed to perceived modern alternatives (such as industrial or biotechnological agriculture) (Novy et al. 2011). Given this contested arena, it is important to undertake any valuation as transparently as possible.¹ In order to answer the overarching research question on the sustainability of organic practices, the chapter includes a detailed walk-through of past work. This includes a review of agricultural sustainability indicators, the methodology and results of an operationalization of a measure of farm-level sustainability index. It is organized into four sections:

The first section 5.1 is an extension of the review of the literature on agricultural sustainability indicators started in Section 2.1.2 on page 24. This includes a discussion of common characteristics of the indicators, the importance of the scale of analysis, and the difference between top-down versus bottom-up approaches. It culminates in the development of context-specific indicators for the Meatu cotton farmers.

The second section 5.2 includes this operationalization of the work by Rigby et al. (2001) in order to answer Hypothesis 2.1 on whether or not organic farmers are achieving higher sustainability scores. Close attention is paid to the methodology and the scoring of the indicators - including its limitations - of the farm-level sustainability index that is created. Via four dimensions represented in a spider-net graph in Section 5.2.2, it answers also whether or not even poorer conventional farmers can achieve higher sustainability scores. This would be an indication that organic innovations trickle not just within, but also down social strata.

¹This call for transparency is heightened given that “[a]ny standardisation and evaluation method is value-laden, in that it carries implicit values due to the choices (e.g. of concepts and data) and fundamental assumptions of the researcher.” (Walter and Stützel 2009, p.1291)
The third section 5.3 includes the analysis of the aggregate index score via multiple regression analysis. In a first step, sustainability levels - as a dependent variable - are predicted. It tests if smaller farmers or earlier adopters are significant predictors of higher sustainability levels - as argued in Hypothesis 2.3. Using net income per acre as a dependent variable, a second multiple regression model is created to test if smaller farmers are also significant predictors of higher productivity.

The chapter ends with a discussion and summary, touching on some limitations and potential further avenues, including the development of a stochastic frontier model in order to measure the technical efficiency.

5.1 Review of Agricultural Sustainability Indicators

More than a decade ago, Jones (1995 cited in Rigby et al. 2001) identified over 386 divergent definitions of sustainable development. As stressed in the literature reviewed in section 2.1.2, given this overwhelming diversity, it is necessary to define at the start the normative positioning of any attempt at measuring sustainability (as advocated by Leach et al. 2010). Walter and Stützel (2009, p.1289) propose to keep it distinct from descriptive elements since “science and scientists play a dual role in the sustainability debate” (Walter and Stützel 2009, p.1289). Such a normative definition of sustainability usually draws on three main elements, including “the securing of particular standards of social equity, economic well-being or environmental quality” (Leach et al. 2010, p. 41).

2For sustainable agriculture, the list includes at least 70 definitions according to a review by Zhen and Routray (2003). Reed et al. (2006) also cites King et al. (2000), who argue that the work on sustainability indicators has become “... an industry of its own”, with Innes and Booher (1999, p.2 cited in Reed et al. 2006) going further in their critique, stating that “... millions of dollars and much time ... has been wasted on preparing national, state and local indicators reports that remain on the shelf gathering dust.” These cautionary words are kept in mind throughout this chapter. It however is also important to note that the reason for the dust gathering is likely to be explained by the inferior or divergent tools developed for assessing sustainability (Ness et al. 2007).

3As we will see later, this problem is especially heightened when entering such sensitive issues as scoring or weighting indicators: “The practice of predicting environmental impacts (and hence the sustainability of particular activities) invariably engages with conditions of complexity and uncertainty (Stirling 1999), which inevitably reinforces the subjective element of assessing sustainability” (Rigby et al. 2001, p.464).
Common Characteristics of Sustainability Indicators

These three strands are widely adopted in evaluations of agricultural sustainability, with the purpose of operationalizing a perceived holistic (yet vague) concept (Izac and Swift 1994). The review of the attributed benefits of sustainable agriculture by Rigby et al. (2001), on whom this research heavily draws, yielded three categories that are similar to the ones espoused by Leach et al. (2010). These categories summarize that sustainable agriculture improves farm-level social and economic sustainability, improves the wider social and economic sustainability, and results in increased yields and reduced losses. As discussed with their cited sources in Figure 6.1, sustainable agriculture is said to directly address the social equity and economic well-being via improved equity (Pretty 1995 cited by Rigby et al. 2001) and sustained profitability of farming (Pretty, 1995; US Farm Bill, 1990; Ikerd, 1993; cited by Rigby et al. 2001).4

A similar set of indicators are also proposed by Zhen and Routray (2003), who developed an operational measure of agricultural sustainability for developing countries (p.43). Their measure of sustainability is explicitly targeting the imperative of “maintain[ing] food production, while preserving the underlying resource base” (ibid., p.35). Derived from this maxim, they articulate five key attributes of the sustainable agriculture concept. These include an emphasis on intensive farming; maximizing internal

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4They differ, for example, in that they integrate the economic and social aspects across two levels of the farm and the community as a whole.
Table 5.1: Common Characteristics of Small-scale Farming Systems in Tropical Africa

Adopted from Izac and Swift (1994, p.106)

| Diverse production goals (e.g., feeding the family, meeting social obligations, achieving a target income) | ✓ |
| Communal responsibilities (e.g. communal labour) | ✓ |
| Poor infrastructure (most roads, schools, etc. provided by farmers themselves) | ✓ |
| Limited market access (poor roads and insufficient transport) | ✓ |
| Major constraints (e.g., unavailability of fertilizers and pesticides, uncertain policy environment, etc.) | ✓ |
| Vicious circle of poverty due to unsustainable agricultural practices | ✓ |
| Diminishing resource base (high population pressure, decrease of the fallow period) | ✓ |
| Small land area (0.5 - 5 ha) | ... |

and optimizing external resource usage; increasing efficiency and profitability in production (via increasing output, per capita products, and net farm income); conserving soil and water resources to support agricultural production over time; and inclusion of local knowledge and practices combined with innovative applications of resource conservation technologies (ibid., p.35).

Moving from a discussion of agricultural sustainability in developing nations to an African context, Izac and Swift (1994) offered one of the most cited sustainability measures for agriculture in sub-Saharan Africa. With a minimum focus on the cropping-system level, the farming-system level, and the village-catchment level – they argue that “a sustainable agroecosystem is one which has the capacity to respond to exogenous change as well as internal disruptions by maintaining non-declining trends in its resources and amenities over a period of at least one decade” (ibid., p. 105). Their understanding of common characteristics of small-scale farming systems in tropical Africa are listed in Table 5.1.

Out of these eight commonalities, three are especially applicable for Meatu District in rural Tanzania. These include that the small-scale farming systems, which in this case involves a form of mixed agriculture with cattle (see discussion in Chapter 4), is
often achieving diverse production goals and includes communal responsibilities (such as drawing on *Bukombakomba*). Four other characteristics are only applicable to a limited extent, as cotton farmers (for example) have ready market access for their cash crop, even though transportation costs are unusually high due to the remote location and poor road networks mentioned earlier. Although the unavailability of external inputs, such as fertilizers and pesticides, have been voiced as a major constraint by conventional farmers, organic farmers have much better access to their inputs. The organic contract (which runs over 5 years and includes an 80 percent purchase guarantee) serves to reduce policy uncertainty at the farm-level, although bioRe and ginners have experienced considerable policy shifts. Given the potential benefits of the introduction of organic agriculture, it also would be too simplistic to argue that they commonly experience vicious circles of poverty due to their unsustainable practices, especially in the context of receiving agricultural extension advice. Similarly, although population pressure has been said to be on the rise (especially noted via a shortage of grazing lands as a sign for a diminishing resource base), the household in general has access to large areas of land that are unusual for sub-Saharan Africa. Consequently, Izac and Swift’s point regarding the small land area (1.25 - 12.25 acres) appears less relevant, with the average land holding of around 80 acres per household (even though fertile, cultivatable land is usually considerably less).

Based on these characteristics, they define agricultural sustainability as a non-declining trend in output (Izac and Swift, 1994, p.107):

“A cropping system is sustainable if it has an acceptable level of production of harvestable yields which shows a non-declining trend from cropping cycle to cropping cycle over the long term.”

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5The study area is also marked by poor infrastructure, with heavily-used roads maintained marginally by the local governments but schools and hospitals often built with the aid of the community themselves.
Importance of Scale of Analysis

The quote above from Izac and Swift (1994) differs noticeably from the earlier definition by Zhen and Routray (2003) in regards to the scale of analysis. For this research, the farming system level (or farm-level) is key for two reasons. First, it is the level where production decisions are made based upon the existing capacities. Second, it is also the smallest (lowest) level where “biological, economic and social considerations are integrated” (ibid., p.110). At this level, declines in one field or with one crop are acceptable, as long as they are off-set by (long-term) gains in others.6

Addressing the question of the aim of sustainability, Izac and Swift (1994, p.107) implicitly appear to speak in favor of organic agriculture, if it could reduce the poverty of the individual farmer:

“Few would advocate the development of systems that are sustainable, highly protective of the environment, and conservative of natural resources yet maintain the individual farmer in poverty. It is equally clear that many of the means to increased productivity and profitability are now perceived by society at large as carrying too high a cost in social disruption, human inequality and environmental degradation. Scientific research cannot resolve these ethical issues, but an operational approach to sustainability must be able to provide options for resolving them.”

This quote emphasizes the additional need for the village-level analysis (or village-catchment area), where ecological, social and economic factors interact. One ecological example is the dispersion of pests or predators or the differing soil types found across villages in an area. A key social and economic example is the village, which still plays a large role in enforcing informal land rights, but also by organizing communal agricultural labor. Furthermore, and of importance for the Sukuma, communal grazing

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6Without increased land pressure, for example, traditional systems of shifting or fallow cultivation are quite applicable for this phenomenon, as noted by Izac and Swift (1994): while crop yields decline, due to lower soil fertility, and pest incidences increase in the cleared field, the fallow land experiences an increase in soil fertility and reduced pest presence.
areas are also often organized at this level (Izac and Swift 1994).\footnote{This is one reason to include village dummies in the statistical analyses.}

In general, evaluations and results of agricultural sustainability - especially organic agriculture - are sensitive to their scale of analysis, as positive effects are often observed beyond the farm-level (Rasul 1999, MacNeidhhee and Culleton 2000, Rossi and Nota 2000 cited in Zhen and Routray 2003). Although this research aims at assessing sustainability at the farm-level while observing differences across the villages, it fails to take into account any impacts beyond these levels.\footnote{Multiple levels could play a key role for example in assessing the complex impact of pesticide usage across the “aquatic and terrestrial ecosystems, on flora and fauna, and on mammals, birds, insects and microbial elements of ecosystems.” (Rigby et al. 2001, p.471, drawing on research by Levitan et al. 1995)}

Other noticeable efforts at measuring agricultural sustainability in Africa include Morse et al. (2001 cited in Zhen and Routray 2003) and Reed et al. (2006). Morse et al. (2001) developed sustainability indicators for a longitudinal research project in a Nigerian village. They distinguish between positive (sustainable) and negative (unsustainable) indicators. The positive ones include crop protection, water resources, labor participation, and credit provision. Negative ones include crop production - via the increased cultivation of legumes that result in lower soil quality - and a decline in firewood. Reed et al. (2006) developed an innovative method for an adaptive assessment of sustainability indicators via participatory methods based on their research in the Kalahari, Botswana.

### Top-down versus Bottom-up Indicators

Reed et al. (2006) also provide a descriptive breakdown in four steps of the two main methodological paradigms that are widely used in designing sustainability indicators (see Table 5.2). Contrasting the two methodological paradigms of top-down versus bottom-up approaches in Table 5.2, they highlight four steps usually undertaken for sustainability assessments. These include establishing context, followed by establishing sustainability goals and strategies. In Step 3, identification, evaluation and selection of indicators is undertaken while in a last stage, data is collected to monitor progress.
The differences exist between what to study (Step 1); how and by whom (Step 2 and 3); and a combination of both for looking to the future (Step 4).

![Breakdown of Top-down and Bottom-up Paradigms](image)

Figure 5.2: Breakdown of Top-down and Bottom-up Paradigms (adapted from Reed et al. 2006, p.409)

Noteworthy is the second step of setting the goals and strategies. The goals are set in a top-down approach often designed without a formal consultation of local communities, although consultations are possibly undertaken informally (Reed et al. 2006). In their bottom-up research in Botswana researchers held focus groups to gather indicators from within the community. These were evaluated based on accuracy and ease of use, with the resulting indicators empirically tested via ecological and soil sampling (Reed et al. 2006, p.410).

This bottom-up approach stands in stark contrast to top-down definitions of sustainability based on national data, which have been criticized for “miss[ing] critical sustainable development issues at the local level and may fail to measure what is important” (Reed et al. 2006 p.406). Bottom-up approaches that draw on stakeholders have the ability to measure phenomena that are relevant at the local scale. Integration of these local community extends towards developing indicators that are used to bring about (positive) change. This method also assists in communicating findings in an easy and effective manner to allow feedback of the stakeholders to flow back into the improvement of a sustainability indicator (Reed et al. 2006).

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9They provide an excellent table showing the criteria to evaluate sustainability indicators on p.411.
One of the key benefits of locally-grounded sustainability measurement is the ability to better adjust the score to the local particularities. One example would be via the establishment of threshold values of sustainable (levels of) pesticide or fertilizer usage. While laudable, there are three points of critique. First, in the case of Meatu District, as noted earlier, considerable variations continue to exist between farming locations, making classic threshold value unattractive. Second, the dominant paradigms of carrying capacities and nature-in-equilibrium have come under increasing assault, as ecosystem change is said to be better understood by studying it as a dynamic, non-linear pattern (Leach et al. 2010; Liverman et al. 1988 cited in Zhen and Routray 2003). Third, as discussed earlier, setting a scientific threshold on agricultural sustainability is often difficult, as even the application of synthetic fertilizer could be necessary in order to lift the productivity of the soil to levels where it could be sustained by continued application of organic manure. In general, critical impact levels or threshold values can be chosen, in addition to a participatory approach, based on international conventions existing in the policy arena or on scientific evidence. Walter and Stützel (2009) prefer drawing on scientists, arguing that “[a]lthough negotiated solutions and participatory techniques have become popular in the context of sustainability, they are inadequate when biophysical realities are involved, as these are not negotiable” (p.1291, emphasis added).

5.1.1 Criteria for Indicators

Ness et al. (2007) provide a good review of what sustainability indicators should achieve. First, they differentiate between indicators, which are “simple measures, most often quantitative that represent a state of economic, social and/or environmental development in a defined region”, and aggregate indicators forming indices (ibid., p.499). Indicators themselves are differentiated between condition indicators and trend indicators (Walker and Reuter 1996 cited in Zhen and Routray 2003), with the former assessing the current condition whereas the latter measuring change over time (ibid.,

10While this study is not using village-level threshold values, it also does not draw on dynamic, non-linear patterns explicitly given the limitation of just analyzing a one-year snapshot.
Based on the work by Dale and Beyeler (2001 cited in Zhen and Routray 2003), eight ideal criteria exist for selecting ecological indicators. These include that they are available and easy to measure, yet sensitive to stresses and changes over time. Furthermore, using time series or simulation modeling, a good indicator can “provide direct information about the future state and development of relevant socioeconomic and environmental variables” (Zhen and Routray 2003, p. 43). Besides using just a single indicator, composite indicators can be used to create an index, which would capture key environmental variables, such as “gradients across soils, vegetation types, temperature, space, and time” (Dale and Beyeler 2001, as cited in Zhen and Routray 2003, p.41). The farm-level sustainability index developed for this study aims to directly address these criteria, although given the snapshot in time, the temporal dynamics are missing.

Walter and Stützel (2009) create a three-step evaluation procedure for sustainability impact indicators. First, they design a standardization procedure. It involves normalizing the indicators by the total impact, with an additional step of adjusting the severity via comparison to a threshold. The second step involves a valuation procedure, used to assess the individual indicators on sustainability. This procedure should include a range within which a value is classified as sustainable and unsustainable. A third step includes drawing the conclusions and developing a strategy from these results. Often times, after this third step, the sustainability assessment returns to the first step to improve upon the identification and assignments of sustainability indicators chosen (ibid., p.1288-9).\footnote{Ness et al. (2007) also prefer forecasting tools.}

Walter and Stützel (2009) argue for using measurements of threats to sustainability (Smith and McDonald 1998 as cited in Walter and Stützel 2009) or constraints to sustainability (Stockle et al., 1994 as cited in Walter and Stützel 2009). These negative

\footnote{To contrast this three step program, Reed et al. (2006) provide a much more substantial adaptive learning process that involves 12 steps. This 12-step circular figure is much more useful for applied research, but not discussed here due to its level of detail and the fact that this study’s research design was developed prior to this main publication.}
indicators are preferred since “being less subject to differing perception” and “often more salient and policy relevant than positive impacts or ‘goods’” (Costanza, 1993, Ludwig et al. 1993, Jamieson, 1998 as cited in Walter and Stützel 2009, p.1289).

In addition, given that data quality is often incomplete or inferior for environmental data, methods exist to better understand the uncertainty existing within a model.\textsuperscript{13} Statistical methods often used to capture the observed changes include cluster analysis, principal components analysis, as well as less common detrended correspondence analysis or canonical correspondence analysis (Reed et al. 2006, p.411). Ness et al. (2007) further list conceptual modeling, multi-criteria analysis (MCA; see also Reed et al. 2006), risk and uncertainty analysis, vulnerability analysis, cost-benefit analysis (CBA), impact assessments (which include \textit{Environmental Impact Assessment} (EIA) and a newer, more comprehensive \textit{Sustainability Impact Assessment} (SIA)) as tools for assessing the criteria.

The indicators chosen for assessing farm-level sustainability in this research builds on a similar assessment of agricultural sustainability undertaken at the farm-level by Rigby et al. (2001).\textsuperscript{14} The indicators include four dimensions against which a farmer’s practice are scored. These are whether or not a farmer’s practice: \textit{Minimizes off-farm inputs; minimizes non-renewable inputs; maximizes natural biological processes; and promotes local biodiversity}. Rigby et al. (2001) use five categories for scoring the various farm practices. These are: \textit{Seed Sources; Soil Fertility; Pest/Disease Control; Weed Control; and Crop Management}. Since they were created with sub-scoring categories for a Western context, they were adjusted for African farmers in general, and the cotton farmers in Meatu in particular. Out of the five categories two were excluded. Seed source was excluded since farmers either are advised to purchase their seeds from conventional traders or co-ops, or have to purchase them from the organic contractors.

\textsuperscript{13}Walter and Stützel (2009) used a stochastic simulation approach using the GenStat statistical software package to evaluate different weighing schemes.

\textsuperscript{14}Rigby et al. (2001) farm-level index continues to be a premier example. Noticing how very few (published) farm-level sustainability assessments exist, they themselves drew on two exceptions of Taylor et al. (1993) and Gomez et al. (1996). One of the reasons for this lack of indicators are the usual strong objections voiced over various scoring decisions, but also the fact that businesses, for example, might prefer a ‘fuzzy concept’ of sustainability rather than a set indicator that “might show them up in a bad light” (Rigby et al., 2001, p. 465).
Although it would be possible, they are rarely reusing their own seeds and are uprooting their cotton each year.\textsuperscript{15} Given that farmers are not using herbicide, cover crops nor compost manure to kill weeds, the Weed Control section was not included.

To replace the two categories, a new Land Tenure variable was included. It distinguishes between farmers that are either owning or renting land which was highly significant as shown in Chapter 5. These two types of land tenure have a strong indirect impact on land management, since farmers who own land are minimizing off-farm inputs by engaging in crop rotation, whereas those that rent have reduced abilities to maximize natural biological processes and promote local biodiversity.\textsuperscript{16} The final four main categories, as listed in the Figure 5.3 below, are: Land Tenure; Soil Fertility; Pest/Disease Control; Crop Management.

<table>
<thead>
<tr>
<th>FARM PRACTICE</th>
<th>DIMENSION OF SUSTAINABILITY</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Management</td>
<td>Minimizes Off-Farm Inputs</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Minimizes Non-Renewable Inputs</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Maximizes Natural Biological Processes</td>
<td>-0.5</td>
</tr>
<tr>
<td></td>
<td>Promotes Local Biodiversity</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Rent</td>
<td>-1.5</td>
</tr>
<tr>
<td>Soil Fertility</td>
<td>Farm Yard Manure</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Combat Erosion (- if no problem)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Intercropping Maize</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-2</td>
</tr>
<tr>
<td>Pest/Disease Control</td>
<td>Sunflower</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biological Pesticides</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Conventional Pesticides</td>
<td>-0.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.5</td>
</tr>
<tr>
<td>Crop Management</td>
<td>Planting Time</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sowing in Rows</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Broadcasting</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crop Rotation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intercropping Chakki</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.3: Scoring of Dimension of Sustainability by Farm Practices

5.1.2 Scoring Criteria for Indicators

The scoring of each farm practice across the four dimensions is based on whether or not a given practice is considered to improve or reduce a farmer’s agricultural sustainability at the farm-level. Analogous to Rigby et al. (2001), the simple absolute scoring ranges between -1 to +1 points. In regards to interpretation, 0 could be ‘no significant impact’,

\textsuperscript{15}A small argument could be made here that organic seeds are better since they minimize non-renewable inputs as they are not coated with pesticides.

\textsuperscript{16}The reason being that people who rent are sometimes prohibited from actively employing certain biological pesticide strategies (i.e. sunflower) and have trouble in promoting local biodiversity since they tend to often mono-crop the land.
0.5 points indicating 'marginal impact', and 1.0 indicating 'significant impact'. This scoring is undertaken based on observed patterns of agricultural practice, rather than measuring their impacts.

First Dimension of Minimizing Off-Farm Inputs

The first dimension, which minimizes off-farm inputs, provides a negative score if a farmer needs access to certain inputs that are not available on his or her farm. Straightforward examples of negative scores are both conventional and biological pesticides, which are obtained from a trader or bioRe respectively. Biological pesticide, which in this case is pyrethrum, receives a lesser score since it is provided with an input-subsidy to the organic farmers. Another example are seeds, which both organic and conventional farmers need to obtain from outside. Broadcasting, which uses more seeds (to the tune of 10-12 kg/ac if broadcasting versus 4-6 kg/ac if sowing in rows), has a negative score, whereas sowing in rows has a positive score. The scoring is consequently undertaken not in isolation, but rather in relative positioning of the farming practice. Another example is the use of sunflower seeds (which a farmer has access to) as a biological pest management method. The scoring there however is only 0.5, since they are also offered by bioRe to the contract farmers if needed.

The remaining scores are based on the assumption that a farmer has improved soil fertility and thus would have a lower demand for (synthetic) fertilizer beyond his farm. These include the ownership of land (which allows for crop rotation), the application of farm yard manure (FYM), the rotation of crops, as well as intercropping (of mung-beans\(^\text{18}\)). Since this study takes place in a low-input environment, where synthetic fertilizer usage is very limited, the scoring reflects this. The assumption nevertheless is that farmers could potentially gain access to FYM outside of his household, even when he has no access to fertilizer. This scoring also is based upon the (potential or

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\(^{17}\) The negative, respectively, would be negative marginal impact for -0.5 for example.

\(^{18}\) An important caveat with the intercropping of mungbeans is that their nitrogen-fixing properties can only work if the corresponding necessary soil bacteria exist in the soil. According to observations by Morganti (personal comm. 2011), this was the case although variations exist in the number of nodules observed. This again highlights that it is impossible to measure and score all agricultural practices accurately.
future) demand for off-farm inputs, especially since a new government initiative – *Kilimo Kwanza* (trans: Farming First) – aims at providing synthetic fertilizer to them. Besides these four practices that increase soil fertility, the last variable, intercropping of maize, decreases it as it increases nutrient-demands of the soil.

**Second Dimension of Minimizing Non-Renewable Inputs**

The *second dimension*, which is closely related to the first, is to minimize non-renewable inputs. Under *Pest/Disease Control*, sunflower, which works by attracting (or so-called *pulling*) of pests, gets a high score, whereas synthetic pesticide gets a negative score. Highlighting the difference of the first dimension, however, we see that biological pesticides, which are an off-farm input, are a renewable input as they use pyrethrum sprays, which are made from the dried heads of the Chrysanthemum flower. Another renewable input, for example, is FYM. Furthermore, crop rotation and intercropping both are minimizing the use of non-renewable inputs as they are enhancing soil fertility without the use of synthetic pesticide. All these benefits however are not scored very strongly, since farmers have limited to no access to external synthetic fertilizer.

**Third Dimension of Maximizing Natural Biological Processes**

The *third dimension* relates to maximizing the natural biological processes. In this case, it also includes any expected increase in yield. As such, for example, rent has a negative impact on maximizing natural biological processes, since a couple farmers have stated that they are prohibited or discouraged from planting sunflowers. FYM and combating soil erosion (measured only if a farmer had a prior soil erosion problem) have a positive impact, whereas intercropping maize is negative. Sunflower is the classic example of an agricultural practice that draws on natural biological processes to do a job that otherwise could be done by conventional pesticides. Biological pesticides, on the other hand, while in theory a strong pesticide, is applied only after scouting for pests in the field. Since its directed application furthermore increases yields, it receives

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19 Rigby et al. (2001) focus on the existence of knowledge of natural biological processes.
a very small positive value on maximizing natural biological processes. It also tends not to kill as many pests.\textsuperscript{20} On the other hand, conventional pesticides have a negative impact, as they are applied more liberally, without supervision as is the case in organic applications. It kills many more than just the target insects. Rigby et al. (2001) score it as -3, which is much stronger than the -1 chosen here. This is due to the fact that farmers often apply pesticide only once, yet increase yields as a trade-off.

With crop management, farmers that plant early are best set to take advantage of the early rainfalls.\textsuperscript{21} Furthermore, farmers who are sowing in rows are taking more evenly advantage of the existing settings, compared to broadcasted cotton. Similarly, crop rotation and intercropping mungbeans draws on natural biological processes to increase yield and soil fertility both in the short- and longer-run.

\textbf{Fourth Dimension of Promoting Local Biodiversity}

The \textit{fourth dimension} is based on whether or not the practice increases local biodiversity. Since farmers who rent are more likely to monocrop or fail to engage in crop rotations, we would expect it to have a negative impact on biodiversity. Sunflower planting, on the other hand, increases biodiversity (as it also provides a habitat for beneficial insects). Biological pesticides and the stronger conventional pesticides decrease it, although at different magnitudes. Finally intercropping in general, and intercropping mungbeans increases it significantly.

\textsuperscript{20}Farmers memorably recounted during the surveys that using the sprays, “wadudu wamechelewatu” (trans: the pests are just getting drunk).

\textsuperscript{21}This point however is quite contentious. As research by Hankins (1973) showed, the push by the government to have farmers plant early was based on findings of their research stations, which did not translate well into the practices employed by Sukuma farmers. As a matter of fact, although presented as in need of ‘modernizing’, Sukuma farmers were behaving quite rational in their planting decisions and adoption of extensive agricultural methods.
5.2 Farm-Level Sustainability Index

This section builds on the above condition indicators in order to answer the research question on the sustainability levels within and between organic and conventional farmers. There are three parts to this section. First is a discussion of the farm-level sustainability index. Second is the comparison of sustainability scores by type of farmer. It includes a comparison of the average organic and conventional farmers (Hypothesis 2.1), as well as the best and worst performing farmers from the respective groups in order to highlight the ability for even poor conventional farmers to adopt the methods (Hypothesis 2.2). The third section attempts to predict farm-level sustainability using a multiple regression model and agronomic categories of farm size in order to answer Hypothesis 2.3. It also includes a similar model predicting not only agricultural sustainability - or efficiency - but also productivity. This draws back to the findings from Netting (1993) and others that small-scale farmers tend to be more efficient and productive as observed in contrast to industrial agriculture. In this case, the contrast is to certified organic agriculture.

5.2.1 Description of Farm-Level Sustainability Index

Building on Zhen and Routray (2003), this index draws on the condition indicators discussed in the previous section, as it describes not a trend, but rather a desired state where adoption of organic methods have the aim of increasing ecological sustainability.22 The valuation of the scoring of the index draws on expert knowledge (as proposed as a validation technique by Rigby et al. (2001)), as opposed to giving larger weight to the knowledge of farmers (Reed et al. 2006). The index however aims to draw on bottom-up approaches by including and sharing findings with local stakeholders, with a clear aim to develop it as a practical tool to guide and improve organic cotton

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22 An analysis of trends, however, is undertaken by the bioRe field staff using a shortened version of the farm-level sustainability index evaluated over the years. Discussions with the staff revealed that the scoring differed only minimally from the scoring used here. It also is important to highlight that although we do not know the impact of organic methods, the assumption used for scoring is the same as the assumption used for diffusing and teaching these methods in the first place, which is based on scientific evidence from other case studies.
Furthermore, given that in certain areas there is a low-adoption of specific organic techniques, this can serve as an opportunity for re-evaluating the weighting (or even scoring) of the measures. As such, it aims to fill the gap between the top-down and bottom-up paradigms described by Reed et al. (2006 citing Batterbury et al. 1997, Nygren, 1999, Thomas and Twyman 2004) and “to develop innovative hybrid methodologies to capture both knowledge repertoires” (p.407). It also aims to provide a framework for organic farming assessments in sub-Saharan Africa that addresses an existing contradiction within sustainability assessment tools. In the words of Ness et al. (2007, p.506):

“On the one hand there is the demand for approaches that have more specific assessment performance, meaning among other things are more case- and site-specific. At the same time there exists the demand for tools that are broader in order to be accessible to a wide user group for differing case circumstances.” (emphasis theirs)

Against the recommendation by Walter and Stützel (2009, p.1289), this index draws on both positive and negative impacts of certain agricultural methods on sustainability. It is based on the belief that sustainability is accurately measured when accounting for both positives and negatives. Walter and Stützel (2009, p.1291) themselves provide a telling clarification:

“Note that the class 'sustainable' should, strictly speaking, be named 'not unsustainable', because conceptually the method assesses constraints or limitations to sustainability, not sustainability as such. Absence of known constraints to sustainability, as measured with impact indicators, does not allow for inferences regarding the sustainability of a system, because other

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23 Based upon this index, bioRe Tanzania has developed a similar, simplified measure that was observed across the years and used to assist extension officers and individual farmers, as well as providing an indication of potential and improvements. The goal, however, is not solely to achieve a specific score (given the limitations of the scoring itself), but rather to observe positive trends, as proposed by Reed et al. (2006, p.410) and in accordance with the definition of sustainability by Izac and Swift (1994, p.107) listed earlier. A focus group with farmers has shown that not only does the index correlate with the farmer’s perception of which year he performed best and worst ecologically, it also showed that the individual weighting was similar.
constraints may not yet be known. The term 'sustainable', although less precise, is here used for reasons of simplicity."

The index also does not use any threshold setting (as for example advocated for by Walter and Stützel 2009 and discussed earlier). It however would be conceivable and practical, in an additional step, to create a critical level of sustainability based on organic certification standards as a proxy - in that measuring actual ecological improvements is not feasible.\footnote{See also Rigby et al. (2001, p.465) for a discussion of the trade-off between the quality of the proxy measure and how easy it is for monitoring it.} This however could be misleading, as these standards are political and were chosen as result of negotiations rather than solely on scientific sustainability criteria. Furthermore, this would run the danger of creating a tautology\footnote{Rigby et al. (2001, p.472) describe the tautology in that “[f]or example, scoring inputs prohibited under organic regulations as ’bad’ and scoring those allowed/encouraged as ’good’, and then producing a result in which organic farms are declared ’more environmentally friendly’ is clearly a self-fulfilling prophecy. This danger of tautology is avoided here because it is not simply the case that organic-approved inputs score uniformly well and those prohibited score uniformly badly. As discussed above, differentiated scoring of synthetic inputs means fertilizers are scored very differently from pesticides, with pesticide scoring more than twice as heavily.”} where this index is just measuring sustainability setting it equal to organic certification.\footnote{bioRe has developed a measure where they categorize the farmers into three risk groups to assess their likelihood of decertification.} As discussed earlier, this would run counter to the index’s aim of critically comparing sustainability within and between organic and conventional farmers.

Given the emphasis on organic versus conventional farmers, the previous index created by Rigby et al. (2001) is adjusted to a local, non-Western context. Similar to their research (Rigby et al. 2001, p.468), this index is based on one last of the three categories of agricultural sustainability outlined in Table 5.1 on increased yields and reduced losses. The scoring takes place across four dimensions and four farm practices. Creating a cumulative index, analogous to Rigby et al. (2001), these scoring methods yield the following possible point distribution, as illustrated in Figure 5.4.

This index builds on existing scientific evidence as much as possible, including the consultation of an organic expert familiar with the region. The evidence chosen here, however, is assumed to be incomplete. As Walter and Stützel (2009) themselves acknowledge on a related discussion of establishing critical impact levels: “[…] it is
important to note that scientifically chosen critical impact levels are not free of values either. However, they are rooted in broader discussions within the pertinent disciplines and are subject to the usual mechanisms of scientific quality control (e.g. peer reviewing)” (p.1291). Weighing the index (i.e. in this case land management versus soil fertility vs pest/disease control vs crop management), involves similar judgement calls that can only partially be derived with the assistance of previous research findings that need to be adjusted to the local context (ibid., p.1292). Rigby et al. (2001) discuss explicitly the incommensurability of indicators and find that weighing their indicators would improve the legibility only minimally at the cost of reducing transparency. The index developed here follows that same logic.27

The derived sustainability index includes, as advocated by Walter and Stützel (2009) and applied by Rigby et al. (2001) and Morse et al. (2001), a range which allows for classifying individual dimensions of sustainability as sustainable (positive values) or not sustainable (negative values). This works best at the level of the individual indicator

27It involves three categories that are between 22 to 39 percent respectively of the total index, with one single indicator (Land Tenure) amounting to only 9 percent. Rigby et al. (2001) had five indicators, with four between 21 to 26 percent and the fifth measuring only 5 percent.
of farm practice, worse at the level of the dimension, and worst at aggregate level of the index as a whole due to the non-substitutability of the scores. Sowing in rows, which for example has a positive impact (of +2) on sustainability by minimizing off-farm inputs and maximizing natural biological processes, can not substitute for the negative impact of conventional pesticides. Pesticides work in addition at the level of maximizing non-renewable inputs and promoting local biodiversity.

This issue of lack of substitutability is furthermore enhanced by the fact that the indicators chosen were readily available. As such, any weighing, based on theoretical reasons, is less feasible, given the data-driven nature of the indicators and subsequent index. For example, if we would have an additional 6 measures of crop management practices, we would potentially have an even larger score for this category compared to the other three. While the reason a larger emphasis would be placed on collecting six additional measures clearly would be partially based on their importance towards sustainable agriculture, it nevertheless would fail to reflect the relative importance. Soil fertility, which is one of the most time- and cost-consuming elements to measure, for example, is much more difficult to expand upon.28

Reflecting the above weaknesses, there is a “considerable debate about whether or not to aggregate data into easy-to-communicate indices or to simply present data in table form drawing attention to key indicators” (Reed et al. 2006, p.413). As a result, the farm-level sustainability index is presented as both a total score (as used in the analyses in Section 5.3 on Predicting Farm-Level Sustainability below), but also illustrated via spider graphs that display each farm practice individually (see also Rigby et al. 2001). While alternate illustrations exist (including sustainability polygons, kite diagrams, barometers, etc.), sustainability webs have been used as early as Bockstaller et al. 1997 (cited in Reed et al. 2006) and form the basis of this assessment. These spider-web illustrations do not need weighing, since they reflect both the absolute score and their relative importance in what ultimately would be the designed index.

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28 Although the classification of a certain farm practice by itself is ambiguous, as intercropping mung-beans (choroko) could be placed in the soil fertility category when evaluating based on the perceived positive impacts on minimizing off-farm inputs and non-renewable inputs.
5.2.2 Comparison of Sustainability Score by Type of Farmer

This section illustrates and analyzes the differences in sustainability scores between the farmer types with the use of three unique spider graphs in order to answer Hypothesis 2.1 and 2.2.

A spider graph represents the farm practices and the respective total score in each according to the four sustainability dimensions used. It displays both the absolute score, but also highlights the relative score compared to the other farm type. The number in the square brackets highlights the weights of each respective practice: Crop management is the largest, with a possible total score of 10.5, equaling 39 percent. Pest and Disease Management equals to 30 percent, or 8 points. Soil fertility is 6 points, equaling 22 percent of the total score. The smallest category, land management, equals to only 9 percent of the total score, with own and rent adding up to a 2.5 points range.

![Figure 5.5: Spider Graph of Average Sustainability Score](image)

Figure 5.5: Spider Graph of Average Sustainability Score
Spider Graph of Average Farmer

Looking at the mean levels in the first spider graph in Figure 5.5, organic farmers, as expected, are outscoring the average conventional farmer on all dimensions. The highest absolute scores for organic farm practices are achieved in the pest and disease management category, as well as land management. In both of them, the corresponding conventional score is much lower, although for conventional farmers land management is the highest absolute score. In soil management, organic farmers also score higher than 50 percent of the possible score. Conventional farmers are scoring similar levels to pest and disease management, although the difference is much smaller compared to organic in the latter. Finally, on crop management, which includes whether or not farmers are sowing in rows or broadcasting, both organic and conventional farmers are scoring very low, below the 50 percent market. This is attributable to the fact that no clear difference exists between organic and conventional farmers in terms of broadcasting (which the vast majority does in both categories). In summary, the spider graph reveals that the average organic farmers, as a group, achieves higher sustainability scores than conventional counterparts as hypothesized in Section 2.2.2.

Figure 5.6: Spider Graph of Top and Bottom 5 sustainability score
Table 5.2: Comparison of Strata by Top 5 and Bottom 5 Farmers

<table>
<thead>
<tr>
<th>Means</th>
<th>Contr Member</th>
<th>No Wives</th>
<th>Cattle</th>
<th>Sheep and Goats</th>
<th>Cotton (kg) sold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom 5 Organic Std Deviation</td>
<td>4.2</td>
<td>1.0</td>
<td>75.2</td>
<td>62.8</td>
<td>2454.2</td>
</tr>
<tr>
<td>Top 5 Conv Std Deviation</td>
<td>2.6</td>
<td>1.0</td>
<td>12.6</td>
<td>28.2</td>
<td>1990.0</td>
</tr>
</tbody>
</table>

**Spider Graph of Top and Bottom 5 Farmers**

The second spider graph in Figure 5.6 is testing how stable these differences are when looking at upper conventional and lower organic farm-level efficiency extremes. Contrasting these levels with the scores obtained by looking at the 5 highest conventional and 5 lowest organic farmer scores, highest scoring conventional farmers are actually getting higher scores than the lowest scoring organic farmers in two cases: crop and soil management. For land tenure or management, the lowest organic scoring farmers are still having higher scores than the conventional, since organic farmers need to own land in order to join bioRe (or possibly rent from certified organic family members). In pest control and disease management, the difference between organic and conventional farmers is also non-existent, as few conventional farmers use pesticides in the first place and many have started to adopt using sunflowers. In organic, again, since the farmers are forbidden to use chemical pesticides, high scores are observed by default. This means that out of the five lowest scoring organic farmers, none of them have used chemicals nor biological pesticides, nor sunflowers. Thus the average is exactly 0.5 (see Figure 5.4 above) or 0 points in the range from -4 to 4 out of all possible values.

Where the best conventional farmers are outscoring organic farmers substantially is in soil and crop management. As a matter of fact, on these two categories, their scores are not only between 1.5 to 3 times higher than the worst organic farmers, but also above the means of organic farmers in the first spider graph. Since one of the largest concerns within organic agriculture is the improvement of soil and crop management techniques, this serves as evidence that, contrary to Rogers (2003), the adoption of the innovation does not solely trickle across, but also down respective social strata.

As illustrated in Table 5.2, the bottom organic farmers still have larger contributing
household members, cattle, sheep and goats, as well as total amount of cotton sold. As indicated by the standard deviations, however, this finding needs a qualification: Socio-economic dimensions surrounding the household are much more stable. Contributing household members are clearly more available for organic farmers. All conventional farm household heads only have one wife (see standard deviation of 0), yet one of the bottom organic farmers has no wife while another has two. This consequently results in a considerable spread.

Regarding livestock, organic farmers again hold significantly more cattle, when just comparing the means of 75 cattle head versus 12 for the best conventional farmers. The largest conventional farmer has a mere 25 cattle, with the lowest having 6. One farmer that has 300 cattle is in the bottom 5 organic group, thus resulting in the high standard deviation. The lowest number of cattle held, respectively, is 16 and 17 cattle by the organic farmers. Overall, while clear absolute differences exist, all conventional farmers, as was hypothesized, have at least a minimum number of cattle they own themselves for their production. At the other extreme, the fact that one organic farmer has 300 cattle yet a very low sustainability provides some support towards the thesis that trade-offs exist between large cattle owners and their relative interest or importance of their organic production, which is discussed further in Section 5.3. Regarding sheep and goats, however, no clear difference exists, as the higher number by organic farmers is due to a much larger range, with the median slightly higher for conventional farmers at 30 sheep and goats versus the conventional counterpart at 19.

Finally, there is some evidence that cotton, in terms of kilograms sold, was higher for the organic farmers, with around 20 percent less cotton sold by the conventional farmers. In sum, although considerable variation exists within and between the groups of farmers, conventional farmers who are achieving higher sustainability scores appear to be on average significantly below their organic counterparts across all three individual dimensions of strata - social, livestock, and income - considered here. This answers Hypothesis 2.2 in that organic innovations trickle down social strata, with successful adoption of organic methods not hinging solely on elements such as the relative abundance of a diverse range of capital. Poorer farmers seem to be equally able to
adopt methods - if seen beneficial to them - as wealthier ones, even if the former are non-certified organic.

Figure 5.7: Spider Graph of Highest and Lowest Individual Farmer

**Spider Graph on Highest and Lowest Individual Farmer**

Finally, the third spider graph – Figure 5.7 – is looking at the lowest total score of any organic farmer versus the highest score of any conventional farmer split into the four dimensions. This particular organic farmer is not adopting any improved crop management methods, while broadcasting his cotton. Furthermore, he has a very poor soil fertility practices, as he is intercropping maize. He however is combating his soil erosion problems.

The highest scoring conventional farmer, on the other hand, owns all the land he farms. He does not use biological, nor conventional pesticides, yet uses sunflower as a trap crop, thus giving him a very high score on pest and disease management. Furthermore, although having only sown his cotton in rows the year prior, he engages in crop rotation. He however fails to intercrop mungbeans, which gives him a low crop management score. Soil management scores are very high, since he uses FYM, combats
soil erosion and does not intercrop maize. These results provide some additional information regarding the fluidity that exists between certified organic and conventional farmers in the region, a topic that will be analyzed statistically in the next section.

Summary

In sum, these three spider graphs illustrate how organic farmers clearly have a much higher score on land management, as they are by default owners of land if they join bioRe project. This reinforces the earlier findings from Chapter 4, where land (either ownership or as percent rented) was the key factor determining membership. However, given that many of the methods are adoptable by conventional farmers, the boundaries between them are much more fluid and adoption might be motivated more by incentives and available land than lack of knowledge or access to it. A good example is the poor soil management scores of both types of farmers, with the exception of the best-performing conventional farmer. 29

Few farmers are using FYM, which, drawing on a Boserupian logic (i.e. Boserup 1965), one would expect high FYM adoption in a situation where population densities increase alongside with resultant pressure on the land. Farmers who do not feel such pressured by land shortages have few incentives to adopt this intensive practice. 30

29On this issue he is an outlier as explained by the following. This particular individual’s father is a bioRe farmer, whereas the son was a member of the local co-op. When asked where he learned his agricultural techniques from (he even stated that the year before the survey, he sowed some acres in rows), the answer predominantly was from mzee - his father. This particular survey also revealed some of the issues at hand. Undertaken as one of the first of the 120+ surveys, the original idea was to interview his father. Since the father was not around (and is reaching a very senior age), usually his sons were assisting in answering the questions as they are working the fields. While as a general rule, both father and son should be with bioRe (especially if they share fields as a so-called household producer), thirty minutes into the interview, it became clear that the son actually was not a bioRe member. Thus the entire survey was redone to ensure that only the son’s fields and his work were included in the study as opposed to the father’s. Nevertheless, even when careful attention is paid, it still will be difficult to draw clear lines (especially as agricultural tools are shared). Also, in some cases, this conflict might have been less apparent or not revealed itself and thus could have gone unnoticed. However, to double-check, each farmer that was said to be bioRe producer, was compared to the databank and the extension reports on hand in the bioRe office.

30A review of the historical literature on agricultural development, as discussed in Chapter 3, finds that intensification measures, of which FYM application would be a key component, have been practiced by the Wasukuma dating as far back as prior to the arrivals of Europeans. Due to ongoing warfare and conflicts amongst tribes, the Wasukuma lived isolated and experienced high population densities, thus resulting in the intensive management of their small farm land. With the arrival of the Germans, they were said to have succeeded in pacifying the area and reducing the inter-tribal struggles, thus reducing
a matter of fact, the previous two variables explaining who is an organic farmer \textit{(acres owned} and \textit{ox ploughs}) highlight a common phenomenon noted by field staff: successful organic farmers are able to expand their production via extensification aided by additional purchases of land. Regarding Netting (1993) finding that small-scale farmers are engaging in more intensive operation, the data is not sufficient to make any conclusions on this given that the acreage was not adjusted for population density. In the next section, however, a greater focus is placed on assessing the role land size - as opposed to just wealth - plays in achieving high efficiency - agricultural sustainability score - and profitability - net income per acre.

5.3 Predicting Farm-Level Sustainability

In this section, the analysis on sustainability is expanded by predicting the cumulative index scores based on key agronomic indicators. In a first step, it aims to statistically confirm the previous findings in regards to Hypothesis 2.1 and 2.2. In addition, the analyses takes into account early adopters and smaller farmers. Starting with a breakdown between bioRe and non-bioRe farmers, analyzing 116 of our farmers and their sustainability levels, bioRe farmers are found to have a significantly higher score than the conventional farmers.\footnote{The reason for drawing on only 116 is that four farmers had missing information on how much cotton that they planted and thus were excluded. Out of all the remaining farmers, one non-bioRe farmer was excluded as he had over 200 acres and a tremendous amount of sheep and goats, which resulted in him being both an outlier that also had significant leverage. With him included, however, the coefficient and their significance did not change dramatically. For the distribution of the shares of sustainability scores, only 112 farmers were used.}

Observing the spread of the distribution of the shares of sustainability scores broken up by conventional and organic farmers in Figure 5.8, we see that most organic farmers...
have significantly higher scores, whereas much variation exists amongst conventional farmers. Rigby et al. (2001) found that 18 out of 80 organic producers - equalling 22.5 percent - had scores below the highest conventional producer. Since in this case, the conventional farmer (discussed in spider graph in Figure 6.7) has a very high score (0.66), 55 percent of the organic farmers fall below that highest scoring conventional producer. This confirms the earlier analysis (as seen in Figure 5.6 and Figure 5.7) of high fluidity of organic adoption across organic and conventional farmers.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.60</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Being a bioRe farmer</td>
<td>10.51</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Total Acreage Owned</td>
<td>0.03196</td>
<td>0.0225</td>
</tr>
<tr>
<td>bioRe: Total Acreage Owned</td>
<td>-0.02987</td>
<td>0.0323</td>
</tr>
<tr>
<td>Cotton Acreage</td>
<td>-0.11</td>
<td>0.2567</td>
</tr>
<tr>
<td>bioRe: Cotton Acreage</td>
<td>-0.02</td>
<td>0.8608</td>
</tr>
<tr>
<td>Income from Cotton (in 1000 Tsh)</td>
<td>0.0010</td>
<td>0.0680</td>
</tr>
<tr>
<td>Number of Cattle</td>
<td>-0.003</td>
<td>0.8260</td>
</tr>
<tr>
<td>Number of Sheep and Goats</td>
<td>-0.013</td>
<td>0.4260</td>
</tr>
</tbody>
</table>

Figure 5.8: Distribution of Shares of Sustainability Scores

Figure 5.9: Model predicting Sustainability Levels
Multiple Regression Model: Sustainability Levels

Breaking the analysis down via a multiple regression model – Figure 5.9\textsuperscript{32} – shows how these scores are impacted by three key dimensions of agriculture: acreages owned and planted; income obtained by cotton; and number of livestock owned. As seen observing the intercept, holding all things equal, a conventional farmer scores 7.60 points on the sustainability score, whereas an organic farmer is obtaining an additional boost to his score of 10.51, which yields a score of 18.11 to start. This high significance of the dummy for bioRe confirms Hypothesis 2.1 that organic farmers as a group achieve higher sustainability scores in general. Moving to an analysis of the independent variables, the interesting pattern is that amongst bioRe farmers, there is also much less variation. For example, as seen in the case of total acreage owned, while the sustainability score is increasing for conventional farmers by 0.03 per acre (which for example would yield an additional 1.5 points on the score at 50 acres of land), for the bioRe farmers there is on average no added benefit of having higher amounts of land available. For a bioRe farmer, the exact amount of each additional acre is $0.03196 - 0.02987 = 0.00209$ points per acre, which is minuscule, as a farmer with even 250 acres would have a lower score by 0.5 points.

The full equation for conventional farmers is as follows:

\[
Sustainability_{\text{conventional}} = 7.60 + 0.03 \cdot Acres_{\text{Owned}} - 0.11 \cdot Cotton_{\text{Acreage}} \\
+ 0.0010 \cdot Income_{\text{cotton}} - 0.003 \cdot Cattle - 0.013 \cdot SheepGoats 
\] (5.1)

The full equation for bioRe farmers reads as follows:

\[
Sustainability_{\text{bioRe}} = 18.11 + 0.00209 \cdot Acres_{\text{ Owned}} - 0.13 \cdot Cotton_{\text{Acreage}} \\
+ 0.0010 \cdot Income_{\text{cotton}} - 0.003 \cdot Cattle - 0.013 \cdot SheepGoats 
\] (5.2)

A logical explanation for such a pattern is that fundamental organic methods that necessitate a large amount of land, i.e. crop rotation, are a mandatory practice in

\textsuperscript{32}Note that two farmers were dropped as they had missing information
organic contract farming and a precondition for certification. On the other hand, the
opposite impact of planting a large area of cotton for conventional farmers is found.
Larger cotton farmers have lower scores, which is indicative of the well-known trend
that small-scale farmers are often operating more efficiently or sustainably (see Netting
(1993)). This is evidence towards confirming Hypothesis 2.3 that smaller farmers have
higher sustainability scores.

This pattern is slightly offset in that farmers who are making more income from
cotton are achieving higher sustainability scores, which seems to partially capture the
positive relationship between *higher productivity* and *net efficiency*. Regarding organic
and conventional farmers, the cotton acreage *per se* only marginally reduces their sus-
tainability levels (see 0.11 and 0.02 coefficient). Both of these coefficients, especially
the interaction term, are not individually significant.

Finally, opposed to conventional wisdom in organic circles (especially findings from
research on the Indian bioRe case study where animal manure is used frequently),
higher number of livestock, especially cattle, does not appear to have a positive impact
on the sustainability levels (i.e. via organic manure availability). As a matter of fact,
although insignificant statistically, cattle is hinting at having a negative impact on
the score, if at all. Correlations of cattle estimate with total acreage or income from
cotton sold also revealed that there are no high correlations that would reduce either
variable’s significance. This appears to reflect the rising conflict between cattle and
cotton, as farmers holding large livestock travel further in search for grazing land.
According to conversations with bioRe management, this comes often at the cost of
timely planting of cotton. Another possible explanation for the negative relationship is
that organic cotton farmers with many cattle are less likely to have incentives to adopt
the most sustainable or productivity-increasing management methods possible\(^{33}\), since
they already are obtaining a minimum income from cattle (which they also can rely
upon as a safety net; Dercon 2009)\(^{34}\). Sheep and goats are also negative yet strongly

\(^{33}\) An alternate regression model which would model this pattern via adding a quadratic term for
cattle was not significant. The number of cattle after a certain number are actually having a negative
effect.

\(^{34}\) This factor was explicitly discussed in a focus group in 2011, trying to understand who was best
One calculation that was not undertaken given the model’s focus on the farm-level, is to compare the average sustainability score obtained at the village level. The purpose of such a descriptive comparison is to contrast it with the average years of bioRe membership that exists in the six villages included in the study. A similar analysis is undertaken in Section G on page 286 in regards to multidimensional poverty score. This focus on the years of membership allows us to test if early adopters of organic agriculture are achieving higher sustainability scores, as stated in Hypothesis 2.3 based on the assumption that there is a learning-by-doing effect.

Figure 5.10 shows the relationship existing across the averages at the village-level.

![Figure 5.10: Relationship between Average Years with bioRe and Total Sustainability Score](image)

It clearly demonstrates a positive trend of increasing scores while moving along the time axis. Both a linear best fit line and a quadratic best fit curve are drawn. Given that the village with the lowest average years with bioRe – Mwananongu – has able to take advantage of the high cotton prices in 2010. The farmers drew a graph showing the monthly fluctuations, which highlighted that cattle prices were reaching their peak levels towards the end of the cotton purchasing season in the months of August and September. There was however considerable discussion whether or not a farmer would sell cattle if occurring a loss due to declining prices. Although they acknowledged that it would make financially sense (given the timing of the high and low cattle prices, the consensus seemed to be that families would cut back on consumption instead of selling cattle.
Table 5.3: Pest Management Scores by Village

<table>
<thead>
<tr>
<th>Village</th>
<th>Pest Management Score</th>
<th>Share of Total Score (in percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minyanda</td>
<td>6.03</td>
<td>37.24</td>
</tr>
<tr>
<td>Mwanyahina</td>
<td>4.88</td>
<td>37.28</td>
</tr>
<tr>
<td>Mwamishali</td>
<td>4.65</td>
<td>34.89</td>
</tr>
<tr>
<td>Sanga-Itinje</td>
<td>5.08</td>
<td>43.23</td>
</tr>
<tr>
<td>Kabondo</td>
<td>5.2</td>
<td>37.20</td>
</tr>
<tr>
<td>Mwamanongu</td>
<td>3.31</td>
<td>27.93</td>
</tr>
</tbody>
</table>

also the lowest score, whereas the village with the highest score has also the highest average number of years – Minyanda – a linear fit line works very well. However, since the second youngest village – Kabondo – achieves a high average score, a quadratic curve provides a superior fit, indicating the increasing returns to learning or adoption over time. The highest scoring village – Minyanda – is a powerful influencer as seen by it being clearly the only one above the mean of 13.25. In sum, although purely observational, the differences are quite stark between the villages and provide evidence towards early adopters having higher sustainability scores.

Alternate explanations however exist for the observed pattern (including for example larger yet more arid land availability). One specific agro-ecological aspect that was investigated in the field work for the lower scoring in Mwamanongu was potentially related to agro-ecological reasons. Focus groups and discussions with the field staff revealed that there appears to be a lower presence of pests than in the other villages. As a result, their substantially and significantly lower score on pest management compared to the other villages could at least be partially attributed to that (see Table 5.3). Not only is Mwamanongu village’s pest management score of 3.31 significantly lower than each other village, it also only contributes to 28 percent of the total score, which is around 7 percent below the next lowest village of Mwamishali at 35 percent. While this clearly highlights the limitations of creating a scoring system that has to fit across the entire Meatu region, it is important to note that similar sub-optimal scorings due to differences in environmental factors can exist in other villages.

In summary, creating a model predicting farm-level sustainability, strong evidence exists that smaller farmers are able to achieve higher sustainability scores. This confirms
the first part of Hypothesis 2.3 on efficiency as postulated by Netting (1993). For early adopters - as measured by the average years of membership in a village - the evidence is weaker, although the descriptive model was quite clear.

5.3.1 Multiple Regression Model: Profitability

The previous regression model showed two patterns: First, organic farmers are much more similar, expressing less variation and having a higher sustainability score by default. Second, while livestock was insignificant, land ownership and production decisions have a significant impact on the sustainability score. In order to better understand the dynamics between owning large tracts of land versus engaging in extensive practices, a similar model is calculated predicting net income per acre. It also draws on using bioRe interaction dummies. The variables included are the amount of cotton harvested, the total cotton acreage planted, as well as the distance of a farmer to the village center. The aim of this model is to answer the second part of Hypothesis 2.3, in regards to smaller farmers achieving higher productivity.

Comparing Net income per Acre with Sustainability

The motivation for this analysis stems from the fact that a simple correlation analysis between farm sustainability levels and net income per acre show no or only a weak non-linear correlation. As seen in Figure 5.11, a weak correlation of only 0.30 exists between the 107 farmers for which both data points were calculated.\(^{35}\)

Nevertheless, a clearer pattern emerges by combining these two calculations: bioRe farmers, labeled with a green dot, are nearly all above the line, whereas their counterparts, conventional farmers, are located below it. This seems to indicate that high net income from cotton can be obtained both via poor or improved agricultural methods. The main reason we see an upward sloping correlation is that towards the upper-right corner, more bioRe farmers seem to exist than conventional ones. Consequently, when

\(^{35}\)Note that the net income per acre in Tsh from cotton was logged, yet the best fit was determined linearly.
re-calculating the best fit line separately for organic and conventional farmers, as undertaken in Figure 5.12, the correlation that previously existed falls below or around the 0.1 mark, represented by the two versions of the dotted lines. That indicates that there is no variation in the sustainability score that explains the increased and diverse net incomes for both farming groups.
Figure 5.11: Correlation between Net Income per Acre and Sustainability Score
Figure 5.12: Correlation between Net Income per Acre and Sustainability Score with Organic and Conventional Best Fit Lines
Predicting Net income per Acre from Cotton

The regression model of the net income per acre from cotton in Figure 5.4 reveals that statistically significant differences exist between organic and conventional farmers. Given the usage of interaction terms, one can differentiate between the impact of variable for bioRe farmers and conventional farmers respectively. The model is highly significant (<0.01) and explains more than half of the total variation in net income per acre from cotton (r-square value of 0.55). Each of the four main variables – the bioRe dummy, amount of cotton harvested, amount of cotton acreage planted, and distance to village center – were either highly significant, or approaching statistical significance.

Overall, the model displays what is common throughout analyses on the difference between bioRe and conventional farmers. The former tend to experience not only higher levels, but also less variation or inequalities. In the case of net income per acre from cotton, holding all else equal, a conventional farmer earns 38,602 Tsh. A bioRe farmer, on the other hand, earns an additional 24,286 Tsh, amounting to 62,888 Tsh per acre, which is a premium of 63 percent. The interaction variable of bioRe however reduces the extra income earned compared to a larger conventional farmer. As such, in the case of total cotton harvested in kilograms, each additional kilo earns 25.2 Tsh. For a bioRe farmer, on the other hand, it is only 23.3 Tsh, indicating that they get a slightly lower premium due to the higher intercept value. It could also be an indication of the larger extensive practices.\(^{36}\)

The large negative impact on net income per acre and productivity comes from increased cotton acreages. Each additional acre of cotton planted reduces the net income per acre by nearly 4,000 Tsh at 3,991.5 Tsh. This penalty is even larger (although the interaction is highly insignificant) for bioRe farmers, at 4,094.3 Tsh. This seems to strengthen the earlier observation on farm sustainability, whereby small-scale farmers tend to achieve higher efficiency. It also confirms the second part of Hypothesis 2.3, whereby smaller farmers are achieving higher productivity.

In regards to the spatial location of farmers, given that many of the conventional

\(^{36}\)Yield per acre was not explicitly included in this model as it by itself explained 70+ percent of the total variation in net income per acre.
Table 5.4: Regression Model predicting Net Income per Acre from Cotton

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>t-value</th>
<th>Pr &gt;t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>38,602</td>
<td>3.91</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Being a bioRe farmer</td>
<td>24,286</td>
<td>1.89</td>
<td>0.06</td>
</tr>
<tr>
<td>Total Cotton harvested (in kg)</td>
<td>25.2</td>
<td>5.21</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>bioRe: Total Cotton harvested (in kg)</td>
<td>-1.9</td>
<td>-0.36</td>
<td>0.72</td>
</tr>
<tr>
<td>Cotton Acreage</td>
<td>-3,991.5</td>
<td>-5.23</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>bioRe: Cotton Acreage</td>
<td>-102.8</td>
<td>-0.11</td>
<td>0.91</td>
</tr>
<tr>
<td>Distance to Village Center (in km)</td>
<td>12,517</td>
<td>1.57</td>
<td>0.12</td>
</tr>
<tr>
<td>bioRe: Distance to Village Center (in km)</td>
<td>-6,957.5</td>
<td>-0.81</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Model significance: 20.92 (sig: <0.01). Adjusted R-square: 0.55. n: 116

farmers interviewed were poorer and had less land, yet located at the village center, we see a positive impact of being further away from the village. Each additional kilometer away adds 12,517 Tsh on the net income per acre. This variable is approaching significance (and was stronger in significance when removing one or two interaction variables). It appears to capture the fact, as described in Chapter 3 through the case of the semi-structured interview with the Sukuma elder in Sanga-Itinje, that after the villagization campaign, many farmers moved back outside of the village for agriculture. On the other hand, those that were unable to do so, as they did not have any customary rights or access to land outside, or those that were late newcomers, were confined to the village areas. These also are the poorest of the conventional farmers as discussed in Chapter 6 and are more likely to rent. Again, for bioRe farmers, the impact is weaker, meaning that they represent even spatially a more homogeneous group. Each additional kilometer away from the village results only in 5,560 Tsh more net income per acre. This could be the case due to the fact that they are already less likely to be located in the village center. Another potential reason is that the smaller quantities harvested by conventional farmers did not result in measurably high transportation costs, thus negating the distance. For bioRe farmers, who harvest larger quantities, on the other hand, these come into play. A calculation of transportation costs shows that even though bioRe farmers were more likely to own an oxcart and oxen, they had average costs of nearly 20,000 Tsh for their entire crop. Conventional farmers, on the other hand, averaged only 11,000 Tsh.
5.4 Summary and Discussion

This chapter answered the question on the sustainability of organic farming practices. It started with the creation and application of an organic scoring index, which was operationalized to all organic and conventional farmers in the sample size. Based on these scores, Section 5.2.2 - via spider graphs - and Section 5.3 - via multiple regression analysis - proved Hypothesis 2.1 that organic farmers as a group achieve higher sustainability scores than their conventional counterparts. A strong statistical evidence towards this finding was the very large bioRe dummy and the offsetting trends of the bioRe interaction variables. Hypothesis 2.2 was confirmed when reviewing the spider graphs focusing on the best versus worst performing farmers. Furthermore, a breakdown of the socio-economic data of these two groups showed that poorer conventional farmers were outscoring wealthier organic farmers. This is an indication that innovations can trickle down, and not just within a social strata. Section 5.3 - via the two multiple regression models - also provided evidence that especially smaller farmers (measured in farm size or area of cotton planted) are actually achieving greater sustainability levels as well as higher net income per acre. This confirms the findings from Netting (1993).

The analyses also revealed that sustainability score are not strongly related to net income per acre. This finding is not unexpected given that organic farming methods aim towards a long-term impact, the sustainability index measured adoption as opposed to intensity, and that the study was based on a snapshot in time. In regards to early adopters having higher sustainability levels due to a learning-by-doing impact of the knowledge-intensive methods, only weaker more descriptive statistical evidence was presented. Both areas consequently would provide avenues for further research on the topic.

Furthermore, although farmers for example with smaller landholdings are generally perceived to have much higher likelihood or incentive to apply farm yard manure (as seen for example in the case of the sister company in India), no clear relationship exists. There is broad agreement across all interviews and focus groups that the reason they are not using FYM is due to the fact that they have substantial land available.
Disagreement however exists whether or not farming households with less land might be more likely to use farm yard manure – a relationship that was tested yet shown to be statistically not too significant. As put by the village elder in Mwamishali, “[application of farm yard manure] depends with somebody. It is not necessary that they have a small piece of land to use manure.”

In regards to the methodological approach chosen, although distance was taken into account, using spatial regression or a stochastic frontier analysis might be preferred. Especially the latter has been used to measure the technical efficiencies of the farmers themselves. This would provide a better idea of whether or not, potentially controlled for location (i.e. rainfall data if available), farmers are making best use of their available inputs. Since the location of each farmer was recorded, both models could be developed as further avenues.

Concerning the construction of the index, one clear weakness is that it is built mostly on only one crop - cotton, as opposed to moving across all the fields (as is the case with Rigby et al. (2001) for example and would be in the spirit of the holistic approach towards organic agriculture outlined in the literature review). This weakness however is offset by three factors. First, the index includes data on the other crops planted (via studying crop rotation patterns, intercropping of mungbeans or maize, etc.). Second, differing from the European or North American situation, where a farmer can only adhere to organic production on parts of his fields, in Africa most certification is undertaken for only the entire farm. This results in all agricultural activity needing to be organically certified. Third, as discussed in Chapter 3, more than half of all income is derived from cotton, with the ratio of cotton planted to other crops being often greater than 1:1. As a result, an attempt could be made to broaden the crops studied, although the impact might be minimal on the final score.

One of the largest shortcomings is that the discussion of the farm-level sustainability index does not include any social or economic dimensions. This shortcoming is addressed in the following Chapter 6, by focusing solely on multidimensional poverty measurements, which includes both of these dimensions to assess the state of poverty and inequality within and between organic and conventional farmers.
Chapter 6

The Impact of Organic Production on Inequality and Poverty

Chapter 4 provided a comparison of net income and total income of households for organic and conventional farmers. It answered Hypothesis 1.3 and found that organic farmers are on average significantly wealthier than conventional farmers in terms of cotton income. Including total income, however, that difference erodes, since the sample contains several wealthier conventional households that are not interested in joining organic agriculture. Access or ownership of land was the key variable that differentiated the two groups. Mungbean production was shown to have a key impact on keeping inequalities in check. The analysis however stayed at the surface, as it failed to create a critical threshold for assessing poverty.

This chapter aims at deepening this investigation by creating a threshold and moving beyond income measurements. The first section 6.1 includes an introduction of the methods used to answer the hypotheses outlined in Section 2.2.3. To my understanding, this is the first application of these methods to the local level analogous to the MPI developed by Alkire and Santos (2010).

The second section 6.2 calculates the classical unidimensional poverty score using a basic need level as a cutoff. It answers Hypothesis 3.1. on whether or not organic farmers are less deprived or poor if measured against this basic need line. It combines an analysis of both the poverty headcount, as well as the poverty gap and squared poverty gap to measure the breadth and depth of poverty.

Moving from a unidimensional analysis of poverty to a multidimensional one, the third section 6.3.2 outlines the composition of the multidimensional poverty index that is used to answer Hypothesis 3.2 and 3.3. Section 6.3.2 specifically calculates the
headcount, and whether or not the breadth of poverty is different for organic farmers, as stated in Hypothesis 3.2. Section 6.3.2 estimates the depths of poverty and inequalities existing between the two groups according to Hypothesis 3.3. In order to identify the largest components to the final poverty score, a decomposition by farm type is undertaken in Section 6.3.3.

The chapter also includes a fourth section that compares the self-designed index to a formal Principal Comparison Analysis (PCA) in Section 6.4. The aim of using a PCA analysis is to compare if a computational approach yields the same understanding of the data as derived from our subjective weighting. It also allows - in further avenues of empirical research - to narrow down the index to less variables (Abeyasekra 2004). The fifth section 6.5.1 includes a brief analysis on the role of price changes on the impact of organic cotton on poverty reduction.

6.1 Method for Calculating Poverty and Inequality

The method used for the calculations on unidimensional and multidimensional poverty is based on the AF method developed by Alkire and Foster (2011a, 2011b) and operationalized by Alkire and Santos (2010). It includes three main components: identification, aggregation and decomposition. In this section, all three steps are explained in the context of applying it to the local level.

6.1.1 Identification

Regarding identification, their leading question is to identify “who is poor?” within each dimension. According to Alkire and Foster (2011a), while the selection of the dimension is important, it is also necessary to establish clear “dimensional cutoffs (to determine when a person is deprived in a particular dimension), dimensional weights (to indicate the relative importance of the different deprivations), and a poverty cutoff (to determine when a person experiences enough deprivations to be considered poor)” (Lustig 2011, p.229 drawing on Alkire and Foster 2011a).

The first step, establishing a deprivation cutoff, is done for each dimension. The
rule is that a person above the defined deprivation cutoff is deprived. In the next step, *weights* or *deprivation values* are chosen. The goal is to adjust the deprivations for their relative importance. This adjustment impacts both the identification of the poor, as well as the subsequent aggregation.\(^1\) With those two measures, a *deprivation count* can be undertaken with each person’s number of deprivation summed up (weighted or unweighted). Their novel approach then includes the use of a *dual cutoff* method: not only the deprivations are counted in a first step, this cutoff is followed by a sequential *poverty cutoff*, where a critical level of deprivations\(^2\) is set in order to determine that somebody is poor. This approach draws on the findings showing that poverty is often experienced simultaneously at a multitude of interrelated dimensions. A final step in the identification process then involves re-coding it into an *identification function* where 1 is usually given to a person that is poor as its number of deprivation cutoffs, taking into account the weights, were above a given poverty cutoff (Alkire and Foster 2011a, p.295-296).

Linking the identification and aggregation is the creation of so-called *censored matrices* (Alkire and Foster 2011a, p.296f). These include the *achievement matrix* - showing the score of each individual - and a subsequent *deprivation matrix* - which replaces the deprivation values with 0 if it is below the *deprivation cutoff*. Using the *dual cutoff* method, the *censored deprivation matrix* is created in a third step where only individuals, whose (weighted) sum of deprivations lies equal to or above the threshold remain, with all other values replaced with 0 (see Figure 6.1 from Alkire and Foster 2011a, p.297). As seen with the step from the *deprivation matrix* to the *censored deprivation matrix*, one individual out of the three in the former that had levels of deprivation was not considered ‘poor’, as he or she scored below the poverty cutoff (in this unweighted example of two deprivation counts) of the *censored deprivation matrix*.

Besides just calculating a poverty head count (in this case two out of four, or 1/2),

\(^1\)In the special case that no weights are used, such as in the case of the Farm-level Sustainability index, there will be no impact on the identification of the poor or aggregation.

\(^2\)This does not have to equal the number of deprivations if we take into account different weights. For example, if we would weigh one dimension three times more than the other two, setting a cutoff of 1.75 of the smaller weighted dimensions would yield an automatic identification of the poor if he or she were deprived under the heavily weighted dimension.
Alkire and Foster (2011a) suggest calculating the normalized gap matrix and the squared gap matrix. The former involves measuring the gap to the cutoff, and then dividing it by the cutoff. The latter involves the same calculation, yet squaring the result, thus giving more weight to the poorest of the poor, highlighting tendencies of inequalities (amongst the poor). The same censored matrices can be created, as seen in Figure 6.2. To use an example, the achievement of the first individual in the first row for the third dimension is 12.5, which is 0.5 under the cutoff of 13. Thus, the normalized gap is $(13-12.5)/13$, which equals to 0.04.

Figure 6.1: Censored Deprivation Matrix, as depicted in Alkire and Foster 2011a, p.297

Figure 6.2: Censored Normalized Gap and Squared Gap Matrices, as depicted in Alkire and Foster 2011a, p.298

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Note, this is a copy from their article. There appear two mistakes. In the censored normalized gap matrix, the second individual’s deprivation should read 0.42, not 0.04. In the censored squared gap matrix, the first individual’s deprivation that is squared should be 0.04, not 0.4.

As noted in the previous footnote, the censored squared gap matrix’s value for that same individual is incorrect, as it should be the square of 0.04.
6.1.2 Aggregation

The aggregation - drawing on the previously developed Foster Greer and Thorbeck (FGT) methods - includes three measures: Adjusted headcount ratio, Adjusted poverty gap and Adjusted FGT. The adjusted headcount ratio equals to the average of the censored deprivation matrix. Out of the 16 possible deprivations depicted in Figure 6.1, we observe 6 deprivations which averages to an adjusted headcount ratio of 6/16 or 3/8. Additional measures are: headcount of the poor, which is 2 out of 4; and intensity of deprivation share, which is the average of 2/4 and 4/4, 3/4. The adjusted multidimensional headcount ratio equals to the product of the headcount times the intensity of the deprivation share, which would yield the same mean of 3/8 noted earlier.\(^5\)

The adjusted poverty gap measures the mean of the censored normalized gap matrix (see left matrix in Figure 6.2). The adjusted FGT measures the mean of the censored squared gap matrix (see right matrix in Figure 6.2). These can be used, if the variables are all cardinally significant,\(^6\) and are useful for analyzing both chorological or chronological changes (Alkire and Foster 2011a, p.299). Starting with an interpretation of the headcount as the “prevalence of poverty in the population” and the intensity as the “[breadth] of poverty among the poor”, one can break down changes in this adjusted headcount ratio and attribute them to either changed in the prevalence or breadth of poverty (Alkire and Foster 2011a, p.299). The adjusted poverty gap and adjusted FGT respectively measure “an increase in the average depth or average square gap across deprived states” (ibid., p.299). It consequently satisfies several axioms, which includes:

- Adjusted headcount ratio: Sensitivity to intensity or breadth of deprivation;
- Adjusted poverty gap: Sensitivity to the depth of deprivation;
- Adjusted FGT (or squared poverty gap): Sensitivity to inequality among deprived states of the poor

\(^5\)Interpreting the headcount as the “prevalence of poverty in the population” and the intensity as the “[breadth] of poverty among the poor”, one can break down changes in this adjusted headcount ratio and attribute them to either changed in the prevalence or breadth of poverty (Alkire and Foster 2011a, p.299).

\(^6\)Meaning ordinal, with each step or increase being the same.
6.1.3 Decomposition

Two types of decomposition can be undertaken with these multidimensional measures. First, they can be decomposed according to subgroups, be it by geography or along ethnic lines. Second, they can be decomposed according to their dimensions. Alkire and Foster (2011a) give the following example. Returning to the Censored Deprivation Matrix in Figure 6.1, in the first dimension only one individual is deemed poor - 1/4 - and the weight of this dimension (and the three equally weighted others) is 1/4. This yields a contribution of the first dimension of poverty to the overall adjusted headcount ratio of \((1/4 \times 1/4)/(3/8)= 1/6\). The second dimension, on the other hand, would yield \((2/4 \times 1/4)/(3/8)=1/3\). Regarding the comparison of multidimensional poverty dimensions in the index and their contribution, they offer an interesting breakdown using the example of findings from their research on the DRC and Madhya Pradesh in India (see Figure 6.3). A similar breakdown is developed for the multidimensional index on organic agriculture in Figures 6.9, 6.10, 6.11 in section 6.3.3.

![Figure 6.3: Percentage Contribution of Indicators to Multidimensional Poverty Index, as published in Alkire and Foster 2011a, p.301](image-url)
6.1.4 Dimensional Cutoffs and Weights

The question of 'who is poor' is answered by using the three dimensional cutoffs described in Table E.1., E.2, and E.3 in the Appendix. Each of the three dimension is equally weighted at 1/3, yielding dimensional weights by multiplying the respective variable’s weight times the dimensional weight. Table 6.4 lists the dimensional weights by variable.\(^7\)

Weights used in Multidimensional Calculations

These weights were used subsequently to calculate the deprivation score of all farmers. As depicted in Figure 6.5, the multidimensional poverty score is broken down into the three poverty dimensions. These households can be depicted as being deprived, with the highest mean score obtained in the first economic dimension (0.081 out of 0.33). The second and third dimension are nearly identical when observing the means (0.061) and the standard deviations (0.065 and 0.066). Due to the lower number of variables, there is a less even spread in the third dimension, with exactly 50 farmers not experiencing any deprivation. Also represented in the graph are the upper quartile (75th percentile) with a dotted line and the 90th percentile marked with a full line.

Based on these distributions, the following rule was designed for moving from the deprivation score to the censored deprivation count: First, any household that had a deprivation score of 0.333 or higher was considered poor. Second, if a household had a score below 0.333 yet scored equal or higher than the 90th percentile on any of the three dimensions, it was also considered poor. As illustrated in Figure 6.5 90th percentile cutoffs were 0.1666 for the first dimension, 0.1251 for the second, and 0.1333 for the third. While this automatically results in at least 10 percent of the households being by default considered poor,\(^8\) it highlights that relatively unusual deprivation in one dimension can not be compensated necessarily by less deprivations experienced in another. The only exception is for farming households whose only deprivation took place

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\(^7\)For example, for net cotton income per acre, the weight is \(2/3 \times 1/3 = 5.56\) percent. A slightly adjusted post-PCA weighting is listed in Figure 6.12.

\(^8\)It is more than 10 percent given that this is only an approximation of the distribution.
**Figure 6.4: List of Dimensional Weights**

<table>
<thead>
<tr>
<th>Weight of Variables</th>
<th>Dimensional Weights</th>
<th>PCA Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household Assets</td>
<td>0.0333</td>
<td></td>
</tr>
<tr>
<td>Land Owned</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Home Value</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td># of Food Grains</td>
<td>0.0333</td>
<td></td>
</tr>
<tr>
<td>Cotton yield/ac</td>
<td>0.0278</td>
<td></td>
</tr>
<tr>
<td>Total inc/contr HH</td>
<td>0.0833</td>
<td></td>
</tr>
<tr>
<td>Net income/acre</td>
<td>0.0556</td>
<td></td>
</tr>
<tr>
<td>Access to H2O/Net</td>
<td>0.0833</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>0.0417</td>
<td></td>
</tr>
<tr>
<td>Membership</td>
<td>0.0417</td>
<td></td>
</tr>
<tr>
<td>Food Security</td>
<td>0.0417</td>
<td></td>
</tr>
<tr>
<td>Self-Sufficiency</td>
<td>0.0417</td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>0.1167</td>
<td></td>
</tr>
<tr>
<td>Past Vulnerabilities</td>
<td>0.0833</td>
<td></td>
</tr>
<tr>
<td>Agricultural Assets</td>
<td>0.0208</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>0.0208</td>
<td></td>
</tr>
<tr>
<td>Years with bioRe</td>
<td>0.0208</td>
<td></td>
</tr>
<tr>
<td>Ratio HH Members</td>
<td>0.0208</td>
<td></td>
</tr>
</tbody>
</table>

- **Third Dimension:** 33.3 %
- **Second Dimension:** 33.3 %
- **First Dimension:** 33.3 %
in that dimension. This unusual pattern results in the household not being counted as poor. After this designation, all scores for households who were above the cutoff were censored with their series replaced with a 0 on all their respective scores.

6.2 Unidimensional Poverty

This section answers Hypothesis 3.1 on whether or not organic farmers, as a group, are less deprived and poor compared to conventional farmers. When assessing traditional, unidimensional poverty levels, two key metrics are often times employed: First, the data used often is income data, where each transactions can be monetized. This step was described in Chapter 4 and Appendix A and B. Second, a fixed threshold is deliberately chosen (often based on expenditure data) to assess whether or not an individual or household rests above or below it.

Choice of Basic Need Line

Three different basic need lines were considered and calculated: 1.25 US$ per day; 2 US$ per day; and basic need line. The first two are derived from the World Banks poverty lines of 1.25 US$ and 2 US$ per person per day, adjusted for the purchasing power
of Tanzania. The purchasing power parity conversion factor (for private consumption using LCU per international $) was 632.42 in 2009. As a result, the 1.25 US$ converted to 284,435 Tsh per year, while the 2 US$ line amounted to 455,097 Tsh.

A third basic need poverty line was based on adult consumption for 28 days, as calculated by the National Bureau of Statistics in Tanzania. These include the household expenditures on food for the poorest 50 percent needed in order to satisfy 2,200 Kcal/day, in addition to non-food expenditures of the poorest 25 percent. Since the NBS (2008) adjusted the lines for four locations in Tanzania, the rural area threshold was chosen. It was set at 13,114 Tsh per 28 days for 2007. It is adjusted by two years of annual inflation of 9.815 percent and multiplied by 12. This yielded a basic need line of 206,154 Tsh for 2009, the year when households sold their cotton.

Out of these commonly used thresholds, the basic need line is preferred and chosen, as it is not only based on actual expenditure data, but also because it is adjusted to the rural setting. Since the line is estimated for adults, the income obtained in a first step was divided simply by the number of contributing household members. While this fails to account for children, as well as elders or disabled adults, it provides for an upper-estimate of the ability to obtain income above that line. This clear shortcoming is partially offset by the fact that many farmers have ready access to numerous staple foods, including sorghum, maize (and depending on their location rice), which would result in lower expenditures needed.

6.2.1 Assessing the Basic Needs

Akin to Section 4.3, the basic need level was assessed on two levels: against the net income from cotton and the total income. These two levels are justified for the two reasons. First, net income from cotton was observed to be significantly different between

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9 It effectively excludes them from the calculations, as they are assumed to need zero income to obtain their basic needs.

10 In a second step, an individual basic need line called contributing plus - could be calculated for each contributing household member, which includes in their basic need line the estimated need for each non-contributing household member. Compared to the upper-estimate taking into account only contributing household members, this second calculation could provide a lower limit, with the correct value resting somewhere in between these two. Given the time constraints, such a calculation was not yet undertaken.
Table 6.1: Basic Need Levels from Cotton by Farm Type

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Above Basic Need</th>
<th>Below Basic Need</th>
<th>N</th>
<th>Percent Above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>10</td>
<td>39</td>
<td>49</td>
<td>20.41%</td>
</tr>
<tr>
<td>bioRe</td>
<td>28</td>
<td>37</td>
<td>65</td>
<td>43.08%</td>
</tr>
<tr>
<td>All</td>
<td>38</td>
<td>76</td>
<td>114</td>
<td>33.33%</td>
</tr>
</tbody>
</table>

The differences in the means between bioRe and conventional was significant at 0.01.

the two groups, while total income was similar. This analysis consequently provides an additional perspective on whether or not organic farmers are less poor when analyzing them using total income levels using the basic need as a cutoff. Second, since the basic need line is calculated on all available income, moving beyond cotton provides a better estimates of what households’ true poverty status might be.

**Basic Need Levels with Cotton Income**

Table 6.1 lists the results using the above income metric of net income of cotton per contributing household members and the basic need line discussed earlier.

For the whole sample of 114 farmers, only 38 out of them were above this basic need line. This amounts to one out of every three contributing farmer being above, or 66 percent below. This number is very low, yet most likely explained by the low cotton prices for the season. Given that there is also the possibility for measurement errors (which can be common when dealing with recall of income data), the more interesting question - outlined in Hypothesis 3.1 - is whether or not the difference between the number of farmers above or below the need line are significant when comparing organic with conventional farmers.

Out of all conventional farmers, only 10 were above the basic need line. This results in an average of 20 percent, which is 13 percent below the mean for all farmers. For organic farmers, the average was 43 percent above, which was 10 percent above the same mean. This spread of nearly 23 percent was tested via a two samples t-test. The results show that the differences in mean are significant at the 0.01 level (with a t-value of -2.59). Answering Hypothesis 3.1, organic farmers on average are more likely to be above the basic need line when just looking at net cotton income per contributing
Table 6.2: Basic Need Levels from Total Income by Farm Type

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Above Basic Need</th>
<th>Below Basic Need</th>
<th>N</th>
<th>Percent Increase from Cotton Inc**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>24</td>
<td>25</td>
<td>49</td>
<td>48.98 %</td>
</tr>
<tr>
<td>bioRe</td>
<td>51</td>
<td>14</td>
<td>65</td>
<td>78.46 %</td>
</tr>
<tr>
<td>All</td>
<td>75</td>
<td>38</td>
<td>114</td>
<td>65.79 %</td>
</tr>
</tbody>
</table>

*: The differences in the means between bioRe and conventional was significant at 0.01.
**: The differences in the change was not significant when looking at all farmers who only were above the basic need line after including the non-agricultural incomes. This was calculated by focusing only on the 75 farmers that were above the basic need line. Out of these, 58 (45) percent of conventional (organic) farmers were only above it after adding total income. This 13 percent difference had an insignificant t-value of 1.06.

Basic Need Levels with Total Income

Based on the previous investigation in Section 4.3, calculating the basic need levels with total income should show a larger percentage improvement for several of the non-poor conventional farmers. The results are presented in Table 6.2.

On average, two-thirds of the contributing household members were above the basic need line when the total income was calculated. Conventional farmers increased from 10 with cotton income to 24 total, which is nearly 50 percent of all contributing household members above the line. For bioRe farmers, the number increased from 28 to 51 households where the contributing household members were above the basic need line. This results in a new average of 78.5 percent.

The 29 percent difference of household members above the basic need line between organic and conventional farmers is still statistically significant (at 0.01). The final column is of special interest given the previous hypothesis on whether or not conventional farmers were lifted up more than the organic farmers. Expressed in percentage change, the number of conventional farmers increased by nearly 140 percent who were above the poverty line. This was above the 82 percent change at which organic farmers were able to climb above that line, thus confirming how off-farm income, as observed in Section 4.3 is more important for conventional farmers. These rates of increases in
income however were not statistically significant.\textsuperscript{12}

In summary, Table 6.2 reveals that, as opposed to looking at aggregate income without a threshold, when focusing on the percentage of farmers above the basic need line, the difference remains statistically significant between organic and conventional farmers. This confirms the pattern found in Section 4.3 that conventional farmers are made up of two distinct wealth groups. Since they - as a group - still experience lower percentages above the basic need line, it provides new evidence that conventional farmers are more likely to be deficient in regards to basic need than their organic counterparts as hypothesized in Hypothesis 3.1.

6.2.2 Unidimensional Poverty Scores

The analysis above has focused on the number and percentages of farmers above the basic need line. Given that we are dealing with a single dimension of income data that was aggregated, the unidimensional poverty headcounts and poverty gaps are calculated (Fisher et al. 2010; Alkire and Foster 2011a, 2011b).

Poverty Headcount

The headcount is straightforward, as it simply involves looking at the number of farmers below the basic need line. Out of the 49 conventional farmers, 80 percent are below the basic need line when just looking at cotton. When including other income, 50 percent remain below it. On the other hand, out of the 65 bioRe farming households, 57 percent were below the line using cotton income. Using the aggregated income data from the survey, this number drops to 22 percent.

This data provides a sense of the existence of monetary poverty. However, it fails to describe the depth of it and fails to emphasize inequalities. For this purpose two additional calculations are undertaken. First, the distance of all the farming household to the basic need line is calculated. This average will yield the poverty gap. In a second

\textsuperscript{12}Looking solely at the 75 farmers that were above the basic need line, we find that although 58 percent only achieved it via the addition of non-agricultural income amongst conventional farmers, 45 percent also did so amongst bioRe. As a result, the 13 percent difference was not statistically significant, with the likelihood of falsely rejecting the null-hypothesis at 0.29.
Table 6.3: Poverty Gaps by Farm Type

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Cotton Poverty Gap</th>
<th>Squared Poverty Gap*</th>
<th>Total Poverty Gap</th>
<th>Squared Poverty Gap*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>134,940 Tsh</td>
<td>22.69</td>
<td>94,530 Tsh</td>
<td>11.27</td>
</tr>
<tr>
<td>bioRe</td>
<td>104,506 Tsh</td>
<td>15.38</td>
<td>76,790 Tsh</td>
<td>8.84</td>
</tr>
<tr>
<td>All</td>
<td>120,123 Tsh</td>
<td>19.13</td>
<td>88,162 Tsh</td>
<td>10.39</td>
</tr>
</tbody>
</table>

Note: Larger numbers are worse, as this is measuring the size of the gap.
*: The squared poverty gap is measured in units of a billion

Looking at the poverty gap from cotton in Table 6.3, the average household that failed to reach the basic need threshold was 120,123 Tsh below it. This gap was around 30,000 Tsh larger for conventional farmers - at 134,940 Tsh - than their organic counterparts. The difference, given that they exhibited equal variance, was approaching statistical significance with a t-value of 1.96, yielding 0.0542.

In regards to the squared poverty gap, we find that even in terms of inequalities there is a significant difference between organic (15.38) and conventional farmers (22.69). This means that not only was the average conventional farming household further away from the poverty threshold, they also are located closer to zero compared to the organic farmers. This difference however is not statistically significant.\(^{13}\)

Moving onto the analysis of the households that were below the basic need line based on total income in Table 6.3, we find similar patterns that are however less pronounced. For the poverty gap, the difference between conventional and organic farmers are much smaller: Organic farmers are around 11,500 Tsh below the mean of 88,162 Tsh for all farmers. Conventional farmers are only 6,500 Tsh above it at 94,530 Tsh. Not only do these absolute figures indicate that the gap is significantly smaller for all farming groups when including non-cotton income, it shows that the smaller in-between farm type difference is not significant, yielding a t-value of 1.02 at 0.31.

\(^{13}\)With a t-value of 1.45 and probability of falsely rejecting the null hypothesis of no difference of 0.15.
In regards to inequalities calculated using the squared poverty gap, for both farm types, it was cut nearly into half. For conventional farmers, it dropped from 22.69 to 11.27 and for organic farmers, it changed from 15.38 to 8.84. This difference is even less significant than the previous squared gap on cotton income at a t-value of 0.54 and a probability of 0.60. Contrasting these two, it consequently becomes evident that not only is inequality lower when including total income (which has to occur by default as only additional income is gained), the between-farm type difference also is even less significant. As a result, while looking at simply the percentage of farmers above the basic need line indicated that conventional farmers continue to be more deprived, observing the inequalities we see that they are actually less than expected when taking into account total income. This reveals that conventional poorer farmers seem to benefit more from income outside of cotton, as already observed when discussing income obtained from mungbeans production.

In summary, the more uniform pattern described earlier of bioRe farmers continues to exist when analyzing both the poverty headcount, gap and squared poverty gap. For non-bioRe households, the analysis confirms the previous makeup of the group with wealthy individuals (which were above the poverty line and thus not included in these calculations) or comparatively very poor households. The addition of income outside of cotton, however, reduces this gap. Analyzed from a unidimensional dimension using solely monetary income and the basic need line as a threshold, we consequently find that organic farmers, as a group, are less likely to be deprived and poor compared to conventional farmers. This confirms Hypothesis 3.1. However, when observing the breadths (poverty gap) and depths of poverty (squared poverty gap), these differences erode and are no longer statistically significant. These results indicate that the introduction of organic agriculture, which appears to have a positive impact on absolute poverty levels when contrasting organic to conventional farmers, has not resulted in increased inequalities between the two groups. At the unidimensional monetary level, it consequently exhibits a pattern of pro-poor growth.

\[14\text{From an equity perspective, this indicates that within organic farmers, the introduction of certified organic agriculture seems to have a pro-poor growth impact.}\]
6.3 Multidimensional Poverty

The above analysis provided insights using the classical monetary variable via a unidimensional poverty analysis. It is plagued by two shortcomings of ignoring non-monetary dimensions and using a threshold that is likely to differ between each household. As discussed in Section 2.1.3, a multidimensional analysis is warranted as it incorporates important additional dimensions of poverty. These include a second dimension on non-monetary goods (Grosse et al. 2008) - i.e. the value of the house or access to water - and a third dimension of vulnerability (Calvo 2008). Using this multidimensional index, it tests whether or not the organic farmers - as a group - experience lower poverty headcounts, breadths of poverty, and depths of poverty (or inequalities) compared to their conventional counterparts.

This section is organized as follows: Section 6.3.1 provides the basis of the multidimensional factors used from the previous chapter on agricultural sustainability. It is followed by the analyses of the three hypotheses using the methods outlined in section 6.3.2. The ecological sustainability column includes ideal variables that are difficult to measure given the need for additional expensive data collection, such as soil nutrient content. However, by focusing on methods used that would have an impact on these, the farm-level sustainability index developed earlier approximates this section. There are however the other two columns of Economic and Social Sustainability that will be of interest. Appendix C lists all these methods.

6.3.1 Basis of Multidimensional Factors

Zhen and Routray (2003) propose a set of operational indicators to measure the three main categories of agricultural sustainability at the farm-level in a developing country (see Figure 6.6).

In Economic Sustainability, crop productivity is measured as ‘yield per acre’ from cotton. Net farm income is calculated as discussed above. Benefit-cost ratio calculations are not entertained for the whole farm, yet a net income of cotton per acre is added as an additional economic variable. Given that plenty of data was collected on non-cotton
production and food self-sufficiency, *food grain production* is included.

In addition to these variables by Zhen and Routray (2003), three additional non-monetary economic variables are included. These are home value, amount of land owned, and an aggregate of household assets.

In *Social Sustainability*, a measure exists for the self-sufficiency of a farming household (i.e. how much food had to be purchased in the market). This dimension is expanded by focusing also on food insecurity, which takes place if a household was unable to obtain (mostly purchase) enough food for the entire household throughout a year. Zhen and Routray (2003) also include an equality dimension, which will be included using both net income availability and distances to the basic need line, which includes mostly food availability. Regarding access to resources and support services, the survey did not include explicit measures of service availability or accessibility. Instead, a measurement of social capital was gathered by asking for the household head’s political and agricultural connections within the region. In addition, levels of connectivity are included by measuring proxies of number of cellphones, radios or televisions owned. Additional variables to be included in this dimension include the access to water resources and number of malaria nets per capita. Furthermore, a ratio of contributing to non-contributing household members is used as a rule of dependency in the household, with farmers who have a small ratio (i.e. 1 contributing to 4 non-contributing household members) having a higher likelihood of facing reduced capacities to adjust to changes.
Finally, regarding the farmer’s knowledge and awareness of resource conservation, years with bioRe, the number of organic farmers who are neighboring his or her largest cotton field, and the level of education are chosen to measure this variable. These are mostly related to human capital as drawn from a sustainable livelihoods framework (i.e. Department for International Development 1999).

In addition to these economic and social dimensions, the multidimensional poverty index includes an analysis of vulnerability. This was outlined by Calvo (2008) and Calvo and Dercon (2005) as discussed in the literature review in section 2.1.3. The dimensions included are focusing on whether or not a household experienced high vulnerability in the past, and if it has access to savings in case the vulnerability would increase (or return) in the future. As a result, they differ from Calvo (2008) in the extent that they are less focused on vulnerability to multidimensional poverty, but vulnerability as an additional category of analysis.\textsuperscript{15}

6.3.2 Multidimensional Poverty Scores

Multidimensional Poverty Headcount

Using the dimensional cutoffs and weights outlined in section 6.1, 33 households were designated as poor. The process described in Section 6.3.2 results in the removal of three farmers, who had an average total deprivation score of 0.16, which is below the mean of 0.21 for the entire sample. This means there were 11 households added (with a mean of 0.25) in addition to the 22 households that were above 0.333. The poverty headcount is 33 out of 114, or 29 percent, providing a sense of the prevalence of poverty in the population. 20 of those 33 farming households were conventional, whereas only 13 were bioRe. Their respective headcount ratio, listed in Table 6.4 was 20 out of 49 for conventional, equaling 41 percent, and 13 out of 65 for bioRe, equaling 20 percent, or around half as much as with the conventional farmers.

The intensity of deprivation share is calculating the averages of the deprivations

\textsuperscript{15}As a result, the computational method of Calvo (2008) and Calvo and Dercon (2005) are not applied.
Table 6.4: Multidimensional Poverty Headcount by Farm Type

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Poverty Headcount in percent</th>
<th>Intensity of Deprivations</th>
<th>Adjusted Headcount Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>20 %</td>
<td>0.32</td>
<td>0.064</td>
</tr>
<tr>
<td>Conventional</td>
<td>41 %</td>
<td>0.42</td>
<td>0.17</td>
</tr>
</tbody>
</table>

across all households. This equals to 0.38. Breaking it down by farm type, conventional farmers have an intensity of 0.42, whereas organic have 0.32. This indicates that the intensity, which measures the breadth of poverty among the poor, is not too different between organic and conventional, with the former only being 24 percent lower.

The *adjusted multidimensional headcount ratio* is the multiplication of the headcount (33 out of 114) times the intensity of deprivation share (0.38 or 38 out of 100), which yields the same 0.11. Conventional farmers experienced a higher adjusted headcount ratio, as the average deprivation was 0.17 compared to 0.064 for bioRe. Contrasted with the poverty headcount, we see that the adjusted headcount ratio now is more than half as much for bioRe. This indicates that the main reason explaining the difference in the *adjusted multidimensional headcount ratio* between organic and conventional farmers is not in the intensity of poverty, but rather the prevalence of it.

These results confirm our hypothesis that organic farmers - when looking at multidimensional poverty - are experiencing significantly lower poverty headcounts and breadths of poverty as measured via the adjusted multidimensional headcount ratio.

**Multidimensional Poverty Gap**

While the adjusted headcount ratio is arithmetically sensitive to the intensity or breadth of deprivation, the adjusted poverty gap gives an indication of the depth of the deprivation experienced. Squaring this poverty gap will be sensitive to the inequality amongst households in a deprived state. It consequently answers Hypothesis 3.3 on whether or not organic farmers are also experiencing lesser depths of poverty and inequalities.

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16 This is identical to calculating the average ratio of deprivations in the sample (see also section 6.1 reviewed earlier). The 33 farmers experienced an average deprivation of 0.38 out of 1, summing up to 12.62. The total possible deprivation is 114. As a result, the *adjusted headcount ratio* equals to 12.62/114=0.11.
The mean for the adjusted poverty gap, calculated via the censored normalized gap matrix, was 0.295. The mean for conventional farmers was 0.332. The mean for organic farmers was 0.239. This indicates that the same trend observed in the intensity and breadth of deprivation continues when observing the depth of deprivations. Conventional farming households have nearly 40 percent deeper deprivations compared to their organic counterparts. Figure 6.7 shows the differences in the distribution of each farming household by farm type. On the left hand side, poor organic farmers households and their poverty gap is depicted, while on the right hand side the conventional farmers are listed. These results, supported by the figure, hint that not only are conventional farming households more likely to be poor, they also are more likely to experience more severe forms of poverty (both in terms of breadth and depth).

![Comparison of Censured Adjusted Poverty Gap Score](image)

Figure 6.7: Comparison of Censured Adjusted Poverty Gap Score

Squaring the results from the censored normalized gap matrix, a new mean is obtained for the 33 farmers of 0.265. This mean indicates the inequality among the deprived states of the poor (Alkire and Foster 2011a). The mean score for the conventional farmers is 0.301, while for organic it is 0.201. Compared with the adjusted poverty gap, this increase of nearly 50 percent is even slightly larger than the previous
40 percent difference observed when adjusting in the previous section the headcount ratio. The Adjusted FGT measure highlights that not only is the depth of poverty potentially deeper for conventional farmers, there also seems to exist significantly greater inequalities in the deprivations experienced. This consequently appears to confirm Hypothesis 3.3 which asked whether or not organic farmers as a group were experiencing lower depths of poverty or inequality compared to conventional farmers using a multidimensional poverty index.

Figure 6.8 compares the scores obtained by each farm group, showing the stark difference. Granted, it is important to note that it does not tell us anything about the distribution of the poor farming households that experience these deprivations. However, it serves as a measure to indicate that the poor organic farming households experienced statistically much smaller gaps to the cutoff on average. The conventional farmers, especially the poorest of the poor, on the other hand, are much worse off compared to their counterparts.

![Figure 6.8: Comparison of Squared Censured Adjusted Poverty Gap Score](image)

Figure 6.8: Comparison of Squared Censured Adjusted Poverty Gap Score
In summary, the *multidimensional poverty headcount* has revealed that organic farmers are less likely to be poor than conventional farmers, as measured using a multidimensional poverty framework. Besides the greater intensity of poverty by conventional farmers, they however had similar breadths of deprivations experienced. As revealed by the *multidimensional poverty gap*, there are growing and significant differences between the depth of the deprivations experienced between organic and conventional farmers. Furthermore, inequalities between the two groups are large, when analyzed by giving greater weight to larger deprivations experienced compared to smaller ones. This shows that amongst the poorest, conventional households are once again worse off than their organic counterparts. Furthermore, the gap between the poorest and the less deprived yet poor is larger amongst conventional farmers than organic households. This confirms Hypothesis 3.3 in that not just the breadth, but also the depth of poverty is larger. It also highlights that when analyzed from a multidimensional perspective, conventional households seem to exist that are not able to benefit from the pro-poor growth impact of the introduction of organic agriculture.

### 6.3.3 Decomposition of Multidimensional Poverty

While the above discussion has centered around analyses of poverty and inequalities within and amongst farming groups in order to answer “who is poor”, the analyses ignored potential underlying differences amongst the two farming groups in the composition of their poverty score. As a result, a decomposition is undertaken analogous to the example outlined in Section 6.1 by Alkire and Foster (2011a).\(^{17}\) Three figures - Figure 6.9 for the economic dimension, Figure 6.10 for the social dimension, and Figure 6.11 for the vulnerability dimensions - were created, splitting up the proportion of the people who were poor according to the respective dimensions.\(^{18}\) Observing the

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\(^{17}\) For a detail of the calculation, the reader is encouraged to revisit that section. The two main components referenced here are the adjusted headcount ratio, which serves as the denominator. The score from the censored deprivation matrix is the nominator multiplied time the weight of the dimension.

\(^{18}\) The original plan was to create a single table, akin to the one published by Alkire and Foster (2011a, p.301). However, since it contains 20 variables, compared to the eight they have used, a decision was made to split it up for legibility. One important caveat is that while the example used by Alkire and Foster (2011a) consists of two groups that had the same censored headcount ratio, in this study, the two groups had significantly different headcount ratios as highlighted in Section 6.3.2. As such, the
distribution of the importance across the three dimensions, we see that for conventional farmers, the first and third dimensions are comparatively more important (indicating greater lacks in economic capital and vulnerabilities). For organic farmers, on the other hand, the second dimension is slightly more important, indicating relative importance of social and human capital in determining overall poverty. What follows is a detailed breakdown of each of the three dimensions. Drawing on the participatory econometrics method, it includes insights gained from the focus groups and interviews.

**First Dimension**  
Figure 6.9 lists the first dimension of economic capital. There are three main noticeable differences that exist. These are on *Total income per contributing household member*, *home value*, and *land owned*.

First, *Total income per contributing household member* is nearly twice as large in percentage for conventional farmers (15.07 percent) than for organic farming households (8.06 percent). This indicates that out of all the farmers considered poor, the conventional farmers are more likely to experience a lack of or lower levels of income per contributing household members. This contrasts to the other two income metrics of net income per acre and cotton yield per acre. The combination of both have the equal weight of total income per contributing household member. For organic farmers, they make up 3.36 percent, while for conventional farmers it is a mere 2.29 percent, with both well below 50 percent of the total income per contributing household member. These results indicate that the poorest of the organic and conventional households do not significantly differ in their agricultural productivity.

Second, *home value* stands out as the one variable in the first dimension of the multidimensional poverty index that is much more heavily weighted for the organic farmers. The 13.30 percent are around twice as much as the 6.48 percent for the conventional households. While investments in houses were assumed to be a good indicator of wealth (with farmers that only have a mud house lacking an iron roof considered poor), focus groups revealed that these investment decisions are not the

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proportion of people who were poor according to the multidimensional poverty index averages up to 100 percent in both cases summing the three dimensions.
Figure 6.9: Decomposition of Poverty by First Dimension

same for every household head.

For example, in the village of Mwanyahina, five farmers (two male and one female bioRe household member, and one conventional male and female) were asked whether or not they would invest first in cattle, land or a house if they would obtain a good harvest and high price of cotton that season. Four out of the five mentioned that they would first invest in the house, with everyone agreeing that they would invest in land afterwards.\textsuperscript{19} The focus group also specifically discussed an iron roof, which has

\textsuperscript{19}The one person who decided not to invest in a house first already lived in a house that had an iron roof and cement walls, thus indicating that, although she would like to continue invest in it, land might
proliferated visibly in the region (and village) as a sign of wealth (see also Jermann 2011).

They cautioned however that a linear connection can not be drawn between a lack of an iron roof and poverty due to three reasons. First, the most basic (and potentially least satisfactory) being that the older household head is lacking education in order to simply understand the benefits of an iron roof. This reason, articulated first by one farmer, did not receive much support. A related cultural argument, however, received much more support, especially from women in the focus group. They stated that older men are “still sleeping on the skin of the cattle”, stating the importance of traditional Sukuma culture. If a revered village member might obtain iron sheets, “others will be saying ‘This man has now become a Swahili man’ ”. Using the example of a 70 year old man, this stigma and the cultural ties result in that such elders “can not agree with [the benefits of an iron sheet]. Even if you are telling him ...”. Focusing specifically on gender dynamics, a third reason crystallized, as women agreed that no matter how old they were, they would see the benefits of investing in the house. When asked if women were able to convince their husbands to invest in iron sheets, one female respondent indicated, although her husband is poor, he’s a nice man and would invest in the house as a first priority if the money were available. However,

“[...] some of them have a husband who has no ability to buy. Yes you can convince him to buy something this and this. [But] some of the men with a lot of cattle, you can be telling him, but he is only a drunken man. So when you are talking he doesn’t care [about] you, so you don’t have any ability to force or to do.”

There are also negatives that come with it, such as increased temperatures or heat for example.

This great conversation continued to discuss mungbeans (choroko) and whether or not women have more power over the decision on how to spend it. One woman replied that it is good to have money from mungbeans, but since 2009 it is a men’s crop as the price has increased. It is possible to get some money from it yourself, “but some of your children have to go to school so you have no ability [to change].” Asked in regards to the change in how it shifted from being a woman’s to a man’s crop, and whether or not they objected, they said

“[We] are just living with a man, but [we] are not saying it is a good condition, because now if the man is taking that money it can go for other means (or only buy cattle). Now
The third variable that was significantly different between the two farming groups was *land owned*. The importance for poor organic farmers of that variable was a mere 2.42 percent, compared to more than double for conventional farmers (at 5.89 percent). This confirms, as identified in Chapter 4, that conventional farmers are more likely to be resource-poor, especially in regards to land ownership.\footnote{As a matter of fact, only two poor organic farming households claimed that they did not own more than 3 acres, which is because they were renting their lands (or 'protecting it') most likely from their fathers. While this indicates weaker land securities, it still indicates households that are better off.\footnote{bioRe farmers score beyond the poverty line by default as they have at least a year of membership. Thus they are having larger social capital.}}

**Second Dimension**  
Figure 6.10 lists the second dimension. Out of the three dimension, this is the only one where bioRe farmers actually had a higher proportional poverty than their conventional counterparts. This is the case, even as the variable of *Years with bioRe/Neighbors* was only applicable to non-bioRe farmers.\footnote{[we] have to look for other crops, like groundnut and sell it, and [I] got a little money so [I] can use it.} Since this variable was created as a proxy to the knowledge adoption of organic techniques, conventional farmers have lower proportions of poor people due to the second dimension, even though 5.89 percent were poor due to neither being a member of bioRe, a coop or a political organization. This provides further evidence that the organic farmers are more likely to be poor due to the second dimension compared to the first. Besides these membership variables and associated social capital, there are three main differences in their relative decomposition by variables.  

First, as indicated by both food-self sufficiency and food security, these variables count more than twice as heavily for bioRe farming households (7.06 percent in both) than for conventional farming households (3.44 percent and 2.95 percent respectively). This indicates that the few bioRe farmers that were poor were more likely to experience food insecurity or lack food self-sufficiency. While more detailed analyses are warranted, it does hint towards the well-known assumption (i.e. see critical literature on contract
farming or cash crop production in section 2.1.1) that farmers who put a greater emphasis on cotton – as a cash-crop – are more vulnerable in case the harvest or price would not be sufficient to sustain food security over the season (and especially into the hungry season). However, given that an organic farmer is advised (with the possibility of decertification) to engage in crop rotation (as well as intercropping strategies), this problem is much less existent compared to conventional monoculture production of cash crop observed outside Africa. An institutional factor that could reduce food availability is that cotton farmers in Meatu are advised by the government (under the threat of
fines and imprisonment) to refrain from intercropping maize (a nutrient-intensive crop) with cotton. A lack of governmental field extension agents however results in a low enforceability of this clause.\textsuperscript{24}

Second and somewhat surprisingly, communication is a variable where the few poor bioRe farmers (at 8.06 percent) are more likely to be impacted than their conventional counterparts (at 3.44 percent). One potential explanation could be in regards to the lack of adoption of cellphones by the older household heads, although there are no significant differences in age between the two groups. Another could be lower educational attainments, as at least four out of the eight organic household heads lack education. What however is likeliest is that given the overall lack of poverty experienced across the bioRe farmers, that this variable acts as a good identifier of poverty amongst that group, whereas other variables, such as total income per capita in the first dimension, or cattle in the second dimension are better discriminators for conventional farmers.

Third, the variable of \textit{agricultural assets}, although small in terms of overall magnitude, is significantly different between the two farming groups. For poor organic farmers, it only had a magnitude of 1.51 percent, whereas for the conventional counterparts, it equaled 3.57 percent, which represents more than twice the share of organic farmers. It is an indication, often observed in the field, that organic farmers are more likely to be secure in these productive assets compared to their conventional counterparts.

\textbf{Third Dimension} Figure 6.11 lists the third dimension on vulnerabilities. While each of them are interesting and different, three stand out: \textit{past vulnerabilities}, \textit{securities in cattle}, and \textit{securities in having a bank account}.

Past vulnerabilities - the first variable - highlights an unexpected pattern, where the poor organic households (14.10 percent) have nearly twice as high proportions for experienced negative years in the past five years compared to conventional households.

\textsuperscript{24}During the survey period, one conventional household mentioned to have been imprisoned by an older, revered extension agent from the government in the village of Mwamanongu, where he was stationed. Repeated intercropping of maize in cotton fields, for bioRe farmers, however is one of the main decertification reasons.
(7.85 percent). At its most basic, this indicates that the largest significant vulnerability component for organic farmers stems from past vulnerabilities (approximately 45 percent). This contrasts strongly from the largest component of conventional farmers: insecurities due to a lack of ownership of cattle (20.61 percent, or approximately 65 percent of the vulnerability total).

What is of greater interest is to understand why these differences exist. One of the likeliest explanations is that the organic farmers classified as poor are those that have experienced vulnerabilities in the past. As a result, these are more likely farmers who have struggled before to have fewer deprivations. On the other hand, for conventional farming households, it would appear that the poor are not necessarily those who have experienced high volatilities before, but rather a more even or lower level of livelihood. Especially when considering that these questions were asked from a subjective perspective of what a very bad year consists, the answers are going to differ for (chronically) poor compared to potentially more hopeful or successful organic farmer that are vulnerable due to price and yield fluctuations.

This second variable of cattle ownership contrasts strongly with the largest variable revealed via decomposition. At 20.61 percent for conventional farmers, it is more than 25 percent larger than the next largest component of the multidimensional poverty index: total income per contributing household member. This highlights the main difference observed in the field, in that especially many conventional farmers are lacking large ownership in cattle, which was expected based on research by Dercon (1998). The proportion of the poor people is much larger in this variable, compared to the other main agricultural asset of land (which was only 5.89 percent for conventional farmers). While 8.47 percent of the organic farmers also experienced a lack of ownership in cattle, its importance is less than half of conventional farmer’s share.

The third variable of ownership of a bank account illustrates and explains the pattern observed in cattle ownership as well. Bank account insecurities, which was measured as a farmer either lacking one and having a decreasing amount of cattle compared to the previous year, was not important for conventional farmers (at 2.36 percent). The likeliest reasoning being that conventional farmers, as shown in their lack of cattle as
security, did not have a decrease in cattle ownership since they did not own any in
the first place. On the other hand, the organic farmers that were classified as poor,
also lacked a bank account. Even poor organic farmers, however, were more likely to
own (or have owned) cattle before, thus resulting in a decrease in cattle owned and a
subsequent increase in the proportion of poor farmers classified as lacking securities.

The overall importance of cattle vis-à-vis other investments might also be on the
decrease. As described in Chapter 3 and the previous discussion on investments in iron
roof in the first dimension, cattle used to have a historically central role in Sukuma
livelihoods and culture, including as a social status symbol and security. However, a shift was noticed when discussing with farmers the relative importance of cattle. Discussions during a different focus group in Mwamanongu revealed that out of all farmers, nobody would invest in cattle first, preferring investments in homes and land over their third choice of cattle. When remarked upon that it might strike one as surprising that a Sukuma would not invest first in cattle, one farmer responded by saying:

“[...] before it was good to buy cattle because even the land for grazing was available. You can go with your cattle and in the land of any people and graze [...] your cattle and nothing came. But [...] when you keep the cattle now, the problem is with the land grazing, when weather conditions [are] not good, [there is] nothing to graze your cattle.” (Mwamanongu Focus Group)

On a final note, the fact that both poor farming groups had a positive outlook on increasing their planting of mungbeans is an excellent sign of their potential mobility to move out of poverty, or especially ability to try to take advantage of new cash crop opportunities, as previously discussed in Chapter 4.

Summary The decomposition of the multidimensional poverty index by farm type has revealed interesting new patterns. For organic farmers, the largest component was the previous insecurities experienced over the last five years and the lower house quality. Both were explained and seemed reasonable given the field observations, surveys and qualitative data gathered. Also, for conventional farmers, it is no surprise that their poverty is defined more by the classic poverty components of lacking ownership in

When asked how many years ago they would have still decided to first purchase cattle, they mentioned specifically 1993. It was at that year “when the people started to rent their land out for grazing. That was the year when the people [realized] the [economic] benefit of their land.” (Mwamanongu Focus Group). Prior to 1993, no land could be rented for grazing. The rule came about as “they saw [it] from the people from the Northern part. When they went to greet other relatives, they saw that rule and adopted it. The people themselves decided on this. They don’t need permission of [the] village council or mwenyekiti [mayor] on renting land. Also [the] village elders [have] no power, but [they] will make sure that there is a path for grazing when passing through your land, so they will protect this.” (Mwamanongu Focus Group)
cattle, land or low income per capita. What for both groups is encouraging, is that they seem to be able to at least plan on taking advantage on shifting production into new profitable areas (such as mungbean). Furthermore, both groups are not poor due to their low yields nor net income from cotton, highlighting that at least the continued cotton production is not directly the reason for their poor performance and subsequent poverty. This highlights that a simple focus on only these two metrics would have failed to adequately capture the diversity and complexity of poverty on the ground. It also shows that increased agricultural production and income, via organic agriculture, seems to be pro-poor amongst organic farmers, but also conventional farmers if they have access to land or cattle.

6.4 Principal Component Analysis

6.4.1 Justification and Method for PCA

The literature review on multidimensional poverty in Section 2.1.3 highlighted principal component analysis (PCA) as an alternative towards evaluating poverty data (see Abeyasekra 2004, Davis 2002, Filmer and Pritchett 2001 for applications; see Jolliffe 2002 for methods). Given the rather subjective approach of the scoring being based on observations and experiences in the field (see Appendix C), the PCA rests at the other extreme: As discussed by Reig-Martinez et al. (2011), it is preferred by researchers “to avoid subjectivity in the determination of weights and proceed to determine them endogenously” (p.3). Especially the first component created is of great interest, as it is often a measure of long-run wealth (Vyas 2006).

An additional reasons to use PCA is to reduce the number of variables and narrow them down to useful components (see Jolliffe 2002, Chapter 4). Although these are often preferred if these components are “intuitively reasonable interpretations”, many cases exist where even the sole fact of reducing many original variables into a few is beneficial enough (ibid., p.63).

Interpretations are undertaken by focusing on the absolute correlation values\(^\text{26}\) in

\[^{26}\text{One of the key decisions to make is whether to use correlations or covariances in the PCA analysis.}\]
the matrix that are at least half of the maximum value obtained within one single component. These are classified as being either positive or negative (see Jolliffe 2002, p.65-66).

Both continuous and discrete variables can be used, “provided that the possible values of the discrete variables have a genuine interpretation” (Jolliffe, 2002, p. 69). As such, they should be ordinal, with the differences in the values being the same across each step; all the variables in the sample adhere to this rule.

The size of the variances is used as a rule of thumb to decide on how many principal components are considered. Called the *Kaiser’s rule*, the PC with larger variances than 1 are kept. This is justified by the fact that a value “less than 1 contains less information than one of the original variables and so is not worth retaining.”27 (Jolliffe, 2002, p.114) For this study, Eigenvectors that are close to 1 are retained.28

6.4.2 Results

Based on the Kaiser rule, the following 11 components were chosen and illustrated in Table 6.5 and 6.629, composed of 30 variables.30

Since covariance matrices are sensitive to the units of measurements (Jolliffe 2002, p. 22), it is not the preferred method as it would result in larger unit values dominating over smaller ones (i.e. income versus assets). The one advantage that Jolliffe 2002, p.24 lists is that the covariance matrices are preferred as it is easier to draw statistically valid conclusions from the sample to the population. “However, in practice, it is more common to use PCA as a descriptive, rather than an inferential, tool, and then the potential advantage of covariance matrix PCA is irrelevant.”27 There are arguments that this will be reduced to too few variables. Jolliffe found that 0.7 is roughly a correct level.

28Another rule of thumb proposed is to include as many components until 70 to 90 percent of the total variation is explained (Jolliffe 2002, p.112). This however would lead, given the lack of strong correlation amongst the variables, to too many eigenvectors chosen, thus defeating the main purpose of trying to reduce the number of variables. A scree plot can also be used to determine where the slope is no longer ‘steep’ enough (resulting in a shallow slope where the difference between two eigenvalues is nearly identical) although this also involves value judgments. They could potentially be presented to accompany the reader.

29In this table, the absolute values of the correlation results are not listed, as only the positive and negative correlations are shown. These are chosen based on the maximum absolute value of the correlation within a specific component. If a respective variable is within 50 percent of that maximum value, it receives a plus or minus sign. If it is within 25 to 50 percent of the mean, it receives a (plus) and (minus) sign. If it is not significant at all, it receives no sign. The goal of this modification is to ease the interpretation of the components. If interested, the Appendix contains all the absolute raw correlation matrices scores by Eigenvectors in Figures E.1 and E.2.

30When including 34 variables for the 114 observations, 11 principal components are above the Kaiser rule of 0.1, accounting for a cumulative 67 percent of the variations. Given the vast number of variables,
Table 6.5: Correlation Results of Principal Component Analysis

<table>
<thead>
<tr>
<th>Component number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td><strong>Economic D.</strong></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Net income per acre</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>(–)</td>
<td></td>
</tr>
<tr>
<td>Total inc per contr HH</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td>+</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Number of Food crops</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
<td>(+)</td>
</tr>
<tr>
<td>Home Value</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Land Owned</td>
<td>+</td>
<td>–</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed</td>
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<td>Motorcycle</td>
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<td>(+)</td>
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<tr>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Members</td>
<td>+</td>
<td>(–)</td>
<td>+</td>
<td>–</td>
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</tr>
<tr>
<td>Ratio of HH Members</td>
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<td>+</td>
<td>(–)</td>
<td>(+)</td>
<td>–</td>
</tr>
<tr>
<td>Purchase of Food</td>
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<td>+</td>
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<td>Food Shortage</td>
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<td>Sum of Memberships</td>
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</tr>
<tr>
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<tr>
<td>Radio</td>
<td>+</td>
<td>+</td>
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<tr>
<td>TV</td>
<td>(+)</td>
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<tr>
<td>Access to Well</td>
<td></td>
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<tr>
<td>Malaria nets per cap</td>
<td>(–)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years with bioRe</td>
<td>(+)</td>
<td>–</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total bioRe Neighbors</td>
<td>(–)</td>
<td>(–)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ox Ploughs</td>
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<td>(–)</td>
<td>(+)</td>
<td>(+)</td>
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</tr>
<tr>
<td><strong>Vulnerability D.</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Neg Years</td>
<td>(–)</td>
<td>(–)</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Pos – Neg) Years</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td>(–)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Cows</td>
<td>+</td>
<td>(–)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Less Cattle this Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Account</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: &gt;cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: &gt;Mungbeans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: Mungbean grown by itself</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eigenvalue | 4.76 | 2.70 | 2.29 | 1.91 | 1.70 | 1.42 |
Cumulative percentage of total variation | 0.16 | 0.25 | 0.33 | 0.39 | 0.45 | 0.49 |
Normalized | .230 | .131 | .111 | .092 | .082 | .069 |
Table 6.6: Correlation Results of Principal Component Analysis [cont.]

<table>
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<tr>
<th>Component number</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<tr>
<td><strong>Economic D.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net income per acre</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total inc per contr HH</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Food crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home Value</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Owned</td>
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<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorcycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social D.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>(+)</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Members</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of HH Members</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase of Food</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Shortage</td>
<td>(+)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sum of Memberships</td>
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<td>(+)</td>
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<td>Cellphone</td>
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<td>Radio</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV (-)</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to Well</td>
<td>(+)</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria nets per cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years with bioRe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total bioRe Neighbors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vulnerability D.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Neg Years</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Pos – Neg) Years</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less Cattle this Year</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Account</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: &gt;cotton</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: &gt;Mungbeans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future: Mungbean grown by itself</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>1.33</td>
<td>1.26</td>
<td>1.19</td>
<td>1.07</td>
<td>1.04</td>
</tr>
<tr>
<td>Cumulative percentage of total variation</td>
<td>0.54</td>
<td>0.58</td>
<td>0.62</td>
<td>0.66</td>
<td>0.69</td>
</tr>
<tr>
<td>Normalized Eigenvalue</td>
<td>.064</td>
<td>.061</td>
<td>.058</td>
<td>.052</td>
<td>.050</td>
</tr>
</tbody>
</table>
As seen in Table 6.5 and 6.6, the 11 eigenvalues account for 69 percent of the total variation of all variables. This is nearly within the recommended range of 70 to 80 percent that is usually aimed for when embarking on an analyses of the individual principal components. This analysis is followed below.

6.4.3 Analysis of First Principal Component (PC)

The first component, accounting for 16 percent of the variation itself, is a broad measure of long-run wealth, captured by assets owned. This reflects the finding in the literature that in an analysis using asset data, that the first component tends to reflect that category (Vyas and Kumaranayake 2006). It is also a confirmation that at least in its initial stages, the components are measuring degrees of poverty as desired by the previous created index in Tables E.1, E.2, and E.3.

Research by Vyas and Kumaranayake (2006) showed that PCA is well-suited to establish a wealth classification. According to their review of previous studies and their own analysis, the first principal component generally tends to measure socio-economic wealth. This is clearly the case in this analysis as well.32

A decision was made to remove any (even if included in the multidimensional poverty index) that were similar as expressed in high levels of multicollinearities (around 0.8 as a cut off). For example, the cotton yield variable was excluded, as it was highly correlated (understandably) at 0.78 with net income per acre (which includes the deducted costs from planting cotton). Other high collinearity exist between electricity and television (0.86), with less than 5 percent of farmers having access to either. Since the three owners of televisions also have electricity (leaving only one single household that does not have a television yet electricity), television sets were chosen to stay and electricity removed. There is also a high correlation with cows and number of land owned. Since this measures essentially different types of access and livelihood strategies, they are both kept in. On the other hand, iron for example was given as an example in focus groups of assets that everyone can obtain and there is less value in owning more than one.31 As a result, it was excluded in the revised calculations, not because of high correlations, but due to the lack of strong predictive powers when observing the principal components. Another variable that was removed was ox carts. As previously discussed, the variance in ox carts is low, as a farmer either has one or none. However, ox ploughs are much more advantageous in obtaining a high income and can be owned in more than just a single plough. Furthermore, ox ploughs and ox carts, whenever significant in the principal component analysis, are so simultaneously, with the same signs.

Education also was excluded. This was not based solely on its correlation with age (both in the correlation matrix (-0.4) and the eigenvalues matrix), but rather because the variable failed to accurately measure human capital, especially for bioRe farmers, as many older household members failed to be able to obtain education, yet their sons might all have attended school. The number of contributing household members was also removed, as it is a product of household members times the ratio of contributing to non-contributing household members. Doing so only 30 variables remain.

They also highlight how out of that first principal components, the socio-economic dimension as a dependent variable can be created using the weights given by the PCA. They subsequently split up the score into quintiles, preferring them over a 40-40-20 split sometimes undertaken in other studies.
Table 6.7: Scoring Factors and Summary Statistics for Variables Entering the Computation of the First Principal Component

<table>
<thead>
<tr>
<th></th>
<th>Scoring Factors</th>
<th>Mean</th>
<th>SD</th>
<th>Scoring per unit*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic Dimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net income per acre (in Tsh)</td>
<td>0.014</td>
<td>72'442</td>
<td>47'792</td>
<td>(0.0000003)</td>
</tr>
<tr>
<td>Total inc per contr HH (in Tsh)</td>
<td>-0.001</td>
<td>427'649</td>
<td>416'143</td>
<td>(-0.000000002)</td>
</tr>
<tr>
<td>Number of Food crops</td>
<td>0.214</td>
<td>4.39</td>
<td>1.53</td>
<td>0.1399</td>
</tr>
<tr>
<td>Home Value</td>
<td>0.083</td>
<td>1.62</td>
<td>0.67</td>
<td>0.1239</td>
</tr>
<tr>
<td>Land Owned (in ac)</td>
<td>0.275</td>
<td>55.57</td>
<td>79.45</td>
<td>0.0035</td>
</tr>
<tr>
<td>Bed</td>
<td>0.341</td>
<td>3.01</td>
<td>2.14</td>
<td>0.1593</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.221</td>
<td>0.10</td>
<td>0.33</td>
<td>0.6697</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.298</td>
<td>1.36</td>
<td>0.97</td>
<td>0.3072</td>
</tr>
<tr>
<td><strong>Social Dimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.155</td>
<td>45.32</td>
<td>14.57</td>
<td>0.0106</td>
</tr>
<tr>
<td>Household Members</td>
<td>0.266</td>
<td>9.91</td>
<td>4.58</td>
<td>0.0581</td>
</tr>
<tr>
<td>Ratio of HH Members</td>
<td>0.007</td>
<td>1.33</td>
<td>0.97</td>
<td>(0.0072)</td>
</tr>
<tr>
<td>Purchase of Food</td>
<td>-0.196</td>
<td>1.89</td>
<td>1.20</td>
<td>-0.1633</td>
</tr>
<tr>
<td>Food Shortage</td>
<td>-0.161</td>
<td>0.19</td>
<td>0.40</td>
<td>-0.4025</td>
</tr>
<tr>
<td>Sum of Memberships</td>
<td>0.162</td>
<td>1.17</td>
<td>0.80</td>
<td>0.2025</td>
</tr>
<tr>
<td>Cellphone</td>
<td>0.252</td>
<td>0.79</td>
<td>0.86</td>
<td>0.2930</td>
</tr>
<tr>
<td>Radio</td>
<td>0.254</td>
<td>0.94</td>
<td>0.85</td>
<td>0.2988</td>
</tr>
<tr>
<td>TV</td>
<td>0.112</td>
<td>0.03</td>
<td>0.16</td>
<td>0.7000</td>
</tr>
<tr>
<td>Access to Well</td>
<td>0.064</td>
<td>0.45</td>
<td>0.50</td>
<td>(0.128)</td>
</tr>
<tr>
<td>Malaria nets per cap</td>
<td>0.023</td>
<td>0.40</td>
<td>0.22</td>
<td>(0.1045)</td>
</tr>
<tr>
<td>Years with bioRe</td>
<td>0.088</td>
<td>2.82</td>
<td>3.04</td>
<td>0.0289</td>
</tr>
<tr>
<td>Total bioRe Neighbors</td>
<td>0.062</td>
<td>1.13</td>
<td>1.06</td>
<td>(0.0585)</td>
</tr>
<tr>
<td>Ox Ploughs</td>
<td>0.343</td>
<td>1.25</td>
<td>0.97</td>
<td>0.3536</td>
</tr>
<tr>
<td><strong>Vulnerability Dimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Neg Years</td>
<td>-0.120</td>
<td>0.53</td>
<td>0.52</td>
<td>-0.2308</td>
</tr>
<tr>
<td>(Pos – Neg) Years</td>
<td>0.128</td>
<td>0.05</td>
<td>0.74</td>
<td>0.1730</td>
</tr>
<tr>
<td>Cows</td>
<td>0.302</td>
<td>24.94</td>
<td>39.04</td>
<td>0.0077</td>
</tr>
<tr>
<td>Less Cattle this Year</td>
<td>-0.018</td>
<td>0.25</td>
<td>0.44</td>
<td>(-0.0409)</td>
</tr>
<tr>
<td>Bank Account</td>
<td>0.154</td>
<td>0.09</td>
<td>0.28</td>
<td>0.5500</td>
</tr>
<tr>
<td>Future: &gt;cotton</td>
<td>-0.072</td>
<td>2.76</td>
<td>1.60</td>
<td>(-0.0450)</td>
</tr>
<tr>
<td>Future: &gt;Mungbeans</td>
<td>0.078</td>
<td>2.63</td>
<td>1.31</td>
<td>(0.0595)</td>
</tr>
<tr>
<td>Future: Mungbean</td>
<td>0.003</td>
<td>0.41</td>
<td>0.49</td>
<td>(0.0061)</td>
</tr>
</tbody>
</table>

*: Calculated by dividing Scoring Factor by standard deviation analogous to Table 1 in Filmer and Pritchett (2001, p. 118). Scoring per unit in brackets indicates those variables that were insignificant. The calculation is derived from the fact that the scoring factor is multiplied by the household’s variable minus the mean, and then divided by the standard deviation. Simply dividing by the standard deviation yields the increase from a one unit change. For example, in the case of Purchasing Food, a household that purchased “some” food (2) versus only “few/little” (1) (which is assumed to be a one-step change), has a score of (-0.017967) for some and 0.145367 for little/few. The one unit increase from 1 to 2 consequently is (-0.017967-0.145367)=-0.1633.
As measured in the scoring factors in Table 6.7, the assets that are highly correlated
with the first component are mostly located within the economic and social dimensions.
In the social dimension, a larger number of ownership of them indicate higher correlations. This is the case for land (0.275), beds (0.331), motorcycle (0.214), and bicycle (0.299). In the vulnerability dimension, the only asset that is strongly correlated\footnote{The strength of correlation is in reference to the + and – signs in Table 6.5 and 6.6. Weakly correlated variables are indicated with (+) and (–) whereas uncorrelated variables are left blank.} is the number of cows owned (0.302), which could also feasibly be included in the economic or social dimension given their importance.

In the social dimension, additional variables that are strongly correlated or loaded include the number of cellphones (0.245) and radio (0.249) owned, as well as ox ploughs (0.346). Weaker correlated is television (0.107), which is strongly positively correlated in the following principle components. In addition to traditional assets, this first component also distinguishes by households that have a large diversity of food crops planted (0.222), which appears to be enabled by the larger than average availability of agricultural assets needed (land, ploughs, cows), in addition to a high number of household members (0.263) that are potentially engaging in agriculture. Out of all the 30 variables, the only one with a strong negative correlation was households with high needs to purchase food (-0.199). This also was partially true for households that had some levels of food shortage during the year (-0.161), or were more vulnerable as measured in higher numbers of very bad years (-0.112) or a positive number of good versus bad years (0.124).\footnote{Other minor variables of interest were age, which was weakly positive (0.153), increased memberships (0.168) or longer membership with bioRe (0.088).}

Beyond these variables with stronger correlations – in the social and economic dimensions – it is essential to discuss those with no significance in this first principal component. These are mainly variables on vulnerability, such as whether or not a farmer plans on planting more or less in the next year, or if he had more or less cattle than last year. A strong sign that this first indicator captures a present state of wealth as a result of past performance (ignoring future performance) is the insignificance of the net income per acre and total income per contributing household member variables.
These have a limited relationship with past performance as measured in increased asset ownership. Also, another key sub-dimension excluded is access to malaria nets or wells, which play a more significant role in other components.

**Comparison of Weights**

Using the scoring weights derived from both the scoring factor and the scoring per unit (with scoring of insignificant variables placed in (...)), those can be compared to the scoring weights designed based on past experiences in Tables E.1, E.2, and E.3.

The comparison can take place on two levels: first, at the level of the dimensions and their relative scoring. Second, at the level of the sub-dimensions and the relative scoring of the variables.

Figure 6.12 illustrates the finding for the dimensions and sub-dimensions graphically. It should be noted, that given the modifications and discrepancies, it is a rough approximation of the relative weights attributed to each variable. For example, instead of aggregation as in the multidimensional poverty score, in the PCA, assets values were not aggregated. Partially as a result of this disaggregation, the asset values were much more strongly valued individually.

**Evaluation at the Level of Dimensions**  Figure 6.12 presents a comparison of the approximate weights via the subjective index and the PCA. Evaluated at the level of the dimensions, the original index scoring of the variables indicated on the right hand side, was evenly weighted across the dimensions, each contributing one-third to the final score. The PCA score on the left hand side shows that this split did not exist in that analysis. The first dimension was 26.4 percent, the second 47.7 percent, and the third dimension slightly the lowest at 25.9 percent. A logical explanation is the uneven distribution of unique variables, with the second dimension – yielding the largest percentage of 47.7 percent – also having 14 out of the 30 variables (or 46.6

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35Since the PCA was run on a more limited set of variables that excluded strongly correlated variables and weak predictors, this represents only an approximate redistribution of the weights. Furthermore, some variables that were originally included, such as education, were replaced with age, which were highly correlated (yet age was more accurately measurable).
### Figure 6.12: Approximate Comparison of Weights by Index Methods

<table>
<thead>
<tr>
<th>Weights of Variables</th>
<th>PCA Score</th>
<th>Own Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future Bean self</td>
<td>0.002</td>
<td>0.0278</td>
</tr>
<tr>
<td>Future &gt; Mungbean</td>
<td>0.028</td>
<td>0.0278</td>
</tr>
<tr>
<td>Future &gt; cotton</td>
<td>0.009</td>
<td>0.0278</td>
</tr>
<tr>
<td>Bank Account</td>
<td>0.070</td>
<td>0.05</td>
</tr>
<tr>
<td>Less Cattle</td>
<td>0.078</td>
<td>0.0583</td>
</tr>
<tr>
<td>Cows</td>
<td>0.045</td>
<td>0.0583</td>
</tr>
<tr>
<td>(Pos-Neg) Years</td>
<td>0.013</td>
<td>0.0417</td>
</tr>
<tr>
<td>Total Neg Years</td>
<td>0.014</td>
<td>0.0417</td>
</tr>
<tr>
<td>Ox Ploughs</td>
<td>0.054</td>
<td>0.0208</td>
</tr>
<tr>
<td>bioRe Neighbors</td>
<td>0.009</td>
<td>0.0104</td>
</tr>
<tr>
<td>Years with bioRe</td>
<td>0.030</td>
<td>0.0104</td>
</tr>
<tr>
<td>Nets per capita</td>
<td>0.009</td>
<td>0.0417</td>
</tr>
<tr>
<td>Access to Well</td>
<td>0.047</td>
<td>0.0417</td>
</tr>
<tr>
<td>TV</td>
<td>0.074</td>
<td>0.0139</td>
</tr>
<tr>
<td>Radio</td>
<td>0.057</td>
<td>0.0139</td>
</tr>
<tr>
<td>Cellphone</td>
<td>0.057</td>
<td>0.0139</td>
</tr>
<tr>
<td>Memberships</td>
<td>0.027</td>
<td>0.0417</td>
</tr>
<tr>
<td>Food Shortage</td>
<td>0.028</td>
<td>0.0417</td>
</tr>
<tr>
<td>Purchase Food</td>
<td>0.019</td>
<td>0.0417</td>
</tr>
<tr>
<td>Ratio HH Members</td>
<td>0.010</td>
<td>0.0139</td>
</tr>
<tr>
<td>HH Members</td>
<td>0.031</td>
<td>0.0139</td>
</tr>
<tr>
<td>Age</td>
<td>0.023</td>
<td>0.0208</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.038</td>
<td>0.0111</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.070</td>
<td>0.0111</td>
</tr>
<tr>
<td>Bed</td>
<td>0.044</td>
<td>0.0111</td>
</tr>
<tr>
<td>Land Owned</td>
<td>0.022</td>
<td>0.05</td>
</tr>
<tr>
<td>Home Value</td>
<td>0.011</td>
<td>0.05</td>
</tr>
<tr>
<td># of Food Crops</td>
<td>0.011</td>
<td>0.0333</td>
</tr>
<tr>
<td>Total inc/ contr HH</td>
<td>0.047</td>
<td>0.0833</td>
</tr>
<tr>
<td>Net income/acre</td>
<td>0.022</td>
<td>0.0833</td>
</tr>
</tbody>
</table>

#### Dimensions
- **First Dimension: 26.4 %**
  - 3.30 per variable
- **Second Dimension: 47.7 %**
  - 3.41 per variable
- **Third Dimension: 25.9 %**
  - 3.23 per variable
percent). Calculating the percentage per variable, one finds the percentage is slightly larger, at 3.41 percent per variable, versus 3.30 percent and 3.23 percent for the other variables. What appears less surprising is that the third dimension of vulnerabilities is the lowest. Especially if we would exclude cows, which could be considered part of the economic (1st) or social (2nd) dimension, one would find even lower percentages.

![Figure 6.13: Difference in Weights ranked from Over- to Underestimation](image.png)
Evaluation at the Level of Sub-Dimensions  Comparing at the level of the sub-dimensions and individual variables, the five largest differences again exist amongst the asset variables in Figure 6.13: TV, motorcycle, radio, cellphone, ox ploughs, bed and bicycle. Bank account and having less cattle, two vulnerability dimensions, are attributed larger weights by the PCA as they are able to explain large variance differences. These differences however are much less than the previously mentioned classical assets.

Especially income variables –net income per acre and total income per contributing household members– were overestimated in the original index score. The statistical explanation would be that these two variables, in addition to other overweighted variables such as improved homes or land (shortages, appear to be of much lesser importance in explaining the variance amongst the variables, especially as it is measuring long-run wealth accumulation and they only capture a single year. As a result, to get a more complete picture, it is imperative to also observe the remaining 10 components that are not solely capturing long-run wealth. This additional analysis was undertaken in Appendix F. It confirms the multidimensional characteristics of poverty upon which the poverty index was based on.

6.4.4 Comparing Total Scores for PCA and Multidimensional Index

The main goal of the use of the PCA analysis, as outlined earlier, is to confirm whether or not the subjective multidimensional index is significantly different from a computational - or objective - measurement of poverty. Although differences in the makeup of the variables that entered into the analyses exist (see earlier discussion above), a correlation analysis - analyzed with the aid of a scatter plot - can reveal the strength

36 Besides ox ploughs, which was ranked twice as large in the original index, as it included originally ox carts, all were ranked well below the mean.

37 The reason it was expected that these variables would yield larger difference is that agricultural profitability and total income per contributing capita were expected to result in better ability of households to invest in these assets in the first place. Similarly, given the prominence of improved homes and land (shortages), these two were also believed to be of greater importance. The remaining variables, such as nets per capita or vulnerabilities over the last five years, were also of lesser importance, giving the indication that the PCA is reflecting more the long-run wealth accumulation, than human capital (as reflected in nets per capita or access to wells) and volatilities.
of the relationship between the two.

Figure 6.14 aims at providing these insights. It is plotting the original multidimensional index score - as a geometric mean of the three dimensions- on the x-axis versus the calculated score obtained by the PCA analysis on the y-axis. Neither score was adjusted with the lowest farmer equaling 0 and the highest 1. The two variables however do exhibit different ranges, with the possible scores ranging from 0 to 1 for the multidimensional index score. The PCA analysis is drawing on the raw results, with a range from -0.889 to 2.364.
Figure 6.14: Correlation between PCA Score and Multidimensional Index
Using the Pearson correlation, we get a value of .65 which is significant at <.0001. This high correlation is not entirely surprising, given the fact that we have few dramatic outliers. This high correlation lends credence to the design of the Multidimensional Index, as the linear line fits well.

Additional support is given by an analysis of the correlation of the ranks (ignoring the absolute scoring) of the 114 farmers. For this purpose, a Spearman rank-order correlation calculation was undertaken. As a very positive sign, the correlation between the rank of a farming household according to the PCA and Multidimensional Scores even increased from 0.65 to 0.68 at the same statistical significance of <.0001.

This analysis can be refined by breaking it down into 3 categories (based on the geometric mean): The Top 20% (wealthiest), the 20 to 80% (middle), and the Bottom 20%. Figure 6.15 shows this classification, with red equaling the bottom 20 percent, green the 20-80 percent, and blue the top 20 percent. The correlation result (using both Pearsons and Spearman rank-order) is shown in Table 6.8.

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38 When removing outliers outside 1.5 standard deviations, we would get a higher correlation of 0.70.

39 Alternate options of using quadratic or cubic fits did not significantly improve the correlation.

40 Please note that this comparison is solely done arbitrarily in order to identify the best correlations amongst these three rough groups, rather to make an absolute statement on poverty.
Figure 6.15: Correlation between PCA Score and Multidimensional Index
Table 6.8: Colored Correlation Results across the 20-60-20 percentiles

<table>
<thead>
<tr>
<th>PCA x Multidimensional</th>
<th>Correlation Pearson</th>
<th>Correlation Spearman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 20 %</td>
<td>0.75727*</td>
<td>0.53162*</td>
</tr>
<tr>
<td>Middle 60 %</td>
<td>0.38537*</td>
<td>0.44724*</td>
</tr>
<tr>
<td>Bottom 20 %</td>
<td>0.24977</td>
<td>0.01412</td>
</tr>
</tbody>
</table>

* indicates significance at <0.01.

Compared to the average correlation observed earlier, only the top 20 percent are more correlated, and only if measured using the Pearson method. It means that both indices work well at distinguishing the upper extremes from the rest. Looking at the middle 60 percent, they are still strongly significantly correlated, although the patterns become more uneven. At least when using the rank-order method, we obtain nearly a correlation value of .45. Looking at Figure 6.15, it seems clear that the weak correlation can mostly be attributed to the large range in PCA scores of values around 0.50 of the multidimensional score.

The lack of statistically significant correlation in the bottom 20 percent can be attributed to the arbitrary nature of the cut-off chosen. The graphical representation in Figure 6.15 illustrates that a stronger correlation exists from 0.10 to 0.30 of the multidimensional index. At 0.35, a clustering occurs where the values are spread nearly vertically along the line. Consequently, if the cut-off would have been set around 10 percent, this correlation score would have been much stronger. In sum, the results from Table 6.8 hint towards the fact that both the PCA and the original multidimensional scoring index are capturing both the very top and bottom extremes, yet fail to be strongly correlated in the middle ranges.

6.5 Discussion

Although the above analyses on unidimensional and multidimensional poverties and inequalities are rigorous, they are exhibiting two shortcomings: spatial and temporal.

First, they ignore spatial relationships that are potentially important in influencing poverty outcomes. Since in both Chapter 4 and 5, spatial dimensions have had significant impacts, it consequently is applicable to test the same in the context of these more advanced poverty analyses. Appendix G contains preliminary analyses using the
village and its center as spatial variables as a fertile basis for further empirical analyses.

Second, the data used above is plagued by only drawing on a single year. Undertaking a longitudinal study was beyond the capacity of this research. However, drawing on participatory econometrics combined with follow up visits to the region, a sense was obtained of the impact that changes in price have on poverty and inequality. This analysis, undertaken in Section 6.5.1, is especially warranted as the price of the 2008-09 season was unusually low and fixed throughout the year due to a lack of demand from buyers. The 2009-10 season, on the other hand, saw historically high prices with a large increase towards the end of the season.

6.5.1 Temporal Analysis: Impact of Commodity Boom on Poverty and Inequality

The prices observed for the cotton crop sold in 2009 were some of the lowest recorded in latest history, as they never got above 440 Tsh (after the 80 Tsh subsidy from the government). The crop planted during the 2009-2010 season however found record setting prices. As shown in Figure 6.16 on page 225, compared to an FAO food basket price index, cotton led the charge between August 2010 to February 2011 in the second global commodity boom after 2007-08.\textsuperscript{41} It however is unclear who exactly is a winner from these prices.\textsuperscript{42}

\textsuperscript{41}As of Summer 2011, it has dropped significantly from its highs. By Fall 2011 it has returned nearly to its pre-boom levels.

\textsuperscript{42}In the organic market neither traders nor consumers nor farmers appear to be clear winner: Traders can struggle to secure high quality organic produce under the increased price competition. Since organic pays a fixed price premium, it has substantially diminished in importance, increasing the dangers of side-selling. These developments are even worse when combined with retailers reluctance to pass higher prices onto consumers, thus changing their strategy away from organics as is the case with Wal-Mart. Farmers, on the other hand, could fail to fully take advantage, since they have either already sold their crops via a contract fixed prior to zenith, or at the other extreme failed to sell their cotton at a high price since they sold most of it in the beginning of a purchasing season. (Ledermann and Leichenko 2011)
Figure 6.16: Cotton Leading the Way in Second Commodity Boom
In this section, the impact of the commodity boom on the farmers in Meatu is analyzed, given its relevance on poverty and inequality. As discussed previously in Section 4.3, conventional farmers were more likely to decrease cotton production for the following 2010-11 season (see Figure 4.6 on page 132). As a result, it would be expected that they already had reduced acreage for the cotton harvested in 2010, due to their plans of reducing their acreage of cotton in the future. Based on their answer, they would also seem less likely to benefit even from the higher starting price at the beginning of the 2011 purchasing season from their 2010-11 season crop.\textsuperscript{43} Based on current data, this would be the preliminary evidence available in regards to the commodity boom’s impact on poverty reduction.

However, as Figure 4.5 on page 130 shows, nearly all conventional farmers also will attempt to increase their mungbeans production for the 2010-11 season. Stimulated by high prices, which rose from around 250 Tsh per kg in the 2007-08 season to nearly 2’000 Tsh per kg by 2010-11, both price and production have skyrocketed.\textsuperscript{44}

It would be expected thus, while cotton boom prices did not have a positive impact on necessarily reducing poverty, as most conventional farmers failed to take advantage, those that increased mungbeans acreage were able to benefit strongly from it, which kept any increases in inequality in check from the differential earnings (potentially even reducing it).

**Impact on Poverty Reduction and Inequality**

The survey undertaken in Spring of 2010 prior to the harvesting in Summer 2010 asked not only whether or not a farmer would increase cotton or mungbeans in the future, but also if he planted more this 2009-2010 season than the previous year (2008-09). The results depicted in Figure 6.17 are similar to the decisions previously shown in Figure 4.6.

\textsuperscript{43}In terms of yield, if they would have reduced their acreage and subsequently increased their ability to plant more intensively, this could offset any potential reductions.

\textsuperscript{44}As with cotton, which has dropped nearly 50 percent from its 52 weeks highs at the world market, the local price for mungbeans has also decreased. The last recorded price (although people stopped buying now given that the harvesting is over) was back to around 1’000 Tsh per kg.
Although slightly less farming households' current cotton fields were recorded (reflected in a smaller \( n \)), the pattern was nearly identical for conventional farmers while organic farmers increased.\(^{45}\) It consequently follows that more bioRe farmers increased their acreage even in the 2009-10 season, compared to conventional farmers, thus situating themselves better to decrease their poverty levels in the aftermath of the high prices potentially available to them in the 2010 (and 2011) purchasing season.\(^{46}\)

In 2009-10 season, the starting price was only 600 Tsh per kg (with one farmer even reporting having sold at 550 Tsh per kg). Figure 6.18 shows this starting level, which existed for around four weeks in the month of July. During the entire month of August, the cotton price rose.\(^{47}\) The second August week saw the largest growth, as the price

\[^{45}\text{Ignoring those who did not yet know in Figure 4.6, the farmers planting less cotton currently were nearly the same compared to those who would increase. Similarly, for organic farmers, the pattern was similar to the one depicted in Figure 4.6.}\]

\[^{46}\text{Instead of undertaking another costly and time-consuming complete round of surveys, three focus groups were held to inquire with farmers who was able to take advantage of the high cotton prices. In addition, follow-up visits were made with several farmers after an analysis of their 2008-09 data showed them either as a severe outliers or that they had missing data. A total of 18 farmers were met with in that way, although for only 12 were specific prices recorded.}\]

\[^{47}\text{Note that the cotton prices are daily adjusted in each village. The last price of the week was just as}\]
rose by 150 Tsh. By September, it leveled off reaching its plateau as cotton traders were continuing to struggle to fulfill their quota even scrambling until the last weeks of the purchasing season for the remaining cotton.

![Development of Cotton Price in Ngeboko From Beginning to End of Purchasing 2010](image)

Figure 6.18: Increase in Cotton Purchase Price in 2010 after stagnant first 4 weeks

Out of the 12 farmers with data available, only two reported to have sold cotton at the high price of 1200. The remaining 10 sold their cotton at a rough average of 650 Tsh, or 50 Tsh above the lowest price of the season. Reasons stated for why farmers were not able to wait with selling were: *Lack of income from mungbeans; had a problem; contributed to wedding; just bad luck; a bad harvest thus not enough cotton to wait; hearing information that the price would fall*. The two farmers that were able to wait had more than one ox cart (around 1000 kg) of cotton harvested and some income from mungbeans.48

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48One sold one ox cart at a higher price, while selling one earlier. This household was also able to buy 5 cattle for 1 million which was a low price. The other farmer also was able to wait with selling...
Moving from their particular selling decisions, the discussion shifted towards a general characterization of which type of farmers they think could take advantage of the higher prices. In the focus group in Mwamanongu, the main reason reiterated was that it was “just out of good luck” that someone was able to wait, and sell at high price. The reason they stated for someone being able to wait and hope for good luck were if they had fewer problem in their house of food shortages, so they did not need cotton money quickly to purchase food. Second, given the comparatively high starting price compared to the previous season (where not only the purchase was delayed but the price ended up being 440 Tsh per kg), they believed that this minimum price offered at the start would be the high of the season as well, as it did not change for nearly a month. Although no farmer cited mungbeans specifically, there was strong agreement that “if you plant a lot of choroko [mungbeans] you have more money and less problem.” (Focus Group Mwamanongu, p.1) This is especially true for the timing of the harvest of mungbeans, which occurs from May onwards in the year, thus yielding an income source for around two months prior to the start of the cotton purchasing season.

Drawing direct inferences from higher mungbeans income and ability to sell cotton at a higher price is difficult. As illustrated by the case of a politically-active farmer in Mwamanongu, although he harvested more mungbeans he however did not wait as the “traders said that the price will be reduced.” So he sold, especially since he was leaving for travels to Dodoma. Once back he clearly was shocked upon the news that the price had doubled. This fear that the prices – as announced by the cotton buyers – could drop was voiced by just about every farmer. When asking bioRe staff, its manager Pattni pointed out that cotton buyers remind the farmers that only the price today is guaranteed yet could fall tomorrow. He says that the price rarely if ever fell so farmers

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49 One farmer who sold one ox cart at 700 Tsh and 1 ox cart at 800 said he did not really try to wait for a higher price as “he was just waiting”, with the second ox cart still being in the field and not yet harvested. He however didn’t cite mungbeans as a reason he could wait, as he didn’t have much money from it.

50 Although in his case, a cellphone call probably informed him well in advance of his return.
know that it is just “part of the game” and one of the easiest answers for a farmer to give.\textsuperscript{51} Farmers however did recall years where the price fell. In Mwamanongu, 2004 was cited as an example, where it declined from 300 to 250 and 180 Tsh/kg. Also in 2005, it was said to have declined. So at least based upon even recent history, they seem to have ample anecdotal evidence.

Coincidentally, in the 2010-11 season, the price dropped: due to declines in the world market, the (guaranteed) floor price of 1,100 Tsh at the start of the season could not be sustained (or at least as argued by the ginners and traders) and was reduced to 800 or 900 Tsh per kg after a long debate with the government.\textsuperscript{52}

One key point of contention and potentially one of the most decisive in terms of inequalities, is whether or not a farmer with a lot of cattle can wait with selling his cotton as he has securities. This discussion proved to be the most interesting in the Mwamishali focus group. Several hours were spent discussing the interplay between cotton and cattle, with Figure 6.19 on page 231 drawn by the participants to illustrate changes in the cattle price across the year and explain them.\textsuperscript{53} The general agreement was that cattle acts as a safety net or security, enabling a farmer to wait selling cotton:

“Those people who sell late they have cattle. They can sell late and keep cotton”

“I can sell cattle and do something that I want to do. If I have problem, I solve that problem. Maybe after selling cotton again, I can buy more cattle to replace [them].”

However, further discussions with the focus group in Mwamishali revealed that even though farmers with many cattle are more likely to be able to wait with selling cotton,

\textsuperscript{51}This was the view I picked up, thus trying to inquire with farmers if they actually remembered a year where the prices fell.

\textsuperscript{52}These negotiations were even more difficult since it was an election year.

\textsuperscript{53}The lowest levels for cattle are in the height of the dry season of January and February where a large cattle fetches around 250,000 Tsh. With the start of the second rainy season it increases to around 350’000 Tsh. The onset of mungbeans selling from May onwards result in it rising to around 500,000 Tsh by July. After the start of the cotton purchasing season, it rises to its peak levels of as high as 600,000 Tsh by August and September.
Figure 6.19: Chart drawn by Focus Group to Discuss the Relationship between Cattle and Cotton
they are reluctant to sell cattle. Asked if a farmer, who was hoping for cotton to increase later, yet found out that it decreased by September, would sell cattle since it has the highest value of the season, they disagreed.

“[A farmer] is not going to sell the cattle he will sell cotton. Some farmers will wait to sell until next year, especially conventional farmers. For bioRe farmers, this is not the case, as they have yield estimations [and thus can’t sell more than their yield estimates].”

“Normally the farmers, they are not business men. I sell cattle once I have a problem. For example my cotton is still in the field to buy labor or I have no food at home, [then] I can sell. Otherwise, [...] you would adjust your income [consumption] to the price you have.” (Mwamishali Focus Group)

An interesting case is the relationship between food prices and cattle prices. When cattle prices are low (in February and March), food prices reach their highest peaks. Correspondingly, after harvest in July to September, cattle prices reach their peak yet food prices are at their lowest given the great supply. Farmers consequently who had to sell cattle in February to purchase food are perceived to be experiencing great difficulties and considered more vulnerable than those that strategically buy food during August for example (Mwamishali Focus Group).

In Mwamanongu, farmers disagreed with the statement that “[a]nother reason a farmer can wait is cattle”:

“It’s not true. [It is] not possible because a farmer who has the cattle it is not possible to sell his cattle to buy anything or sell anything instead of selling cotton. It is better to sell cotton.”

When confronted with the possibility to wait for good luck by gambling for a higher price later and if it would have dropped I could sell the cattle, meaning “just knowing that I have cattle lets me take this risk”, farmers in Mwamanongu objected:

“The problem for the farmer is that they already think that if I sell my cotton then I will have to add another cattle. Another problem is that if I
stay with my cotton, I will do nothing. So I have to sell cotton which can help me rather than selling cattle [...] For few farmers know [how to use cattle to be able to take a risk like that]. Many farmers know that if I sell my cattle, I will be finished. Some of them know that if they sell their cattle rather than selling their cotton [...] some farmers with education.”

In summary, the discussions with farmers showed that price increases rarely translate directly to higher incomes obtained by all households. The most interesting factors listed for why a household would be unable to take advantage were a lack of income from either mungbeans or low cotton harvest, lack of cattle as a safety net, and overall vulnerabilities experienced by the household. Although the sample size was too small to draw inferences from the farmers who were able to wait, they strongly agreed that households that plant mungbeans are more likely to wait selling cotton. This is because the income necessary for purchasing basic necessities - given a lack of savings - will reduce the pressure to sell cotton early. In case savings exist - in the form of cattle most likely - farmers are also able to wait. As a result, in regards to the commodity boom’s impact on poverty and inequality, it becomes evident that all farmers certainly benefit from higher cotton prices, although organic farmers were more likely to have planted higher acreages of cotton and thus harvest larger gains by default. Conventional farmers, since they embraced the planting of mungbeans enthusiastically, are however able to keep inequalities in check that would arise from organic farmers’ abilities to wait longer with selling. These same conventional households however are less likely to own cattle - a lump sum investment (Dercon 1998) - which act as a safety net. As a result, they are more dependent on continued high prices for mungbeans.

6.6 Summary

This chapter answered the question whether or not organic farmers are less poor and experience less inequality compared to their conventional counterparts. It drew on the unidimensional and multidimensional method outlined in Section 6.1 of measuring and calculating poverty and inequality. This research consequently advanced the work
by Alkire and Foster (2011a, 2011b) by constructing and applying a multidimensional measurement to the local level.

Section 6.2 answered Hypothesis 3.1, whether or not organic farmers were less deprived or poor compared to conventional farmers using a unidimensional approach. This was based on the basic need line for rural Tanzanians. It found that organic farmers are less likely to be deprived and poor compared to conventional farmers. However, when adding income from outside of cotton and focusing on breadth of poverty - poverty gap - and inequalities or depths of poverty - squared poverty gap - the differences between the group are smaller and not significant. One key factor attributed for this change is the rise of mungbean production as an alternate income source outside of cotton.

Section 6.3 answered Hypotheses 3.2 and 3.3 on whether organic farmers experience lower poverty headcounts, breadths of poverty and depths of poverty using a multidimensional approach. Hypothesis 3.2 is confirmed in that organic farmers are experiencing significantly lower poverty headcounts as well as breadths of poverty. Focusing solely on the poor farming households, we furthermore can confirm that even in regards to inequalities - measured via a squared poverty gap - they are larger amongst conventional farmers, thus confirming Hypothesis 3.3. A decomposition undertaken in Section 6.3.3 showed that for organic farmers, the social dimension is of greater importance in determining who is poor, compared to more classical economic dimensions for conventional farmers. These included a lack of access to cattle, land or low income per capita.

Section 6.4 compared the multidimensional index created to a PCA. Although weights are considerably different, a comparison of the total PCA and multidimensional index scores show that they are strongly and significantly correlated, thus giving additional strength to the robustness and validity of the earlier findings.

Finally, Section 6.5 highlighted two shortcomings of the analyses, which were their lack of a spatial and temporal components. The spatial analysis in Appendix G shows evidence of dynamic external economies of scale, as farming households in older bioRe villages experienced lower levels of poverty. The temporal analysis in Section 6.5.1 investigated the impact of higher global commodity prices in the 2009-10 season that
followed the survey year. Drawing on participatory econometrics, it found that especially farmers that have access to cattle - as a safety net - and have income from mungbeans - as an early and alternate income source - are more likely to be able to wait with selling their cotton and thus take advantage of potentially rising prices. Since bioRe farmers were more likely to not have reduced or increased their cotton acreages, they overall were better positioned to harvest the gains from higher prices, as a farmer would need to obtain at least one ox cart of cotton. However, as identified throughout the research, mungbean production can work as an inequality and poverty reducing component, especially since conventional farmers have eagerly embraced its production.

54 They also own more cattle.
Chapter 7

Conclusions

The global food and financial crises revived long-standing debates on the importance of research and growth in the agricultural sector. Traditionally, agricultural development strategies focused on the transfer of technologies developed under the Green and Biotechnology revolutions. While both can increase output, due to their capital-intensive nature, they have failed to reach the poorest of farmers in sub-Saharan Africa.

The search for a new, sustainable direction in agricultural development - as outlined in the IAASTD (2009) - provided the impetus for the present study on the Organic revolution. As a labor- and knowledge-intensive revolution, the agricultural practices and their impact on poverty and inequality were analyzed through a case study of an organic cotton export operation in one of the poorest regions of Tanzania in East Africa. Besides the work by Bolwig et al. (2009) this research presented one of the first comparative studies between organic and conventional farming households in a de facto organic environment. Drawing on household survey data gathered from 122 farmers, three main research questions were answered. These were to test who becomes an organic farmer, whether or not organic farmers are more sustainable, and ultimately the impact of the introduction of organic agriculture on poverty and inequality. This research consequently contributed to a long history of analyses on economic growth by investigating the fundamental question of what sustainable economic development looks like with the introduction of a new innovation - organic agriculture.
7.1 Research Findings

Chapter 4 - *Who is an Organic Farmer? Adoption of an Organic Innovation* - analyzed the socio-economic differences existing between organic and conventional farming households. This represents an empirical contribution to the literature by evaluating who becomes an organic farmer in the context of a developing country. The results found that organic farmers, on average, own larger farms and also are wealthier compared to their counterparts. There was no significant difference in their level of education in comparison to conventional farmers. This indicates that a potential lack in human capital is not acting as a barrier towards the diffusion of organic methods (and subsequent membership in bioRe). These methods are more labor- and knowledge-intensive rather than capital-intensive as compared to other agricultural revolutions.

As revealed in the review of the history of the area, one of the key sources of unevenness - beyond the classical variable of cattle ownership - in recent years is access to land. An investigation on who becomes an organic farmer using a logit model showed that having less access to land (measured in increased percentage of land rented) reduces the likelihood of becoming a bioRe farmer. In the contract farming environment, the minimum requirement of owning 3 acres of land consequently questions the extent to which early-adopters are self-selecting. Furthermore, no clear differences in education nor farm size exist that would explain membership, strengthening the finding that early adopters do not fit the classical profile of being wealthier, better educated farmers with larger farms (Rogers 2003).

An analysis of differences in net income and total income obtained revealed that there also exist wealthy conventional households that are *by choice* refraining from joining bioRe, as they have developed alternate income sources. While organic households on average are obtaining significantly larger income from cotton, the results do not support the hypothesis that conventional farmers by default are poorer when looking at total income. As Chapter 3 noted, the physical geography (especially low rainfall) of Meatu limited opportunities for alternate cash crops. With the rise of mungbeans in recent years - introduced as a nitrogen-fixing agricultural method by bioRe - this has
changed. Conventional farmers especially were responding to changes in prices, thus strengthening their ability to diversify and take advantage of less laborious and land-intensive cash crop than cotton. It is argued that this novel opportunity for the Meatu district has an inequality-reducing impact. Organic farming methods consequently contribute towards economic diversification and improved equity.

Chapter 5 - *Measuring Sustainability of Organic Agriculture* - investigated the introduction of these organic practices (including the intercropping of mungbeans). This investigation situated organic agriculture as an innovation and represents a major empirical contribution by operationalizing an organic sustainability measurement (Rigby et al. 2001) to the local scale in a sub-Saharan African context. The results show that organic farmers as a group are achieving higher sustainability scores than their conventional counterparts. As a pattern seen throughout the research, organic farmers as a whole represent a more coherent group. Given the knowledge- and labor-intensive nature of organic agriculture, however, it was hypothesized that even poorer conventional farmers can take advantage of these techniques. This was confirmed as the best performing conventional farmers were significantly poorer compared to the worst performing, yet wealthy, organic households. This provides evidence towards organic agriculture - as an innovation - trickling down social strata, as opposed to across (Rogers 2003).

The results also showed that farmers that own less land are engaging in more sustainable agricultural practices. They also earn a higher net income per acre. These positive findings on sustainability and profitability confirm the findings in the agricultural sustainability literature (Netting 1993). While the review of the history of intensive agriculture in Chapter 3 showed that farmers had previously intensified their production (i.e. via integration of farm yard manure) when faced with large population densities, given the low levels of FYM applications, no significant relationship was identified.

Chapter 5 focused solely on ecological sustainability, yet sustainability in agriculture is best assessed by including social and economic dimensions (Zhen and Routray 2003) which was undertaken in Chapter 6 - *The Impact of Organic Production on Inequality*
and Poverty. Drawing on the concept of multidimensional poverty, this chapter investigated - as a major empirical contribution - the impact of organic agriculture on poverty and inequality between organic and conventional farmers. This application of the multidimensional poverty index (developed by Alkire and Santos 2010, Alkire and Foster 2011a,b) to the household level represents a significant methodological contribution.

Starting with a unidimensional analysis using the basic need levels as a threshold, the research confirmed the earlier findings from Chapter 4 as organic households were less poor and deprived compared to their conventional counterparts. However, this difference was eroded when including total income. Mungbean production in particular was identified as reducing the poverty and inequality between conventional and organic farmers.

The same analyses were undertaken using a multidimensional approach. This included the calculation of geometric averages of three dimensions: economic, social and vulnerability. Using this advanced metric, the findings illustrated that organic farmers have significantly lower poverty headcounts as well as breadths of poverty. Even in regards to inequality, they are experiencing lower magnitudes of depth of poverty. A decomposition analysis showed how standard economic variables (lack of access to or ownership of cattle, land or low income per capita) are more important in determining conventional households’ poverty levels.\(^1\) Given the subjective nature of the index construction, the robustness and validity of the findings were confirmed via a PCA analysis.

In sum, this research - as a major empirical contribution - confirms that organic farmers are less poor in income and beyond.\(^2\) Observing the ecological sustainability, conventional farmers, however, also adopted organic methods successfully, indicating that the Organic revolution is not driving inequality. This is attributed to two main factors: First, organic agriculture is a knowledge- and labor-intensive revolution, as opposed to the more capital-intensive nature of other agricultural technologies. Second,

\(^1\)Poor organic farmers, on the other hand, are marked by deprivations in social dimensions.
\(^2\)These include their lower poverty scores looking at non-monetary measures, including social and vulnerability dimensions.
as a serendipitous development, the push for planting mungbeans as a nitrogen-fixing legume by bioRe coincided with a boom in price. As a result, even conventional farmers rapidly adopted the method and are able to diversify their income.

Looking forward, mungbean production also proved to play a supplemental role in enabling a farmer to wait for higher prices when selling his cotton. This became of great importance in the last two seasons, as cotton prices reached record levels in the aftermath of a global commodity boom. Since traditionally mostly farmers with cattle were able to take advantage of increases later in the season, this furthermore strengthens the legume's inequality-reducing potential.

It is however important to note two limitations of the crop. First, this novel availability of an alternate cash crop in the study region is predicated on continued high prices. As of Summer 2011, its price was on the decline, reminding us that it by far is not a panacea given that farmers are exposed to similar market volatilities as with cotton. This is coupled with the fact that most farmers grow mungbeans without attention to its nutrient-fixing potential, as they are motivated by the higher prices. Consequently, it is questionable to what extent its production would continue in the aftermath of a price decrease, potentially resulting in a negative impact on the farm-level sustainability score. The rapid adoption, however, can serve as a great opportunity for strengthening farmers’ knowledge on sustainable methods. A second limitation is that when observing the poorest of the poor, we find that they lack access to land, being dependent upon renting annually. Mungbean production is favorable to their situation given the need for only smaller plots of land and less labor. With the boom in mungbean and cotton prices, as well as shortages in grazing land, however, rent paid for land has increased each year, with the costs becoming larger for smaller farmers, especially if they lack the networks to obtain access. It is feasible, if analyzed over a longer time period, that some of the poorest will no longer be able to diversify.
7.2 Policy Implications

One of the main impetus for this research was the increased interest by policymakers at the international and national levels in organic agriculture as a viable development alternative. Drawing from the empirical results presented above, the findings of this study consequently serve to inform these decision makers on the feasibility of organic agriculture as a pro-poor, sustainable development strategy. It provides support towards the ability for organic contract farming to have a positive impact on livelihoods for certified organic farmers, especially via the price premium.

The research furthermore highlights that organic agriculture can have an impact beyond the intended certified export crop: First, the focus on increasing biodiversity and soil fertility via intercropping strategies and crop rotation had the additional benefit of enabling the marketing of a legume crop, mungbeans. This economic diversification has important positive economic impacts for farmers. Second, moving beyond the certified organic farmers that are recipients of the extension advice and training, the study has shown that viable organic methods can even be adopted by poorer conventional farmers. This highlights the strength of organic agriculture as an open source innovation that, in a low input environment, can reach a wide audience. Policy recommendations consequently include to broaden this study to other crops, as well as environments, in order to investigate the diffusion and intensity of adoption of organic methods by both wealthier and poorer farming households.

Observing cotton yield data, the research area of Meatu district, however, continues to have comparatively low levels of agricultural productivity as most increases still took place via extensification (see also Schuknecht 2010). As a result, there are two interrelated policy recommendations. First, much larger investments are needed in agricultural research, especially but not limited to advanced seed breeding and improving soil fertility via organic methods. Increasing public funding on organic research and its dissemination is warranted, given the limited ability for private actors to market the technology and protect their investment analogous to patenting, prevalent for example in modern biotechnology. Second, derived from the example of the long history of
promoting farm yard manure, yet continued low adoption in the region, new organic innovations should be introduced that offer a novel avenue for ensuring fertile soils. Agroforestry, green manure or nitrogen-fixing grasses represent potential options. In addition, a new push strategy could be employed that works in combination with the successful adoption of sunflowers by both conventional and organic farmers to harness its pull effect on pests. As a policy lesson, promoters of agricultural development consequently should pay careful attention to not just transpose organic methods developed in Europe, but work towards developing innovative local methods that emerge after an understanding of the geography and farmers’ struggles and motivations.

In addition to increasing yield via agricultural technologies, the study showed that especially the poorest conventional households are lacking access to land or cattle. As a result, they struggle to improve their livelihoods using rented land. Soil fertility improving measures - a key focus in organic agriculture - for example are less applicable if farming on rented land that changes annually in ownership. A key policy challenge coming out of this research is how to provide these households with more secure access to capital in order to enable them to either obtain land ownership or diversify away from agriculture into another activity. Without secure access to land, the incentives for investments in organic agriculture are likely going to be too low for a long-term sustained adoption of the technologies.

For wealthier farmers with secure access to land, their rain-fed production often is perceived as needing conversion to an irrigated production scheme. Although not a focus of this study, organic agriculture has been shown to increase soil moisture retention. Given the arid environment, instead of attempting at increasing production via irrigation, combining organic methods with an institutional provisioning of crop insurance, for example, could provide a more sustainable tool to reduce volatilities and resultant vulnerabilities. A similar program for supporting cattle prices during drought years would assist this effort. Last but not least, only a limited applications of mobile technology to assist in timing the selling of cash crops or cattle was noticed in the field. This could provide a viable avenue for policy support to connect farmers to other markets in order to increase their capabilities at making informed decisions when
entering the exchange.

7.3 Limitations of the Study

Before reaching a conclusion on the superiority of the Organic revolution, four important limitations of the study should be considered.

First, drawing on the methodology of participatory econometrics complemented the econometric analyses with a combination of focus groups and semi-structured interviews. This involved at its most basic level the sharing of findings with the individuals that partook in the study. It also resulted in the adjustment of the research questionnaire in the beginning - with a more detailed focus on labor and mungbeans - and subsequent re-interpretations of the data based on discussions held. There are three specific insights gained from participatory econometrics for the re-interpretation of the data. The first example is how the discussion of the focus groups highlighted the important role of cattle and sales of mungbeans in regards to who is able to benefit from the higher intra-seasonal cotton prices. These discussions revealed the interrelationship of diversifying income sources and obtaining savings in order to accumulate higher profits and combat poverty. The second example is the participatory discussions of regression results and their significance. Especially the role of land ownership and the significant distance variable was better understood after holding interviews with village elders and identifying the significance of former development interventions, such as villagization. A third related example was in regards to the (lack of) adoption of certain intensive agricultural methods, i.e. farm yard manure. Drawing on participatory econometrics provided a better understanding on the historical resistance to adoption of these labor-intensive methods (especially as they relate to less labor-intensive methods, such as intercropping choroko) and their perceived benefits by farmers.

While participatory econometrics was especially successful in regards to (unidimensional) poverty, the discussion of the multidimensional poverty index and its findings on inequality could have been enhanced by further studies in the field. This would be especially beneficial in regards to contrasting the subjective weighting of the index (based
on fieldwork), the PCA weighting, and weighting from the focus groups. Although inequality was included in the analysis and discussion, it could certainly be measured in more nuanced ways, including a revision of thresholds and cut-offs.

Second, an overarching limitation of the research is that the survey data collected on the 122 farmers was from one year only. While limited data was gathered in follow-up visits with farmers, answering questions in regards to poverty and inequality, as well as organic methods adoption, would have benefited from a longitudinal study, in addition to an increased application of spatial econometrics. Furthermore, decertified farmers were not included in the research. As noticed in the assessment of organic sustainability, there is a considerable fluidity between the two groups and their respective scores. Consequently, it would be interesting to increase the sample size and include specifically decertified farmers (as was originally intended) in large enough numbers. This lack of the focus on certification - as a process that delineates two groups - also sidesteps critiques on fairness, justice and equality that are the focus of previous research within Geography in general and organic and fair-trade agriculture in particular (i.e. Mutersbaugh 2005; Getz and Shreck 2006). It also fails to include an analysis on the powers held by farmers, such as via side-selling.

Third, beyond certification and its impact on households, two key areas that received limited attention is the question of organic agriculture’s impact on labor and gender. Labor would deserve increased attention in future research, given that it is a potential key revenue source of income for poorer conventional farmers. Studying organic agriculture’s impact on labor incomes would also reveal more soundly the intervention’s pro-poor potential, especially as previous studies (see for example Jaffee (2007) on fair trade coffee) showed increased costs of hired labor. Furthermore, calculating wage rates for non-hired family labor could have a significant impact on the perceived profitability of organic agricultural production, as measured in net income for example. Given the focus on the household (head) in the surveys, gender also received only limited attention. While studies by Schwaller (2005) and Jermann (2011) directly

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3A similar exercise was successfully undertaken with bioRe staff and farmers on the organic sustainability index created for bioRe Tanzania.
address this issue for bioRe India and Tanzania respectively, the shift of mungbeans - a traditional women’s crop - to the household head as an income source received limited discussions. In addition, given the fact that organic agriculture is in theory a more labor-intensive practice, this study did not provide any evidence in regards to its impact on the gendered division of labor within the household. As a result, by not analyzing intra-household dynamics, this research provides very limited additional insights to a large body of literature (see for example Schroeder (1999)) that has consistently focused on analyzing the attributed benefits of development interventions from a gendered perspective. Addressing this limitation in future studies would break down the gains obtained from organic agriculture within both conventional and organic households by combining a change in the gendered divisions of labor with an analysis on who exactly in the household has access to any potential income gains. As addressed in one focus group, this need for further studies is accentuated by the fact that mungbeans was traditionally a women’s crop. Given its prominent role in this study, assessing both the potential increased labor demands by women and losses in their discretionary income from mungbeans would provide fertile ground for future studies.

Fourth a limitation exists in regards to the lack of in-depth investigation of the ecological pressures. This takes place at the level of the soil, where the farm-level sustainability measure for example is not measuring actual improvements in soil, but rather based on assumptions of improvements based on methods applied. It however extends beyond the soil to a political ecological investigation of the interplay between politics and ecology. With the noted increased pressures on land in the study area, the research was not able to expand upon the historical work by Schuknecht (2010) on the Sukuma Development Scheme under the British and Kamata (2005) on more contemporary government interventions in regards to livestock.4

4Furthermore, the discussion on adoptions could benefit from a potential application of insights from science technology studies by investigating more thoroughly reasons for adoption and non-adoption, adaptations to the adoption, as well as capacity to innovate beyond the training and teaching of the extension officer. A current research undertaken by Morganti and sponsored by ICEA/FAO is focusing on identifying and stimulating avenues of farmer-to-farmer learning and innovations.
7.4 Directions for Future Research

Based on these limitations, three theoretical and four empirical avenues for future research are outlined below.

7.4.1 Theoretical Avenues for Future Research

Since the study focused mostly on the impact of organic agriculture as a pro-poor growth strategy at the farm-level, it sidestepped important theoretical avenues. For example, one key theory motivating the Tanzanian government’s push towards increasing productivity in agriculture is to free labor for non-agricultural activities (United Republic of Tanzania 2010). Since organic agriculture is perceived as more labor-intensive, a future avenue of research would be to evaluate the extent that its promotion reduces pressures or incentives for migrating out of rural areas. Theoretically, increased cotton prices (via the organic premium) and labor demands could lead to higher costs of hired labor, which should reduce poverty yet also reduce the push factors of migration (see Ruttan 2004).

In analyses reviewed of the agricultural revolutions, important questions were raised in regards to the existence and importance of increasing economies of scale. Although Appendix G provided some preliminary insights, the study would benefit from a theoretical study of the existence of increasing economies of scale, both internal and external (see World Bank 2009), and their impact on poverty and inequality. These include an extended study on the existence of spillovers and learning at the farm-level, but also beyond at the level of the rural economy as a whole. Such an assessment would advance the theories developed under the new economic geography literature into a rural, agricultural, developing country setting.

A third theoretical avenue would address the lack of theoretical inquiry on equity. Given that one of the pillars of organic agriculture, per its IFOAM definition, is fairness, a future study would find fertile ground for expanding this inquiry in two areas: First, as noted, the success of organic export production as a motor for development is dependent upon sustained demand in consumption (Ton 2007). This raises important
questions regarding the sustainability and motivations of this alternative development strategy (Fridell 2003, Goodman 2004, Thompson 2001). Second, the research findings on the ability for conventional farmers to benefit from the organic innovations links back to previous studies on the ability for contract farming - a historically uneven power relationship - to benefit smallholders.

Finally, discussions of the Organic revolution were focused on a comparison to the Green and Biotechnology revolutions. One future theoretical avenue would include stepping back from this strong agricultural development context and answer questions on the revolutionary character of the introduction of organic agriculture. It would connect to broader studies on the societal impact of these technologies, as for example undertaken by Scott (1997) on the green revolution in Southeast Asia. Such a study would also investigate the organic nature of these technologies, by expanding and extending on the agricultural history reviewed in Chapter 3.

7.4.2 Empirical Avenues for Future Research

In addition to these three theoretical avenues, this section contains four empirical avenues. The first three future avenues for empirical research are drawn from areas identified in Chapter 4, 5 and 6 respectively. The fourth introduces one of the most potent yet controversial avenues to research: the planned introduction of GM cotton.

Adopters of Organic Innovations

When discussing who becomes an organic farmer, one difficulty was to distinguish whether or not early adopters of organic cotton, for example, were already wealthier prior to joining bioRe. This is a fundamental question that could be addressed by expanding the research via a longitudinal study that observes interannual changes for a set of farms. At present, undertaking additional surveys are beyond the possibility of this research project. bioRe Tanzania, however, has created a so-called Double-Purchasing Power survey, which was undertaken annually on a set of around 150 organic farmers. Additional research could consequently draw on that dataset to assess differences across the years between farming households, focusing on specific key assets identified
(i.e. via the PCA) to monitor changes in poverty. An alternative is to create a more
detailed analysis of the changes across bioRe farmers by years. This future research
avenue could also answer the question of *Who is no longer a bioRe farmer?* by studying
decertification data and following up with visits to farmers to discuss what influenced
them in their decision making, or assessing their perspectives and capabilities in the
process in general.

An additional avenue would include testing the monopsony power (Jones, 1988;
Jones and Krummel, 1987; Lofgren, 1986, 1992) of the contracting operation - bioRe
Tanzania - versus the power for an organic farmer in side-selling his cotton. Such an
analysis could involve the construction of a regression model that contrasts the ratio of
cotton sold to the cotton estimated (by field extension officers) with the distance from
the selling post, years of membership, size of the farm, and other variables of interest.
Since the amount (and reasons) of cotton side-sold was recorded during the survey, an
alternate approach could be to revisit these farmers via focus groups. Following the
participatory econometric technique, this could include a presentation of the findings
from the previous outlined regression analysis. A third technique could be to under-
take participation observations at the cotton purchasing station during the purchasing
season, mixed with interviews of both farmers and extension officers involved.

**Measuring Sustainability**

One way of interpreting side-selling, measured as the amount of cotton sold out of the
total that was estimated for the household, is to assess it as a degree of *loyalty* to bioRe.
This loyalty would be expected to be larger for farmers that were early-adopters of
organics. This question of adoption provides a promising avenue of additional research.
One example outlined is to study the impact of learning-by-doing of early adopters,
as only weak descriptive statistical evidence was calculated. This study would focus
specifically on social capital and try to assess how innovations travel from one farmer to
another. Since the survey did ask each household *where they learned the method from,*

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5 Upon request, work was already undertaken to create a bioRe sustainability index score, which
combines an ecological, social and economic dimension.
more detailed analyses using that data would be warranted as a start. This includes a better analysis of the role that neighbors play, including their years of production and measuring the likelihood of adoption when the neighbor used the same technique. All this data would be available from the survey. This work would link to earlier studies in agriculture undertaken by Conley and Udry (2005) and Foster and Rosenzweig (1995) in regards to the importance of neighbors. It also would contribute to an analysis of organic farmers’ sharing of information and expertise amongst themselves (Parker and Munroe 2007).

Another example of furthering our understanding of the relationship between early and late adopters is to include a more detailed analysis of the groups and the differences existing amongst them. This would focus not solely on a coarse binary, but rather use the differentiation used by Läpple and Van Rensburg (2011; see also Rogers 2005). One important component to include in this analysis would be to investigate the spatial locations of farms to see if buffer requirements play a significant role (Bichler et al. 2005; Lewis et al. 2008). Since the geographical location was recorded for each farming household, this analysis could be undertaken if each farming household in a village could be mapped drawing on spatial autoregressive models (Bichler et al. 2005).

Spatial location is also expected to have a large impact on the necessity for a farmer to adopt certain (organic) methods in the first place. In order to better assess sustainability, the maximum farm-level score could be adjusted for clusters of households in villages. In an attempt to measure the technical efficiency of farmers, a stochastic frontier analysis would be promising (see Kumbhakar and Lovell 2003). This would control for location (i.e. soils, rainfall) to see if farmers make best use of the inputs available.

**Multidimensional Poverty**

While the multidimensional poverty analysis included a comparison of weights via PCA, the findings from the PCA can be used also to narrow down the index to fewer variables (Abeyasekra 2004). This especially could be applicable in the context of undertaking a second round of surveys that would be more focused. Another option would be to
redesign the make-up of the multidimensional poverty index completely based on the PCA results and the participatory econometric method that would involve adjusting the weighting based on local metrics.

Another direction is to strengthen the analysis of multidimensional poverty. This could include linking the analysis with the research field on spatial econometrics. Work by Duclos et al. (2004) for example analyzed differences between rural and urban areas. In our case, the spatial component could include an analysis that incorporates the differences between the villages, or at least the three soil regions existing within the district. A multi-level analysis (see for example Silva 2008) that moves beyond the household level and assesses the benefits at the regional level would have strong policy implications, given the limited understanding of the impact of organic agriculture on poverty reduction and inequality at the local, regional and national levels. Another avenue would be to focus on the impact of organic cotton, as outlined above, on labor and gender. Such an analysis could be undertaken via an ethnographic gendered approach focused on within household and non-family labor sources that so far was beyond the scope of the research. Another future avenue would be to quantitatively estimate non-hired labor costs beyond the expenditures given by households for example in the case of *bukombakomba*. Introducing these estimated costs into the econometric models would reveal how relevant labor factors are to net earnings and the economic and ecological sustainability of the organic methods.

**Impact of GM Cotton**

One of the most promising yet controversial avenues for future research is to investigate the (potential) impact of the introduction of GM cotton on the organic operation. As discussed, given the rapid rise (and subsequent pressures in sustainability) of GM cotton faced by bioRe India, the topic is of great interest to bioRe Tanzania. Since GM

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6Such an analysis was undertaken, via dummy variables, for bioRe Tanzania calculating the benefits of organic methods on productivity. It showed that farmers in the Northern and Central zone have significantly larger yields per acre. Furthermore, the panel analysis over three years showed that increased organic index scores were explaining productivity increases, even when controlling for rainfall and prices. (Ledermann 2011)

7A commissioned report is being written for ANSAF Tanzania on this topic.
cotton is set to be released by 2014/5 in Tanzania, an initial study could investigate the findings of challenges faced in similar economies. One case study that would be of great interest in the African context is Burkina Faso, where the legalization of GM production has resulted already in strains on the feasibility of organic production (Coulter 2011). Vitale et al. (2007) also did an attempt at modeling the benefits of its introduction in neighboring Mali.

For geographers, the study of GM cotton is especially interesting given the spatial requirements of production that come with it: For example, with the cultivation, buffer requirements (Bichler et al. 2005) are necessary to either protect from contamination from GM or slow down the development of resistance in pests to the inserted bacterium that thwarts pest attacks. From a spatial perspective, in both cases, small-scale farmers would seem to be at a strong disadvantage: organic farmers, as their smaller plots would lose a disproportionate amount to buffers created to avoid contamination, while GM farmers would have to create a refuge pest management strategy that also involves buffers that result in loss of yields. These spatial requirements could accentuate pre-existing inequalities based on uneven access to land, moving the debate beyond the traditional questions on who can get access first to this advanced technology and its impact on yield and profitability.

The investigation of the (potential) impact of GM cotton consequently connects to a broader literature on coexistence of both organic and GM agriculture. Work by Novy et al. (2011) discusses this coexistence in sub-Saharan Africa, noting that although organic and GM advocates seem to be diametrically opposed, at the national level increased events of GM research or production are correlated with increased organic production. Work on coexistence on the local level in cotton production, consequently, could not only shed insight into the potential problems faced, but also guide policy for key stakeholders, such as bioRe Tanzania or the Tanzanian Cotton Board. This is especially important given that the Tanzanian Cotton Board is strongly supportive of organic cotton production, guarantees the continued supply of non-GM seeds, yet appears potentially unaware of the risks that could come from (cross-)contamination if no exclusive organic cotton zone would be created. This question on whether or not to
exclude certain areas from GM application has received increasing attention, as shown by the reaction (and later retraction) of the US Department of Agriculture (USDA) on soybeans. It also raises questions on fairness and equality, as conventional farmers (which are still in the majority in Meatu district) would not have access to the new technology nor the organic price premium, although the benefits of the introduction of improved non-GM seed varieties could be more substantial. Furthermore, as the introduction of GM technologies in developing countries has shown, even where legislation would prohibit it, stealth seeds could be introduced; halting the transfer of GM seeds via legislation at a district border might just give the false appearance of no threat of contamination.

In summary, these theoretical and empirical avenues for further research are of great interest not only to this study, but also towards furthering the research on understanding the impact of the Organic revolution in sub-Saharan Africa, especially as it coexists and competes alongside the push of the traditionally input- and capital-intensive alternatives. Continued research on this topic will yield key insights towards the sustainability of achieving economic growth via the new technology of organic agriculture.
## Appendix A

### Household Survey

**SHORT HOUSEHOLD QUESTIONNAIRE**

<table>
<thead>
<tr>
<th><strong>Village:</strong></th>
<th><strong>Coordinates</strong></th>
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<tbody>
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<tr>
<th><strong>Date:</strong></th>
<th><strong>Xi:</strong></th>
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<table>
<thead>
<tr>
<th><strong>Name:</strong></th>
<th><strong>Yi:</strong></th>
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<table>
<thead>
<tr>
<th><strong>Ethnicity:</strong></th>
<th><strong>Time Start End</strong></th>
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<tbody>
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<table>
<thead>
<tr>
<th><strong>Farmer’s code number</strong></th>
<th><strong>Sex</strong></th>
<th><strong>Age</strong></th>
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<tbody>
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<td></td>
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<table>
<thead>
<tr>
<th><strong>Lead Farmer</strong></th>
<th><strong>No. Wives</strong></th>
<th><strong>Household Members:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th><strong>Education</strong></th>
<th><strong>bioRe</strong></th>
<th><strong>HH Members Contributing:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Farming</strong> <strong>Animal Husbandry</strong> <strong>Small Business</strong> <strong>Employment</strong> <strong>Other</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Roof of Main House</strong></th>
<th><strong>Tombe (Thatch)</strong></th>
<th><strong>Iron Sheets</strong></th>
<th><strong>Other</strong></th>
<th><strong>Rent</strong></th>
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<td></td>
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<td></td>
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<table>
<thead>
<tr>
<th><strong>Material of the Walls</strong></th>
<th><strong>Cement</strong></th>
<th><strong>Soil Type</strong></th>
<th><strong>Other</strong></th>
<th><strong>Own</strong></th>
</tr>
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<table>
<thead>
<tr>
<th><strong>Member of HH Political Office</strong></th>
<th><strong>Member of Cooperative</strong></th>
</tr>
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<tbody>
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<td></td>
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<table>
<thead>
<tr>
<th><strong>Have you ever visited bioRe HQ?</strong></th>
<th><strong>What purpose of visit?</strong></th>
</tr>
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<tbody>
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<td></td>
<td></td>
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<table>
<thead>
<tr>
<th><strong>Notes:</strong></th>
<th></th>
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<td></td>
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</table>

If bioRe: What is your father’s name if he is also bioRe?

Write notes regarding if he has two or more HHs, do they share income? If not, just focus on the HH here.

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Figure A.1: Household Survey
1. How many acres of land are owned by the HH?

2. How does this amount of land owned compare with one year ago?

<table>
<thead>
<tr>
<th>Less Now</th>
<th>Same Now</th>
<th>More Now</th>
<th>Don't Know</th>
</tr>
</thead>
</table>

3.1 Does the HH use land it does not own? If yes, how much? (3.2)

<table>
<thead>
<tr>
<th>No</th>
<th>Rented</th>
<th>Other (e.g. sharecropped)</th>
</tr>
</thead>
</table>

3.2 Do the HH use land they do not own? If yes, how much?

4. How does this other amount of land owned compare with one year ago?

<table>
<thead>
<tr>
<th>Less Now</th>
<th>Same Now</th>
<th>More Now</th>
<th>Don't Know</th>
</tr>
</thead>
</table>

5.1 How many head of cattle (and other large livestock) are currently owned by HH?

5.2 Do you own a grazing area? If yes, is it Ngiteli? If they do not know Ngiteli, it means no.

6. How does this number of livestock compare to the number one year ago?

<table>
<thead>
<tr>
<th>Less Now</th>
<th>Same Now</th>
<th>More Now</th>
<th>Don't Know</th>
</tr>
</thead>
</table>

7. How many sheep and goats are currently owned by HH?

8. How does this number of animals compare to the number one year ago?

<table>
<thead>
<tr>
<th>Less Now</th>
<th>Same Now</th>
<th>More Now</th>
<th>Don't Know</th>
</tr>
</thead>
</table>

9. Does the HH own any of the following? If yes, how many?

<table>
<thead>
<tr>
<th>Iron 9.1</th>
<th>Radio 9.5</th>
<th>Television 9.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed 9.2</td>
<td>Bank Account 9.6</td>
<td>Ox Plow 9.10</td>
</tr>
<tr>
<td>Motorcycle 9.3</td>
<td>Cellphone 9.7</td>
<td>Ox Cart 9.11</td>
</tr>
<tr>
<td>Electricity 9.4</td>
<td>Bicycle 9.8</td>
<td>Rent Father</td>
</tr>
<tr>
<td>Mosquito Net 9.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. What is the main source of drinking water?

|----------------|--------------|-----------|-----------|

11. How many meals per day does your HH usually have?

12. In the past week, how many days did your HH consume meat?

13. Out of the total acre ____ (0.3.5), on how many did you grow ____ last year?

<table>
<thead>
<tr>
<th>COTTON (13.1)</th>
<th>ACRES Greenwood</th>
<th>MTAMA (13.4)</th>
<th>MAIZE (13.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOROKO (13.2)</td>
<td>SWEET POTATO (13.5)</td>
<td>FALLOW (13.8)</td>
<td></td>
</tr>
<tr>
<td>RICE (13.3)</td>
<td>KARANGA (13.6)</td>
<td>OTHER 1 (13.9)</td>
<td></td>
</tr>
</tbody>
</table>

14. How many bags (or other) were you able to sell last year?

<table>
<thead>
<tr>
<th>COTTON (14.1)</th>
<th>MTAMA (14.4)</th>
<th>MAIZE (14.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOROKO (14.2)</td>
<td>SWEET POTATO (14.5)</td>
<td>FALLOW (14.8)</td>
</tr>
</tbody>
</table>
### Household Survey – Samuel T Ledermann

#### Reference No./No. ya Rumbukumbu

<table>
<thead>
<tr>
<th>RICE (14.3)</th>
<th>KARANGA (14.6)</th>
<th>OTHER 1 (14.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EST. YIELD FOR COTTON LAST YEAR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COTTON (15.1)</td>
<td>MTAMA (15.4)</td>
<td>MAIZE (15.7)</td>
</tr>
<tr>
<td>CHOKOKO (15.2)</td>
<td>SWEET POTATO (15.5)</td>
<td>FALLOW (15.8)</td>
</tr>
<tr>
<td>MPUNGA (15.3)</td>
<td>KARANGA (15.6)</td>
<td>OTHER 1 (15.9)</td>
</tr>
</tbody>
</table>

#### Questionnaire (cont.)

15. How many bags (or other) did you keep for yourself last year?

<table>
<thead>
<tr>
<th>COTTON (15.1)</th>
<th>MTAMA (15.4)</th>
<th>MAIZE (15.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOKOKO (15.2)</td>
<td>SWEET POTATO (15.5)</td>
<td>FALLOW (15.8)</td>
</tr>
<tr>
<td>MPUNGA (15.3)</td>
<td>KARANGA (15.6)</td>
<td>OTHER 1 (15.9)</td>
</tr>
</tbody>
</table>

16. Was this last year’s harvest enough for the whole year or did you purchase food? (self-sufficient)

<table>
<thead>
<tr>
<th>None</th>
<th>Few</th>
<th>Some</th>
<th>A lot</th>
<th>All</th>
</tr>
</thead>
</table>

17.1 Did you experience food shortage in January/February this year? (food security) Yes/No

17.2 Did you receive assistance from relatives or families during this time? Yes / No

18.0 Did you sell any livestock last year? If yes, how many? Check here if trader Yes / No

<table>
<thead>
<tr>
<th>OXES (18.1)</th>
<th>COWS (18.2)</th>
<th>SHEEP/GOATS (18.3)</th>
<th>CHICKEN (18.4)</th>
</tr>
</thead>
</table>

19. What was the best (19.1) and the worst (19.2) price last year for you?

20. Did you sell all your cotton to boro? this year? (20.0) Yes / No

<table>
<thead>
<tr>
<th>Rejected by boro (20.1)</th>
<th>Low price difference to conventional trader (20.2)</th>
<th>Pick up by conventional trader (20.3)</th>
<th>Too much work for manual cleaning (20-4)</th>
</tr>
</thead>
</table>

21. Last year, was income from cotton the largest income source? Yes / No

21.1 If it is not the largest income source, was income from cotton the largest income source in other years? Yes / No

21.2 If yes, when and why?

25. Did you have any of the following expenditures for cotton last year?

<table>
<thead>
<tr>
<th>Hired Labor (25.1)</th>
<th>Seeds (25.4)</th>
<th>Fertilizer (25.5)</th>
<th>Rent (25.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bukumbakomba (25.2)</td>
<td>No. Harvesting</td>
<td>No. Weeding</td>
<td></td>
</tr>
<tr>
<td>Lageda (25.3)</td>
<td>No. Harvesting</td>
<td>No. Weeding</td>
<td></td>
</tr>
<tr>
<td>Pesticides (25.6)</td>
<td>Why not use?</td>
<td>Did it work?</td>
<td></td>
</tr>
<tr>
<td>Transportation (25.8)</td>
<td>From Field to HH</td>
<td>From HH to Selling</td>
<td></td>
</tr>
</tbody>
</table>

26. When did you start growing organic cotton?

<table>
<thead>
<tr>
<th>Who influenced you to grow organic cotton? Name up to two people.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
</tr>
</tbody>
</table>

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Confidential

Page 3 of 8
11/7/11

Figure A.3: Household Survey (cont.)
22.0 | Do you have any income from outside of agriculture? | Yes/No

<table>
<thead>
<tr>
<th>REMITTANCES (22.1)</th>
<th>SMALL BUSINESS (22.2)</th>
<th>LABOUR (22.3)</th>
<th>OTHER (22.4)</th>
</tr>
</thead>
</table>

23 | Which one is the most important non-agricultural income source and why? | Why?

<table>
<thead>
<tr>
<th>REMITTANCES (23.1)</th>
<th>SMALL BUSINESS (23.2)</th>
<th>LABOUR (23.3)</th>
<th>OTHER (23.4)</th>
</tr>
</thead>
</table>

24 | How many hours and weeks did you work in ___? What was your income (salary/pay) per hour? |

<table>
<thead>
<tr>
<th>HOURS PER WEEK</th>
<th>DAYS PER MONTH</th>
<th>WEEKS PER YEAR</th>
<th>SALARY/PAY (PER DAY) (PER MONTH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMITTANCES (24.1)</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SMALL BUSINESS (24.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LABOUR (24.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER (24.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income renting land</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What methods with cotton are you using? Who did you learn them from? Since when are you using them? (Can also be before joining bioRe) How much cotton acre this year?

<table>
<thead>
<tr>
<th>Methods</th>
<th>Using [%]</th>
<th>Who Did you Learn From</th>
<th>Since when?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing in Rows</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Ox Plow Weeding</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Sunflower (Trap Crop)</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Intercropping Legumes/Cotton</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Intercropping Maize/Cotton</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Crop Rotation (no cotton after cotton)</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
<tr>
<td>Combat Erosion</td>
<td>28.1</td>
<td>28.1</td>
<td>28.1</td>
</tr>
</tbody>
</table>

When did you start sowing your first field of cotton this year? (29.1)

When did you start sowing your last field of cotton this year? (29.2)

Figure A.5: Household Survey (cont.)
Katika ukurasa huu, tuchore ramani ya eneo lako kuonyesha majirani illiyo pakana nao. Tunaomba uandike majina yao, kama wanalima pamba isiyu mahulu ku au mahulu. Wao hutumia njia zipi binafsi? Kama ni wakulima wa bioRe, tangu lini wamekuwa wakulima wa pamba mahulu?

N: 30.1 ws: 30.1.0 Es: 30.2 Ef: 30.3 We: 30.4
Draw using largest cotton plot as center

<table>
<thead>
<tr>
<th>Kupanda kwa mistari</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kupaliila kwa jembe la kisas</td>
<td>30.1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alizeti (zao mtego)</td>
<td>30.1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuchanganya mimea jamii ya mikunde kwenyi pamba</td>
<td>30.1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuchanganya mahindi kwenyi pamba</td>
<td>30.1.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzunguko wa mazao (hairuhusi kurudia pamba kwenyi eneo moja)</td>
<td>30.1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mbolea ya samadi</td>
<td>30.1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>30.1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure A.6: Household Survey (cont.)
### 31 How do you compare the overall economic situation of the HH with one year ago?

<table>
<thead>
<tr>
<th>Much worse now</th>
<th>A little worse now</th>
<th>Same</th>
<th>A little better now</th>
<th>Much better now</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 32.1 How do you compare your overall yield per cotton acre of the HH compared to your conventional/bioRe neighbor?

<table>
<thead>
<tr>
<th>Much worse</th>
<th>A little worse</th>
<th>Same</th>
<th>A little better</th>
<th>Much better</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 32.1 How do you compare your overall economic situation of the HH compared to your conventional/bioRe neighbor?

<table>
<thead>
<tr>
<th>Much worse</th>
<th>A little worse</th>
<th>Same</th>
<th>A little better</th>
<th>Much better</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 33 How do you compare the overall economic situation of the community with one year ago?

<table>
<thead>
<tr>
<th>Much worse now</th>
<th>A little worse now</th>
<th>Same</th>
<th>A little better now</th>
<th>Much better now</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Next year, do you think you will be planting more or less cotton than now? [35.1]

Why? [35.2]

How much choroko did you plant this year?  Ac (by itself)  Ac (intercropped in _________)  

How much next year?  Ac (by itself)  Ac (intercropped in _________)  

If more, how? (Extensive [35.2.1]/Intensive [35.2.2]) (ongeza tja)

For Conventional Farmers: What are the main constraints to becoming an organic farmer?

<table>
<thead>
<tr>
<th>Land Size</th>
<th>Unable to hire due to limited numbers</th>
<th>Increased labor demands</th>
<th>Low Yields</th>
<th>Few Animals/No Tenure</th>
<th>Other</th>
</tr>
</thead>
</table>
Can you think back to your living conditions during the last 5 years, since Kikwete’s election as president. We would like to know about periods of serious hardship in terms of wealth and living conditions, and also periods that were very good. Please tell me about the conditions in the household you were living in, even if this is not the same household you live in now.

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Event</td>
<td>Kikwete</td>
<td>Drought</td>
<td></td>
<td>High price</td>
<td>Low price</td>
</tr>
<tr>
<td>What type of year was it?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If very good, why was it?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If very bad, why was it?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If very bad, how did you cope?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Response Codes**

**If very good, why...**
1. High Crop Prices
2. Bumper Harvest
3. Livestock
4. Wage Employment
5. Off-farm employment
6. Remittances
7. Gifts/Dev’ Aid
8. Returns from assets
9. New Assets
10. Shift to organic
11. Enough Rain
12. Other

**If very bad, why...**
1. Low crop prices
2. Poor harvest (rain)
3. Poor harvest (other)
4. Livestock
5. Wage employment
6. Off-farm employment
7. Remittances
8. Gifts/Dev’Aid
9. Eviction/Res’tlement
10. Death of Member
11. Serious illness
12. Loss of assets
13. Organic conversion
14. Anthrax
15. Inflation
16. Other

**If very bad, how did you cope...**
1. Reduced consumption/expenditures
2. Sold livestock
3. Sold land
4. Sold other assets
5. Started selling processed food
6. Started other business
7. Casual employment
8. Introduced other crops
9. Relied on support from organizations
10. Relied on Support from Family/Friends
11. Migrated to Work elsewhere (fishing)
12. Migrated to work elsewhere (other)
13. Off-farm wage employment
14. Took Children from school
Appendix B

Calculations of Net Income for Cotton

This appendix outlines the decisions made for the calculations of net income for cotton. While it mostly was based on the primary data collected, for bioRe farmers, extensive additional data is available on actual cotton sales and some expenditures. These are not available for conventional farmers, where the amount of cotton sold was translated directly into gross income figures before deducting expenditures listed.

Regarding the quantity of cotton obtained, farmers were encouraged to recount the amount in terms of ox carts (equaling 900 kg) and sheets (equaling 89 kg). Since in our year the price was fixed at 440 Tsh for conventional farmers and 500 Tsh for organic farmers (after obtaining the 60 Tsh organic premium), the gross income was derived via a simple multiplication. The one minor objection is that some farmers reported to have sold their cotton at 360 Tsh, which was the initial price that we offered prior to the government stepping in and deciding to subsidize the purchasing of cotton. Since these were in the minority, 440 Tsh was used throughout, especially as it seems more realistic that even farmers who were aware of the lowest price (asked in Q.19.2.) that existed were most likely to have sold all at the higher, fixed price (asked in Q. 19.1.).

Several decisions were made in the spirit of improving the likelihood of getting closest to the real amount of cotton sold by bioRe farmers.

- Cotton sold is larger than recorded by bioRe. All the cotton sold to bioRe was multiplied with the price of 500 Tsh per kg, whereas all the remaining amount of cotton sold outside of bioRe was assumed to have been side-sold (which was a large problem in 2009-10) at a price of 440 Tsh per kg. This decision is most likely the least controversial.

- Cotton sold is smaller than recorded by bioRe. All the cotton sold to bioRe was
multiplied by 500 Tsh per kg. However, this is not unproblematic, as a farmer might not have responded for all the cotton sold in his household. This would result in a serious inflation of the yield figures, since the acreage he responded on was lower than it would have been if all cotton from all the household members were included. As a result, the cotton acreage figures from the primary data was compared with the cotton acreage figure from bioRe data. The yield was subsequently calculated with bioRe acreage and sold figures to have a second value to compare it to.

**First Rule** As a result, a first rule was created whereby if the cotton acreage from the primary survey was larger than the bioRe cotton acreage and cotton sold was smaller than the amount recorded by bioRe, then the yield used for the study is the cotton sold to bioRe divided by the cotton acreage recorded in the survey. The income from cotton not adjusted per acre is based on the cotton sold to bioRe data. The reasoning behind this decision is that the farmer might have had more land under production than recorded. As a general rule, it is better to err on the upside whereby the yield was not overestimated, but rather underestimated. The benefit from this is that the estimates are somewhere in between for yield, whereas they would have been lower if used solely the cotton sold recorded by the survey.

**Second Rule** A second rule is needed if the cotton acreage from the primary survey was larger than the bioRe cotton acreage and cotton sold was larger than the amount recorded by bioRe, with a farmer indicating that he did not sell all of his cotton to bioRe (see Q. 20.0). In that case, the yield figure was calculated using the cotton amount sold reported in the survey divided by the cotton acreage from the survey. In the case he mentioned that he did sell all of his cotton to bioRe, then the yield is also calculated as above, if the yield is larger than the yield figure obtained from bioRe sales data. In both situations, the income obtained was calculated as outlined earlier.

---

1There is also a small possibility that the farmer might have been cheating.
Third Rule A third rule is needed if the cotton acreage from the survey was reported to be lower than the bioRe cotton acreage, yet the amount of cotton sold was larger than the amount sold to bioRe. In the case that the farmer mentioned he did not sell all his cotton to bioRe, then the amount not sold to bioRe was reviewed and added onto the total from bioRe. If there was a missing value for the amount of cotton not bioRe (Q.20.6), it was replaced by the calculation. If the farmer said that all his cotton was not sold to bioRe, but a small amount was actually recorded to having been sold, then it was adjusted. If there was a large difference (see for example Farmer Code 111), then the survey was consulted. In that situation, all the acreage figures were those that were reported from the farmer. The reason for this decision is that he might not have weeded all fields as reported by bioRe. If the change between estimated cotton not sold to bioRe and the cotton sold minus the cotton sold recorded by bioRe was large, decided to calculate it backwards (see Farm Code 207 for example). This resulted in a new yield, where cotton sold from the survey was combined with a corrected cotton amount not sold to bioRe, divided by the cotton acreage from the survey. This overall was the same for farmers who mentioned that they sold all their cotton to bioRe, except in cases where the difference was small.

Fourth Rule A fourth rule is if the cotton acreage in the survey is lower than the cotton acreage reported by bioRe and the cotton sold was smaller than the cotton sold reported by bioRe. This category proved to be the most difficult, as they involved taking a close look at the respective yield figures. If they were similar, it seems most likely that the respondent just give his figure for his area as opposed to the whole area. If farmer knew acreage, but not yield, used the yield data from bioRe, as we were unsure how much he might have referred to (see for example Farm Code 601). Another option would be to calculate share of his area using bioRe yield. Critical Farm Codes to review were 602 and 611. If the difference was very large, yet the difference in acreage was small (see for example Farm Code 414) then the
In regards to seed expenditures, most farmers (especially bioRe) had difficulty providing an answer (see Q.25.4). If they did, that figure was used. If they didn’t, the amount was estimated via an average expenditure figure of 1,500 Tsh per acre. This is essentially the same for both bioRe and conventional farmers, using an estimated average of around 10 kg per acre (versus an estimated 5 kg per acre if they would sow in rows) (Pattni 2011, personal comm.). Internal calculations from bioRe show that small differences exist between years, where the price per seed was slightly higher in 2008-09 (at 2’500 Tsh per kg) and lower (at 1,000 Tsh per kg) in 2009-10 due to (theoretical) government subsidies. Overall though, seed expenditures were a small expenditure, amounting to only 12 percent of all costs or 3 percent of net income from cotton. While expenditures are small, especially in years where farmers had to resow (such as during one of the return trips in 2011), several mentioned that they had problem obtaining either the seeds or securing financing to purchase additional seeds.

Pesticides were calculated using either the figure provided by the farmer, or calculating a figure based on two sources of data: amount used as described in the survey or the number of organic pesticide purchased as recorded in the bioRe database. The cost for a bottle of conventional pesticide was set at 8,000 Tsh per bottle, with exact amounts being 7,875 per acre per 1/4 bottle needed for organic and 9,000 Tsh per acre per full bottle. The rule established was that if there were no bioRe expenditures recorded by bioRe, yet he mentioned he had expenditures, then the expenditures remained (as it could be that it either wasn’t recorded or he obtained pesticide - although not allowed - from alternate sources). If more expenditures than bioRe or less, then it was adjusted to bioRe expenditure data. In case a farmer told me he had expenditures but did not enumerate, then no calculation was done. If he told me he sprayed 5 bottles but no bottles were recorded by bioRe then multiplied it with the conventional pesticide price (at 8,000 Tsh per bottle) as recording the organic bottle price (31’500 Tsh per
bottle) that wasn’t recorded would have been too large.\(^2\) Pesticide expenditures for all 114 farmers amounted to solely 7.5 percent of total costs. However, when excluding the 55 farmers that didn’t have any expenditures on pesticides at all (due to lack of spraying), the average increases to 14.5 percent.

- Costs for renting land was used as enumerated by the respondent. The usual price paid averaged between 25,000 to 35,000 Tsh per acre. Out of the 28 farmers that rented land, only two were bioRe farmers. This confirms the earlier discussion of the regression analyses in Chapter 5 that not only are bioRe limited in their ability to rent (from other certified farmers) but also are conventional farmers lacking land ownership.

- Transportation costs were only calculated if a farmer told us that he needed to actually pay for borrowing an ox cart or oxen, as well as possible labor. Only 40 farmers reported expenditures for transporting the cotton.

Deducting these expenditures from gross cotton income yielded a positive or negative net income for cotton. If it was below zero, indicating a loss, it was not increased to zero as it is realistic that some farmers made a loss in their production.\(^3\)

---

\(^2\)One farmer mentioned that he used 5 liters of bioRe pesticide, yet didn’t have a single recorded amount of pesticide usage. As a result, they were counted as conventional bottles which amounted to 40,000 versus a potential 157,500 Tsh.

\(^3\)The story of one farmer stands out who had his cotton stolen from his fields. Or another who had bad luck with rains, since he planted in swampy areas, and obtained very little yield.
Appendix C

Calculation of Total Income

This appendix highlights the steps undertaken to get from the net income figure described in Appendix A to the total income figure.

Additional income outside of agriculture was gathered in the form of: remittances, small business income, labour, or other.

Additional Income from Sales of Crops

Additional income from within agriculture could be the source of several sales, such as: mungbeans (choroko), rice, sorghum, sweet potato, maize and sunflower. It was only choroko which amounted to a significant amount. Rice for example was never sold.

However, as opposed to cotton, no expenditures were deducted that the farmers might have had. This is realistic, as they often times use their own farm labor, and in the case of choroko, intercrop it within cotton, thus negating the need for additional weeding. Also in most cases, no pesticides are used. If they were used, it was often done unsuccessfully.

For choroko, an estimated average price was 25,000 Tsh per tin, which equals to approximately 20 kgs. One bag was estimated to contain 4 tins, totaling 80 kgs or around 100,000 Tsh. This yields a price of 1,250 Tsh per kg.

Sorghum sold was calculated as being worth 12000 Tsh per bag which contains 80 kg. This amounts to 150 Tsh per kg. Only 4 farmers sold sorghum.\(^1\)

Sweet potato sold was calculated as 350 Tsh per kg. Only 2 farmers sold sweet potatoes, worth 400 kg and 480 kg respectively. These figures were more difficult to

\(^1\)The current market price for sorghum in July 2011 was 270 Tsh/kg, which makes the 150 Tsh per kg figure seem plausible
estimate given the different weights and the fact that they are sold not by weight, but rather in towers.

Groundnuts, on the market, were traded at 1,600 per kg in July 2011. Two years back this figure was estimated to be closer to 800 Tsh per kg, with the farmers who sell it receiving an estimated 400 Tsh per kg. Only two farmers sold groundnuts.

Maize was sold by only one farmer. The price per 20 kg was estimated at a low 5,000 Tsh.

Sunflower sold was valued at 150 Tsh per kg. There were four farmers who sold sunflower. This is a very low number.

Sesame was very difficult to estimate, as it was not sold on the market but only via traders. Farmer (Code 509) reported to sell it for 17,000 Tsh per tin (which equals to 20 kg). There were only 3 farmers who sold sesame.

For tomato, the single farmer directly reported the amount sold at 130,000 Tsh.

In total there were only 16 farmers that obtained any additional income from selling other crops, with the smallest amount equaling to 36,000 and the largest equaling 1,020,000 Tsh. All the farmers who sold other crops (besides choroko) were already above the basic need line for 2009-10.

**Additional Income from Sale of Livestock**

The inclusion of this variable is important, given the Sukuma’s long history of animal husbandry. Unfortunately data is quite difficult to collect, and it quickly became evident that one needs to separately keep track of any cattle bought or sold over the course of the year. Just observing changes in the number of cattle might not be sufficient, given how cattle can shift to family and friends temporarily for grazing etc. However, as not enough consistent information was gathered on buying of cattle, this income figure is reflecting only the number of cattle sold as opposed to any net amount of cattle gained or sold during the year. Special notes were made with a few farmers who engaged in cattle trade to get a better measure of their buying and selling patterns.

The price of a cattle was set at a low 150,000 Tsh, with a sheep or goat equaling
30,000 Tsh. Chicken that were sold were priced at 12,500 Tsh.
Appendix D

Categories of Labor and their Importance

*Bukombakomba* was the most common type of labor - with 95 percent of households engaging in it. It was already referenced by the British as highlighted in Chapter 3. It is a communal labor support system, whereby each household makes a contribution to help in other families' fields for the provision of free food and reciprocal labor aid at a later date. As such, the expenditures are often the smallest per labor unit of the three options. If farmers only used this labor expenditure, it is most likely that they are much better integrated into the community, given that social capital is needed to command (an invitation to) this reciprocal labor arrangement.

Although *luganda* was just as common as the hired labor category - with 29 percent of households having expenditures in either category - it appeared to be more affordable than the latter. It is a form of organized labor whereby (often young) groups are hired for a base rate to weed or harvest a designated area. This is often either done in the form of paying per acre (for example for weeding) or per tin (for example for cotton). Similar incentives also exist in *bukombakomba*. These incentive schemes (e.g. for harvesting more cotton) have received considerable scrutiny, since bioRe farmers face tougher quality rules for their cotton. Careless harvesting undertaken to win the 'first price' in a *bukombakomba* or *luganda* harvesting session for example was named

\[\text{This problem was identified at first by the bioRe management and integrated as an example of participatory econometrics. As a result, considerable time was spent with several farmers in the field work discussing their incentive schemes in order to establish the magnitude of the problem. It seems that farmers were aware of the negative impact, but faced difficulties controlling it. One innovative farmer suggested to give a price not for the largest quantity of cotton picked, but rather for the \textit{cleanest} cotton. Others, who said that they had no problem with their cotton being contaminated by plant residue due to *bukombakomba*, highlighted how they actually spent significant time supervising the labor which seemed to result in better cotton quality. As such, it most likely were farmers that were not well informed (either via mouth-to-mouth or via the extension officer of alternatives) or didn’t have the capacity for increased supervision (both the ability to supervise in the first place if working alongside, but also the power to impose any degrees of supervisions).} \]
one of the main culprits. Some of these groups were well-organized (even wearing matching sport-like uniforms) whereas others seemed to be much looser. In all cases observed, (unemployed) youths were employed by the people who did not have enough bukombakomba labor to fulfill their whole demand or lacked strong social capital ties to participate in such a scheme. As such, especially farmers who lack access to family labor or other social networks were more likely to hire them.

The most formal type of labor was hired labor. In the survey, it served as a catch-all in many cases of other services undertaken on their lands that did not fall into the two previous categories. As mentioned in the previous paragraph, 29 percent of farming households had expenditures for some form of hired labor. While it is perceived to be the most expensive form of labor, the average amount spent, 117,000 Tsh, was actually less than the 156,000 Tsh spent on luganda, with the median being nearly identical. In their respective samples, 54 and 57 percent were bioRe farmers respectively (which is not significantly different from the sample average of 57 percent bioRe). Nevertheless, it could be broadly classified as the form of labor hired when neither bukombakomba nor luganda were available to the farmer. This potential hypothesis regarding the hired labor reflecting social and economic status is informally supported by the difference in total net income earned from cotton: farmers who used luganda earned 991,000 Tsh on average, compared to 715,000 Tsh of those that hired labor. Also, the amount of cotton planted was higher for the former, with 14.5 acres, compared to the latter, with 11.6 acres.

---

2 Others include failure to harvest cotton on time thus resulting in discoloration by rain; failure to successfully combat the cotton stainers - kangambili - thus resulting in yellow discolorations that are not only difficult to clean, but also result in a loss of weight as the pests suck out the seeds; storing the cotton for too long, thus not only losing weight (due to the cotton drying) but also picking up impurities from the sandy soils.
Appendix E
Calculations of Multidimensional Poverty Index

E.4

There are three dimensions calculated for the multidimensional poverty index. These are a monetary and non-monetary economic dimension; a social dimension; and a vulnerability dimension.

First, the dimensions and their variables are listed and described. In the next section, the calculations are shown for the index.

E.1 First Dimension: Economic Sustainability

E.1.1 Monetary

The monetary dimension includes the net cotton income per acre and total net income per contributing household members as outlined in Appendix B.

E.1.2 Non-Monetary

In addition, it includes the following non-monetary dimensions:

Yield per acre as a measure of crop productivity in cotton.

Food grain production as a count of the diversity of agricultural activities undertaken.

Home value as a strong indicator of wealth and proxy of farmer’s ability to undertake investments.

Land owned as an indicator of the security of production.
Household Assets as an alternate indicator of wealth, including whether or not a household has access to electricity, or owns an iron, bed, motorcycle, bicycle, ox plough or ox cart.

E.2 Second Dimension: Social Sustainability

E.2.1 Self-sufficiency

Food Self-Sufficiency as measured by whether or not a family had to purchase a majority of their food from the market.

Food Security as measured by whether or not a family had enough money to obtain all the necessary food throughout all of the year. Also includes a measure of how many meals they had per day (as asked during the survey period between February and June).

E.2.2 Social Capital

Member of Village Government as an indicator of political connectedness.¹

Member of Cotton Organization is believed to be more connected in the community, especially as farmers were loyal to the strong cooperatives that previously had a monopoly on the cotton marketing. Several conventional farmers interviewed were actually members or even local leaders. bioRe members were automatically included in being member of a cotton organization.

Visited bioRe HQ or bioRe leader as a measure if a farmer took advantage of the knowledge available by bioRe staff or to petition for a loan, or any other issue. While the latter can only be done by bioRe farmers, even conventional farmers would have access to bioRe if they would seek so. In the case that the farmer was

¹This variable may contain some bias, as the conventional farmers were chosen at random from the most extensive list of households in the village that existed. In some villages, these included lists of farmers who obtained pesticide from the village provided for by the government, which is unproblematic. In few other cases, lists existed only for farmers that were present at the latest village meeting. These lists however included at least 100 individuals and care was made not to allow any departure from a random selection pattern.
a bioRe location leader that hosts bi-weekly trainings, this would also indicate
greater social capital.

**Communication Assets:** cellphone, radios, televisions as indicators of methods
of communication. Although no cotton radio programs specifically for organic
farmers exist (as for example they do in Kenya under Biovision), it nevertheless
can provide important information on agricultural markets and government
decisions.

E.2.3 Health

**Access to Water** as a key indicator whether or not a family has ready access to water.
While distance wasn’t measured, the source of the water was recorded, with some
families having access to (bioRe sponsored) shallow wells, while others needing to
fetch from the rivers.

**Malaria Nets per capita** as an indicator of a family’s exposure to malaria, which in
its mildest cases will have a negative impact on productivity.

E.2.4 Human Capital in Agriculture

**Ratio of Contributing to Non-Contributing Household Members** as a
measure of the dependency of a household, with farmers who have a small ratio
of contributing household members for non-contributing members facing greater
risks at lacking the capacity to adjust to changes.

**Years since joining bioRe** measuring the belief that farmers who have been with
bioRe for a longer time are likely to have had higher acquisitions of knowledge to
sustain agricultural production and deal with uncertainties or challenges.

**Number of organic neighbors** as a very crude indication of the existing support
network that would be readily available for a farmer. Also as an indication if a
farmer is able to learn or benefit from spillovers of neighboring farmers.
Level of Education as a classic yet crude measure of the household head’s level of education. The same qualifications mentioned earlier continue to hold.

Agricultural Assets in the form of ox carts and plough, as farmers who have access to them are likely to be more able to apply their human capital.

E.3 Third Dimension: Vulnerabilities

Past Vulnerabilities as a count of past experiences over the last 5 years where the households experienced a very difficult year.

Current securities: Cattle as a reserve in years of low prices, droughts or other unexpected events.

Current securities: Bank Account as a reserve in years of low prices, droughts or other unexpected events.

Outlook on Planting as an indication if the farming household was planning to expand choroko production, cotton production, or even choroko by itself.

E.4 Design of Multidimensional Index

E.4.1 Scoring Criteria

The scoring criteria always include a discussion of the overall scoring, but also the establishment of a poverty threshold.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Scoring Criteria</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cotton income per acre</td>
<td>Excluding household labor. Variable measures profits obtained. Poverty threshold is set to 0. 95th percentile is the upper limit of 149,510 Tsh. Lower limit of -75,084 Tsh used for calculation.</td>
<td>2/3*0.25</td>
</tr>
<tr>
<td>Total income per contr HH member</td>
<td>Most important monetary measure, including income from all activities. Poverty threshold is. basic need line. 95th percentile is 1,393,000 Tsh. Lower limit is -41'166 Tsh used for calculation.</td>
<td>0.25</td>
</tr>
<tr>
<td>Cotton yield per acre</td>
<td>Uses 95th percentile as upper-value, the share is calculated out of all these. Sample average 220 kg/ac. Poverty threshold set at 100kg/ac. Upper 95th percentile is 383.33 kg/ac. Lower limit 8.40 kg/ac due to theft. Is alternate measure to net income per acre (no expenditures).</td>
<td>1/3*0.25</td>
</tr>
<tr>
<td>Food Grain Production</td>
<td>Instead of measuring the total amount of grains produced, which was already included in the total income calculations, it measures the number of grains or legumes produced in addition to cotton. The poverty threshold is set at 1. The possible values are: choroko/mungbeans; rice; maize; sorghum; sweet potatoes; groundnuts; sunflower; and others. Since rice can only be planted in limited areas, it was not counted towards total. The share is the number of alternate crops planted out of seven possibilities - 95th percentile.</td>
<td>0.1</td>
</tr>
<tr>
<td>Home Value</td>
<td>Is the aggregate from the material of the roof and the floors. In this case, if someone is having an iron sheet roof and a cement floor equaling the highest possible score of 3. Having either an iron sheet or a cement floor equals 2. Whereas having neither (a thatch roof and a soil floor) equals 1. Three farmers who either rented or had no value recorded were set to 0. The poverty threshold is set at 1. The share is calculated out of 3.</td>
<td>0.15</td>
</tr>
<tr>
<td>Land owned</td>
<td>The amount of land owned by a household. The poverty threshold is set at 3 acres, which is below the minimum amount needed to be able to join bioRe. The share calculated is out of the 95th percentile, which is 200 ac. The 99th percentile would be 350 ac.</td>
<td>0.15</td>
</tr>
<tr>
<td>Household Assets</td>
<td>Calculated as the share of the 5 values, each valued at 1/5 of the total. Electricity is a dummy equaling 0 or 1. For iron, bed, motorcycle and bicycle, the rounded down 95th percentile is chosen. This equals to 1 for iron, 6 for beds, 1 for motorcycle, and 3 for bicycle. Poverty threshold is set if a farmer has no beds or his total share is 0.2 or less.</td>
<td>0.1</td>
</tr>
<tr>
<td>Variable</td>
<td>Scoring Criteria</td>
<td>Weight</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Food</td>
<td>Including all farmers that had no food shortages throughout the year and purchased no food. These receive a score of 2. Farmers that bought few or some of their food, score is 1. Remaining have a score of zero, including those with missing answers. Poverty threshold is set for farmers that had to purchase most or all of their food, yet were still food insecure.</td>
<td>1/2*0.25</td>
</tr>
<tr>
<td>Self-Sufficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Security</td>
<td>As above, but only assessing if a family had food shortages. If they did not, then their score is equal to zero. The poverty threshold is set for families that failed to be food secure.</td>
<td>1/2*0.25</td>
</tr>
<tr>
<td>Member of Village Govt or Cotton Org</td>
<td>Binary variable. 1 if member of the family is a member of either the village govt, bioRe, a cotton producer organization, or a bioRe location leader. Since bioRe members are all members of coops, the maximum score is 3 for bioRe and 2 for conventional farmers. Both farmers receive one point if visited bioRe HQ, with max of 4 and 3. Poverty threshold (social exclusion) set at 0.</td>
<td>1/2*0.25</td>
</tr>
<tr>
<td>Communication: Phone, Radio, TV</td>
<td>Similar calculation to Table D.1. Uses 95th percentile as upper limit. Poverty threshold set where farmers neither own cellphone nor radio.</td>
<td>1/2*0.25</td>
</tr>
<tr>
<td>Access to Water and Nets</td>
<td>Binary variable. 1 indicates access to improved water source (i.e. government or bioRe well). Additional health indicator is number of mosquito nets per capita, with 1 as upper limit. Poverty threshold set where less than 1 net for every 4 members, and access to water from river, not well.</td>
<td>0.25</td>
</tr>
<tr>
<td>Ratio of HH Members</td>
<td>Ratio of non-contributing household member supported by contributing members. 5th percentile of 1:4 ratio as upper limit. Poverty threshold set at 3 non-contributing to 1 contributing.</td>
<td>1/4*0.25</td>
</tr>
<tr>
<td>Years with bioRe or bioRe Neighbors</td>
<td>bioRe farmers only: longer bioRe members have human capital to adapt and cope. Conventional farmers: greater ability to adapt and cope if more organic neighbors (out of max of 4). Poverty threshold set at zero organic neighbors and not being bioRe.</td>
<td>1/4*0.25</td>
</tr>
<tr>
<td>Level of Education</td>
<td>Assessed for household head. No education (=0), primary education (=1), completed the primary (and beyond) (=2). Poverty threshold set if farmers had no education and was under age of 40.</td>
<td>1/4*.25</td>
</tr>
<tr>
<td>Agricultural Assets</td>
<td>Uses 95th percentile as upper-limit. Assesses if farmer owns ox plough or cart. Poverty threshold set if he fails to own neither an ox cart and plough, or if he owns one of these yet has no cattle.</td>
<td>1/4*0.25</td>
</tr>
</tbody>
</table>
Table E.3: Scoring Criteria of Third Dimension

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scoring Criteria</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past Vulnerabilities</td>
<td>For the last 5 years, farmers were asked to identify the very good and very bad years. For the very bad, reasons were discussed. This measure is an absolute count of the number of very bad years. The poverty threshold is set when a farmer had a count of at least one very bad year and a negative score when combining the very good with the very bad years.</td>
<td>.25</td>
</tr>
<tr>
<td>Current securities: Cattle</td>
<td>Surveys and focus groups have shown farmers are reluctant to sell cattle. As safety nets and investments they are a great measure of reduced vulnerabilities. The 95th percentile of 100 is the upper limit. Poverty threshold is set at 4 cattle, as with less using ox tools are difficult.</td>
<td>0.35</td>
</tr>
<tr>
<td>Current securities: Bank Account</td>
<td>Only very few farmers actually owned a bank account. As a binary variable, the upper limit was 1. The poverty threshold is a farmer that had no bank account and less cattle this year compared to last year, indicating negative savings.</td>
<td>0.15</td>
</tr>
<tr>
<td>Outlook on Planting</td>
<td>The farmers were asked to provide information if they will increase cotton or choroko production. The scoring is 3 points, if farmers not only increase cotton, but also choroko by itself. 2 points if the farmer increases both choroko and cotton, or only choroko by itself. 1 point if he only increases choroko or cotton. Poverty threshold is set if a farmer is not increasing choroko, as reducing cotton production made economic sense given the price signal.</td>
<td>.25</td>
</tr>
</tbody>
</table>
### Table E.4: Poisson Model predicting Years with bioRe

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.695</td>
<td>17.31</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of Wives</td>
<td>0.238</td>
<td>0.52</td>
<td>0.4725</td>
</tr>
<tr>
<td>Number of Contributing HH Members</td>
<td>-0.264</td>
<td>4.03</td>
<td>0.0447</td>
</tr>
<tr>
<td>Education</td>
<td>-0.191</td>
<td>0.12</td>
<td>0.7338</td>
</tr>
<tr>
<td>Rented Land (in %)</td>
<td>-0.033</td>
<td>12.91</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Number of Ox Plough Acres (owned)</td>
<td>0.475</td>
<td>2.00</td>
<td>0.1574</td>
</tr>
<tr>
<td>Model Fit and Coefficients</td>
<td>0.004</td>
<td>1.21</td>
<td>0.2722</td>
</tr>
</tbody>
</table>

**Model Fit**

| AIC                                           | 537.89               | Likelihood Ratio | -260.95   |

### E.5 Older Poisson Regressions with Overdispersion
Table E.5: Poisson Model predicting Years with bioRe

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.613</td>
<td>23.95</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Acres (owned)</td>
<td>0.0163</td>
<td>8.96</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Bed</td>
<td>-0.0238</td>
<td>0.02</td>
<td>0.886</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.3527</td>
<td>0.10</td>
<td>0.747</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.6544</td>
<td>3.33</td>
<td>0.068</td>
</tr>
<tr>
<td>Cellphone</td>
<td>-0.4952</td>
<td>1.45</td>
<td>0.228</td>
</tr>
<tr>
<td>Radio</td>
<td>-0.963</td>
<td>4.97</td>
<td>0.026</td>
</tr>
<tr>
<td>Television</td>
<td>3.080</td>
<td>2.54</td>
<td>0.111</td>
</tr>
<tr>
<td>Cattle</td>
<td>-0.0133</td>
<td>1.14</td>
<td>0.286</td>
</tr>
<tr>
<td>Bank Account</td>
<td>-0.579</td>
<td>0.30</td>
<td>0.584</td>
</tr>
</tbody>
</table>

Model Fit | Intercept and Coefficients | Model Significance | Chi-Square
AIC       | 544.52                 | Likelihood Ratio  | -261.26

Table E.6: Poisson Model for only bioRe farmers predicting their Years with bioRe

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.330</td>
<td>96.45</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Acres (owned)</td>
<td>0.009</td>
<td>3.26</td>
<td>0.071</td>
</tr>
<tr>
<td>Bed</td>
<td>0.290</td>
<td>3.00</td>
<td>0.083</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>-0.951</td>
<td>0.48</td>
<td>0.487</td>
</tr>
<tr>
<td>Bicycle</td>
<td>-0.184</td>
<td>0.29</td>
<td>0.588</td>
</tr>
<tr>
<td>Cellphone</td>
<td>-0.082</td>
<td>0.03</td>
<td>0.858</td>
</tr>
<tr>
<td>Radio</td>
<td>-1.068</td>
<td>7.71</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Television</td>
<td>5.380</td>
<td>5.80</td>
<td>0.016</td>
</tr>
<tr>
<td>Cattle</td>
<td>-0.012</td>
<td>1.01</td>
<td>0.316</td>
</tr>
<tr>
<td>Bank Account</td>
<td>-2.306</td>
<td>4.83</td>
<td>0.028</td>
</tr>
</tbody>
</table>

Model Fit | Intercept and Coefficients | Model Significance | Chi-Square
AIC       | 277.19                 | Likelihood Ratio  | -127.59
E.6 Principal Components Data
Table E.1: Eigenvectors for Principal Component Analysis

<table>
<thead>
<tr>
<th>Eigenvectors</th>
<th>PRIN1</th>
<th>PRIN2</th>
<th>PRIN3</th>
<th>PRIN4</th>
<th>PRIN5</th>
</tr>
</thead>
<tbody>
<tr>
<td>net_inc_per_acre</td>
<td>0.01304</td>
<td>-0.28459</td>
<td>0.024267</td>
<td>0.171011</td>
<td>-0.330106</td>
</tr>
<tr>
<td>total_inc_per_cont_hh</td>
<td>-0.01398</td>
<td>0.135415</td>
<td>-0.025595</td>
<td>0.114536</td>
<td>0.494945</td>
</tr>
<tr>
<td>d_count_food_grain</td>
<td>0.21334</td>
<td>-2.59953</td>
<td>-2.36903</td>
<td>0.064623</td>
<td>-0.06997</td>
</tr>
<tr>
<td>home_value</td>
<td>0.065264</td>
<td>0.277279</td>
<td>0.128131</td>
<td>0.052310</td>
<td>0.036777</td>
</tr>
<tr>
<td>land_owned</td>
<td>0.275487</td>
<td>-1.76215</td>
<td>0.808870</td>
<td>-0.55974</td>
<td>0.15463</td>
</tr>
<tr>
<td>bed</td>
<td>0.340654</td>
<td>0.121715</td>
<td>0.031789</td>
<td>-0.39589</td>
<td>-0.63223</td>
</tr>
<tr>
<td>motorcycle</td>
<td>0.221453</td>
<td>0.625242</td>
<td>0.127877</td>
<td>0.062408</td>
<td>0.001061</td>
</tr>
<tr>
<td>bicycle</td>
<td>0.298452</td>
<td>-0.685817</td>
<td>0.124228</td>
<td>0.065577</td>
<td>0.078634</td>
</tr>
<tr>
<td>age</td>
<td>0.154416</td>
<td>-0.65763</td>
<td>-1.02842</td>
<td>-1.84738</td>
<td>-2.14533</td>
</tr>
<tr>
<td>hh_member</td>
<td>0.256564</td>
<td>0.13490</td>
<td>0.22324</td>
<td>-2.48199</td>
<td>-0.09762</td>
</tr>
<tr>
<td>ratio_hh</td>
<td>0.007063</td>
<td>0.093272</td>
<td>0.235137</td>
<td>-3.15949</td>
<td>0.291936</td>
</tr>
<tr>
<td>purchase_food</td>
<td>-0.19057</td>
<td>0.197825</td>
<td>0.356544</td>
<td>0.15079</td>
<td>0.036939</td>
</tr>
<tr>
<td>d_food_shortage</td>
<td>-0.16099</td>
<td>0.137089</td>
<td>0.395682</td>
<td>0.071966</td>
<td>0.012287</td>
</tr>
<tr>
<td>sum_member</td>
<td>0.162274</td>
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<td>0.357875</td>
<td>0.301565</td>
<td>0.036079</td>
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</table>

Figure E.2: Eigenvectors cont.
Appendix F

Analysis of the 11 Principal Component Scores

Having interpreted the loadings of the first component illustrated in Table 6.7, this section extends this analysis to the 10 other components in Table F.1. They are ranked from highest to lowest amount of variation explained.

The identification of the meaning of these principal components is based on Jolliffe (2002, p. 66), who argues that the interpretation should be based “only [on] the general pattern of the coefficients that is really of interest, not values to several decimal places, which may give a false impression of precision.” Table 6.5 and 6.6 was created based on these rules described earlier in order to complement the interpretation in Table F.1.

While the first component is measuring long-run wealth, the second component adds to our analysis by capturing the very wealthy. This is revealed by the fact that now both TV and bank account are significantly correlated. These households also seem to earn more income outside of agriculture, as indicated by the low acreage, net profitability, numbers of food crops planted and the lack of self-sufficiency. This second component consequently corresponds nicely with the fact observed in the field that several households, especially non-bioRe ones, were quite wealthy households for which agriculture was only making up a minority share of their total income.

Out of the first three principal components, the third one captures households that are experiencing present and past vulnerabilities and insecurities. These households are larger and have a high ratio of non-contributing household members, which most likely explains the food shortages and purchases. The vulnerability variables of the last 5 years also seem to indicate that this insecurity was more likely to exist prior to the study.

The fourth principal component is the first component to strongly capture the future
Table F.1: Interpretations for the 11 PCs for all farmers

<table>
<thead>
<tr>
<th>Component</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component 1: Long-run wealth (15.88 %)</td>
<td>Long-run wealth, as measured in assets and securities, with households that are food insufficient and insecure.</td>
</tr>
<tr>
<td>Component 2: Non-Farming Wealth (9.02 %)</td>
<td>Wealthy (as indicated by motorcycle, TV, and bank account) operating outside of agriculture (indicated by low agricultural profitability, acreage, numbers of food crops and lack of self-sufficiency) with others.</td>
</tr>
<tr>
<td>Component 3: Vulnerability (7.65 %)</td>
<td>Large families, with a low ratio of contributing to non-contributing members, that have fewer food crops, need to purchase food and experience higher vulnerabilities over the last years than others.</td>
</tr>
<tr>
<td>Component 4: Outlook (6.38 %)</td>
<td>Smaller and younger households that have a large net income, and key assets (radio, TV, bank account), experienced past insecurities yet have a positive outlook on expanding production, with others.</td>
</tr>
<tr>
<td>Component 5: Social Capital (5.67 %)</td>
<td>Households that not only obtain a high income per acre from agriculture but also a high total income per contributing household member than others. They have higher social capital.</td>
</tr>
<tr>
<td>Component 6: Poorer Non-Farming (4.72 %)</td>
<td>Small households that have fewer assets compared to others. Also have lower incomes and are likely laborers or shop owners.</td>
</tr>
<tr>
<td>Component 7: Small Farming (4.44 %)</td>
<td>Smaller and poorer farmers (less land owned, cattle, and home value) that are food secure and are increasing mungbean production with others.</td>
</tr>
<tr>
<td>Component 8: Declining Output (4.19 %)</td>
<td>Older families (age; negative ratio) with poor outlook in agriculture (reduce cotton) and livestock (decrease) than others. Also food shortages and bad home.</td>
</tr>
<tr>
<td>Component 9: Security (3.97 %)</td>
<td>Large land-owning farmers with many cows that experience fewer vulnerabilities than others.</td>
</tr>
<tr>
<td>Component 10: Profitability (3.58 %)</td>
<td>Profitable, older farmers with a good home and bank account than others.</td>
</tr>
<tr>
<td>Component 11: Stagnant (3.46 %)</td>
<td>Profitable farmers that were less likely to plant mungbeans than others.</td>
</tr>
</tbody>
</table>
variables. These are smaller households with a positive ratio of contributing household members, larger number of assets, and a younger household head. While negative experiences in the past like the last principal component, the farmers were more likely to increase both cotton and mungbean production. As a result, these are classified as potentially prospering households with a positive outlook.

The fifth principal component is the first one to capture the social capital. This is especially strong with households who have a high income, be it from agricultural income per acre and total income per contributing household members.

The sixth principal component is unique in that both net income per acre and total income per household members are negative. These are smaller households that have few assets. A weaker yet very negative sign of this group is that they also plan on not expanding mungbean production, which is very unusual and most likely an indication that this group contains unsuccessful households that depend on non-agricultural income.

The seventh principal component captures to a degree success stories of smaller farmers (measured in land owned) that have few vulnerabilities, yet are also planning on expanding both cotton and mungbeans production. These are not very wealthy farmers (as indicated by the low home value, small number of land, few cows and lack of TVs), but they could be perceived as improving.

Starting from the eighth principle, it becomes more difficult to determine the meaning. The eight principle component features older household members (with most likely less children) that have a negative outlook in agriculture (by reducing cotton) and livestock (less cattle this year). While not lacking assets per se, they are poorer as assessed by the poorer access to wells and home value owned and a declining output.

The ninth principle component shows rather secure households with key agricultural assets. It captures the larger, secure land-owning farmers with many cows. They are experiencing fewer vulnerabilities than others.

The tenth principle component is focusing on older household heads, and more

\[1\] More inexplicable are motorcycles and televisions.
profitable farmers. They are an established group, as they also are more likely to have a good home and bank account compared to others.

The eleventh principle component is unique as it captures wealthier farmers that were not increasing mungbeans, which is unusual. As a matter of fact, it might capture the farmers that have already expanded mungbeans to the acreage that they wanted the year before, and thus are stagnant.
Appendix G
Spatial Analysis of Poverty

Drawing from the findings in Chapter 5, especially section 5.3.1, two spatial analyses are added: First, a test to see if poverty score is lower in villages with higher shares of early adopting farmers, which would reveal potential dynamic external economies of scale. Second, drawing specifically on the significant influence of distance on net income per acre, a test on whether or not the poverty score is related to distance to the village center.

Poverty Score across the Villages

One of the key economies of scale that might influence poverty levels are external economies of scale (see Krugman 1991a, 1991b, World Bank 2009). These can operate specific to organic agriculture or the village economy as a whole.

Regarding agriculture, external economies of scale include potential trickle down effects, whereby a diffusion occurs across the farm types (see World Bank 2009). As Chapter 5 showed, this seems to be the case, as organic methods are even adopted by conventional farmers, thus increasing their abilities to improve their net income per acre or productivity. Similarly, in terms of the adoption of organic techniques, given that it is a knowledge intensive practice that shows its largest impact over a longer period of time, it is likely that villages that have more farmers who joined bioRe early on are more likely to have fully embraced the techniques compared to villages with lower average years. As seen in Figure G.1, out of the six study villages, three are below the mean of 7.17 years, whereas the other three are even or larger than the mean. This indicates a good spread exists amongst the study sample.

Regarding the village economy, increased wealth generated (as seen in the higher
Figure G.1: Ranked villages according to average number of years with bioRe

net income per acre and total income of organic farmers) would indicate that there also should be a greater demand for services of all kinds. Given that especially the poorest conventional farmers were estimated to have worked as either laborers or in small-shops or services (such as selling water or repairing bicycles), one could expect to see a positive relationship with reduced poverty and the average duration, as measured in years of, bioRe members.

To test this relationship, three plots are designed showing the number of years with bioRe: First, against the censored poverty headcount. Second, against the poverty gap. Third, against the squared poverty gap. While the calculations focus on multidimensional poverty scores, the same calculation could be undertaken in a future step with unidimensional poverty as well.

\[^1\] For the calculations of the average poverty gap scores, the decision was made to not just average it by the nth number of households deemed poor in the censored statistic, but to average the sum of the poverty gap score across all households in the village. The same decision was made for squared poverty gap score.
Figure G.2: Strong relationship between years with bioRe and poverty scores at the village levels
Given that the survey included only six villages, the averages were calculated at each village level to estimate the village-level poverty score. The results are represented in Figure G.2. Although drawing statistically significant conclusion from the small sample size\(^2\) would be objectionable, a clear descriptive pattern emerges: As one moves along the time axis (represented by the x-axis in this case), on each of the three poverty measures, the score decreases. The village with the longest bioRe membership, Minyanda, has the lowest score in each of the three measures, thus significantly influencing the observed pattern. Mwamanongu, the village with the shortest years, on the other hand, has the highest score in two out of the three. This indicates that the relationship is strongest when focusing on the depth of poverty and inequalities, as opposed to the breadth that would be measured by the poverty headcount, since dynamic external economies of scale are expected to reduce the severity of the deprivations experienced as more people are lifted up by the increased demand and/or diffusion of agricultural methods. Figure 5.10 in Chapter 5 supported that higher organic scores exist in villages with longer membership. This inverse relationship between multidimensional poverty and organic score when looked across the years hints at the positive impact of organic agriculture via external dynamic economies of scales, thus increasing its pro-poor growth potential.

**Poverty Score and Distance of Farming Household**

The previous section drew back to the spatial pattern identified in Chapter 5 on the organic score. Another spatial relationship discussed earlier in Chapter 4, Section 5.3.1, proved in Table 5.4 that the distance from the village center had a positive impact on net income per acre. As hypothesized, conventional farmers deemed poor are more likely to be located near the center of the village. For organic farmers, the negative interaction coefficient indicates that this distance effect is much lower.

As a follow-up to that earlier spatial analysis, the same relationship is investigated with poverty scores. For this purpose, the poverty gap score was chosen, as it measures

\(^2\)The correlations are at least 0.7 for the six villages.
the depth of poverty.\textsuperscript{3} The results from the relationship between all households who have score larger than 0 are shown in the left plot in Figure G.3.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig_g_3.png}
\caption{Relationship between Distance from Village Center and Poverty Gap Score}
\end{figure}

The pattern observed is a very weak linear correlation (-0.15) between increasing distance and lower poverty gap scores. The correlation is especially poor around the smaller distances, where most farmers are clustered. Looking at differences between the two farm types, conventional farmers are much more likely to have higher poverty scores and be underestimated by the line, whereas organic farmers are more likely to be overestimated. One farmer that sticks out as an unusual case is the organic farmer that is not only the furthest away (4 km) from the village center, but also has the highest organic poverty gap score. If this household would be removed, as seen in the right hand plot in Figure G.3, the correlation improves in significance from -0.15 to -0.31.\textsuperscript{4}

Recalling that the relationship between distance and net income per acre was the strongest for conventional farmers, the scatter plot in Figure G.4 shows the distribution for these farmers only. Given that below 30 observations exist, the analysis is limited to visual interpretations. At least when looking at the three farmers with the highest

\textsuperscript{3}Choosing the squared poverty gap is expected to result in nearly identical results.

\textsuperscript{4}Although a distance decay of poverty would appear to fit the pattern observed, plotting a cubic or a quadratic function to fit the pattern does not significantly improve this correlation.
poverty score, they are also living closer to the village center. However, at least the farmer with the largest distance appears as an outlier, since his household also has one of the higher poverty scores.

Figure G.4: Relationship between Distance from Village Center and Poverty Gap Score for Conventional Farmers only

In summary, Figure G.3 shows that the five households with the largest poverty scores are within 1 km of the village center. These five households are also all conventional farmers. This confirms the earlier finding in Section 5.3.1, that the analysis of space reveals additional patterns in regards to the levels of net income per acre, as well as multidimensional poverty. From a strict statistical standpoint, however, only weak evidence exists for a strong relationship. With the removal of a bioRe outlier in the right hand scatter plot in Figure G.3, a stronger statistical relationship becomes evident. In the case of solely observing conventional farmers in Figure G.4, at least visual evidence exists to support the previous findings that farmers that live closer to the village center are having not only having a lower net income per acre, but also
higher depths of poverty.\textsuperscript{5}

\textsuperscript{5}Further studies consequently would focus on a more in-depth analysis of the spatial patterns that exist in the region, including any potentially off-setting costs in transportation for larger farmers outside the village or differences in accessibilities to services. Although in the case of transport costs, the survey data showed that they are not having a significant impact, given that most farmers living further away have ready access to ox carts and oxen either via ownership or their ability to borrow (for free or limited costs) from a neighbor.
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