BUILDING LIVELIHOOD RESILIENCE IN SEMI-ARID KENYA:

WHAT ROLE DOES AGROFORESTRY PLAY?

by

AMY KATHRYN QUANDT

B.S., University of Puget Sound, 2005

M.S., University of Montana Missoula, 2010

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirement for the degree of

Doctor of Philosophy

Environmental Studies Program

2017

This thesis entitled:
Building livelihood resilience in semi-arid Kenya: what role does agroforestry play?
written by Amy Kathryn Quandt
has been approved for the Environmental Studies Program

____
Dr. J. Terrence McCabe

____
Dr. Maxwell Boykoff

____
Dr. Lisa Dilling

____
Dr. Joel Hartter

____
Dr. Myles Osborne

Date____________________

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB protocol # 14-0059

ABSTRACT

Quandt, Amy Kathryn (Ph.D., Environmental Studies)

Building livelihood resilience in semi-arid Kenya: what role does agroforestry play?

Thesis directed by Professor J. Terrence McCabe

Livelihoods must adapt to global and local changes in order to maintain livelihood resilience. Agroforestry is one potential livelihood activity which can help farmers adapt to changes and shocks. This dissertation explores if and how agroforestry is building livelihood resilience in the face of environmental and socio-economic shocks in Isiolo County, Kenya. Drawing from resilience thinking and political ecology, this research focused on general livelihood resilience, along with livelihood resilience to floods, droughts, violent conflict, and wildlife crop raiding.

Field work was conducted in 2014-2015 in the communities of Burat and Kinna. A mixed methods research approach was used including archival research, collection of ecological data, key informant interviews, household surveys, and qualitative case study households. The sustainable livelihoods approach was used to develop indicators of resilience, organized by the five capital assets (physical, human, natural, social, and financial). A total of 339 quantitative household surveys were conducted in addition to 20 qualitative household case studies, which were interviewed three times throughout the year. The qualitative household case study interviews were coded using QSR NVivo 10, and the quantitative data was analyzed with Microsoft Excel and Stata IC13.

Results suggest that agroforestry can help build livelihood resilience both in general and to flood, drought, violent conflict, and wildlife crop raiding. The major benefits were shade and fruit for sales and household consumption; the main tree species included mango, papaya, banana, guava, and neem. The average of all five livelihood capital scores was 10% higher for households practicing agroforestry. During floods and droughts agroforestry helped to build livelihood resilience by providing livelihood and environmental benefits. The majority of survey respondents listed agroforestry as very important during drought (55% of respondents) and flood (60%). Burat experienced a violent conflict in 2012. The results show how agroforestry helped build livelihood resilience during and after this conflict by providing a source of income, food, places to hide from attackers, and construction materials for rebuilding homes. When exploring livelihood resilience to wildlife crop raiding, 56% of survey households reported that agroforestry provided income when other crops were damaged by wildlife.

DEDICATION

This dissertation is dedicated to my grandmother Mary Quandt. She always has been, and continues to be, an inspiration to our family. I am happy to have inherited her sense of adventure and thirst for knowledge (and also her stubbornness).

This dissertation is also dedicated to the people of Isiolo, Kenya. My friends in Isiolo became my family while I was there and it was a pleasure to get to know the farmers who stories are included in this dissertation.

ACKNOWLEDGEMENTS

My thanks and gratitude go out to the many people who supported me and helped keep me laughing during the entire dissertation process; from developing my research proposal back in 2013 until now. In fact, my motivation for this dissertation goes back as far as 2004 when I first stepped foot in Kenya on a study abroad program. It was then that I fell in love with Kenya, field research, and travel. That experience has forever changed my life. Additionally, much appreciation goes out to my friends, both American and Tanzanian, who spent two years with me as a Peace Corps Volunteer in Tanzania. It was then that I truly gained an understanding of what it is like living in a small farming community in East Africa and learned to speak Kiswahili, which was invaluable for my dissertation research

This dissertation would not have been possible without the financial and logistical support which assisted both in proposal development and conducting field work. The Red Cross/Red Crescent Climate Centre provided support for my first visit to Isiolo County in 2013. I spent three months traveling around Isiolo conducting a livelihoods survey, which was an invaluable introduction to Isiolo and its people. This trip in 2013 would not have been possible without Sirak Abebe Temesgen, my supervisor, Abdi Doti, my driver whose love of Ace of Base is equal to mine, and Antony Kimathi, my faithful research assistant. The staff and volunteers at the Kenya Red Cross Society – Isiolo were incredibly welcoming and continued to support me throughout my dissertation with friendly faces, great conservsation, and Paulina's chai, which she delivered to my desk at 10am every morning (best chai I have ever had). I thank the Kenya Red Corss Society – Isiolo Branch for their continued support thoughout the years and the entire research process. This first trip to Kenya would also not have been possible without Max Boykoff and Lisa Dilling and their work to start and manage the University of Colorado Boulder's Red Cross/Red Crescent Climate Centre Internship Program. I honestly have no clue where I would be today without this internship, which profoundly shaped my dissertation work and graduate school experience.

For my dissertation research, I spent an entire year, July 2014 to July 2015, in Isiolo, Kenya. This would not have been possible without the financial support from the U.S. Borlaug Fellows in Global Food Security Graduate Research Grant. I am indebted to this great program which fosters the next generation of researchers and leaders in the field of food security. As a requirement for this grant I developed a partnership with Dr. Henry Neufeldt at the World Agroforestry Centre in Nairobi. Henry's support and mentorship throughout my dissertation research has been invaluable. His knowledge of agroforestry has contributed significantly to the development and analysis of my dissertation research. I am forever thankful to Henry for taking a chance on me. Thanks also go out to the World Agroforestry Centre staff who took care of all the paperwork required for this project. They saved me a big headache!

I also need to thank the Environmental Studies Program at the University of Colorado Boulder for their continued support and flexibility. The faculty and staff always supported me, helped find me funding, and more importantly gave me the flexibility to explore whever my research took me. Thank you Penny Bates for answering my endless questions about anything related to graduate school, you are a valuable resource for the Environmental Studies Program.

I am forever in gratitude to my friends in Kenya that both supported my research and provided laughter and companionship. Without them I would have accomplished nothing. Noor Hussein Noor and Tonny Mwiti were the two best research assistants I could have asked for. They put up with all my crazy requests and ideas, and most importantly, made research enjoyable. I will never forget that rainy motorcycle ride back from Burat with all three of us on one motorbike, splashing through puddles and laughing the entire way home. Special thanks go to Noor Hussein Noor who not only helped me in research, but was my best friend in Isiolo. I also need to thank the Red Cross Volunteers who worked for me as survey enumerators. They all did a fantastic job conducting surveys, and always had smiles on their faces, even on days where we walked 10+ miles in the heat of the day. A big debt of gratitude goes out to all my friends who spent endless hours sitting and chatting with me at Kim's used clothing corner shop. This companionship helped me integrate into the community and provided me with much laughter and conversation. Special thanks to Kim, Boyz, Kings, Flex, Honey Boy, Metro, Antony, Ghost, and the many others. Kim, I will always admire your spirit and commitment to your family and community. I hope my epic going away party will be in your memory and remind you of the fun year we spent together (Amy ni Murua!). I also need to thank the staff at the Waso Dispensary, particularly Mama Clinton and Doctor Purity for the female companionship. I thoroughly enjoyed our weekly lunches together and will cook you sukuma anytime you want!

Of all my friends in Isiolo, none do I appreciate more than Moon. Thank you for taking me into your home as one of the family. I will never forget our afternoons cooking together during Ramadan. Your kindness and generosity is unparalleled. Much appreciation also goes to the gang of kids and neighbors that were always over at your house including Mickey, Nana, Pascalina, Yeyo, and G. You all provided many afternoons of play, fun, and food!

In great debt of gratitude and appreciation I would like to thank my dissertation committee members Terry McCabe, Max Boykoff, Lisa Dilling, Joel Hartter, and Myles Osborne. Your expertise and assistance throughout the research process was invaluable. You all never failed to answer my questions about survey instruments or data analysis. Thank you Joel for pushing me to use GIS and helping me gain experience with ArcGIS. These are invaluable skills that I am sure will prove useful in the future. Without Lisa and Max, I never would have made it to Isiolo in the first place. And thank you Myles for stepping out of the box and providing a different perspective. You still owe me 10 bucks from my trip to the Kenya National Archives in Nairobi!

To my advisor, Terry McCabe, special thanks and gratitude. Your guidance and support over the years has been invaluable. You introduced me to resilience thinking, which turned out to be a major component of my dissertation. While I have enjoyed our meetings here in Boulder, the time we have spent together in Kenya is much more memorable. I thoroughly enjoyed our time spent at the Town Lodge in Nairobi. Thanks for not laughing too much when I ate sushi for breakfast! It was a pleasure to bring you to both my research sites, Burat and Kinna. I am glad you got to experience these two communities for yourself, they are truly unique places. But most importantly, our six week road trip around Kenya in May/June 2016 was one of the most memorable adventures I have ever had. It was fantastic to see different parts of Kenya and conduct interviews with you. I will never forget the evenings spent drinking wine and looking out over the landscape at the Ngari Hill Lodge in Maralal. And I will definitely never forget the road to Maralal! Thank you for everything and I hope to continue to work together into the future.

Of course, I have much gratitude to my friends and family here in the United States. To all my friends in Boulder who made graduate school a memorable experience: this beer is for you! Thank you to old friends Nate, Kimber, and Joe for providing instant friendship and support when I arrived in Boulder. I hope we can all visit Montana together some day. To Ian, Kanmani, Allison, Katie, Adrianne, Laura, Xi, Abby, Sara, and others in ENVS, thank you for the many study dates and keeping me sane with hiking, beer, and skiing adventures. I know that I have many lifelong friends among the bunch. Of course, special thanks go out to my two besties Emily and Stephanie. Even from afar I know I can always call on you Emily when I need someone to talk to! And thanks Stephanie for visiting me in Isiolo, it meant a lot! And of course, a very special debt of gratitude goes out to Kenny. Thank you for your love and support. You have been my rock over the past year and I hope we have many years ahead of us.

I count myself lucky that I have a family that does not question my decisions and instead supports them. My parents have never questioned why I would want to live in East Africa for months and months and instead have provided much support with weekly phone calls and many care packages (when they actually make it). I am very happy that my brother Erik was able to visit me in Kenya and we had a great time in Isiolo, Barjomot, on Safari, and in Zanzibar! I am thankful for my grandmother Mary Quandt, who has supported me throughout my education both emotionally, and also by buying all my school books. I know that if you were born in a different era, you also would have gone to school, and this gave me motivation to work hard and do well.

Lastly, many thanks to the people of Burat and Kinna. You were welcoming and accepting of my many questions. My favorite times during this whole dissertation research process were sitting with you on your farms, discussing life. There was rarely a day that I finished fieldwork without filling my backpack with fresh fruits and veggies from your farms. Without the farmers in Burat and Kinna who spent their precious time with me, I would have no dissertation at all. Asanteni sana na mungu awabariki.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

> "Today, when we are faced with the grave challenges of climate change, environmental degradation, food shortages, poverty and global financial downturn, it is important more than ever before to redouble our efforts to protect and rehabilitate the environment, reduce emissions of greenhouse gases and provide smallholder farmers with sustainable ways of increasing their production and meeting their livelihood needs. Expanding our existing, time-tested, integrated, tree-based practices…would make a huge positive impact on the environment and related global problems. Yet, even as the climate changes, food production, environmental services and rural livelihoods must improve – not just be maintained – if we are to meet the demands of the population that is growing at an exponential rate. Trees have an important role not only in climate change mitigation but also in reducing vulnerability to climate-related risks" (Maathai 2012, pg. 4-5).
>
> - Dr. Wangari Maathai (1940 – 2011), Founder of the Green Belt Movement, 2004 Nobel Peace Prize Winner

Introduction

As stated by the late Dr. Wangari Maathai, people around the globe are currently facing a wide variety of challenges that impact both the environment and the lives and livelihoods of humanity. Finding sustainable solutions to both environmental issues and poverty alleviation is critical to creating a better future for people and our planet. At its core, this dissertation aims to explore one solution to these challenging issues: agroforestry. Agroforestry, the integration of trees into an agricultural landscape, is touted as providing benefits for the environment such as acting as wildlife habitat and preventing soil erosion, and providing benefits for people such as fruit, income, fuelwood, medicine, and construction materials (Rocheleau et al. 1988; Franzel and Scherr 2002). But how well does agroforestry prepare people for the uncertain future ahead?

How will it help rural smallholder farmers cope with future environmental and socio-economic shocks?

Many researchers and development practitioners are now looking at the challenges of conserving valuable natural resources while helping people better their lives through the lense of resilience. Building resilience is important because within this century ecosystems are expected to face an unprecedented combination of challenges (flooding, drought, wildfire, etc) and other global change drivers (land use change, pollution, over-exploitation of resources) (IPCC 2007). A major challenge is to identify and develop resilient agricultural systems where ecosystem functions are maintained and livelihoods are protected or improved (Lin 2011). Livelihoods, such as practicing agriculture, are increasingly caught between major global transitions in both climate and social systems (Tanner et al. 2015). Tanner et al. (2015) propose that the lens of resilience "requires greater attention to human livelihoods if it is to address the limits to adaptation strategies and the development needs of the planet's poorest and most vulnerable people (pg. 23)." These authors instead promote a livelihoods resilience perspective to solving issues of environmental conservation and maintaining livelihoods because it places emphasis on human agency and empowerment. People have the ability to build livelihood resilience to an uncertain future.

Therefore, identifying environmentally beneficial livelihood practices that can help people survive, or even thrive, during shocks and disturbance is critical. Thus, the goal of this dissertation is to explore and analyze the contribution of agroforestry to building livelihood resilience to a variety of shocks.   This dissertation provides factual, empirical evidence of how agroforestry is and can continue to build livelihood resilience for smallholder farmers in semi-arid Isiolo County, Kenya.

The Research Gap

This dissertation addresses the call from both the academic and development communities for more empirical evidence about the links between agroforestry and livelihood resilience (Lin 2011; Maathai 2013; Nair and Garrity 2012; Thorlakson and Neufelt 2012). While there has been significant research about agroforestry technologies, much less is know about how agroforestry may be able to build livelihood resilience (Thorlakson and Neufeldt 2012). De Leeuw et al. (2013) reported that “although many people intuitively associate trees with resilience there is very little factual evidence on the roles of trees in building resilience (pg. 3).” Nair and Garrity (2012) stated that the main areas for future agroforestry research with application potential include food security, economic benefits, and climate change mitigation and adaptation. Lin (2011) elaborates by saying that "although the idea of resilience has been studied in a broad range of ecosystems, from coral reefs to forests, this idea has not been well studied in an especially important system to human society: the agro-ecosystem (p. 183)." This dissertation aims to address this gap in understanding and provide specific, comprehensive, empirical evidence.

Research Questions

In order to address the research gaps identified above, research question were formulated. This research was based around one main research question and four sub-questions that help to answer the larger research question. The research questions are as follows:

Research Question 1: Does agroforestry enhance livelihood resilience to environmental and socio-economic change and if so how?

> Sub-question 1: How do households use agroforestry to cope with, and build resilience against, the impacts of floods and droughts, if they do?
>
> Sub-question 2: How do households use agroforestry to cope with, and build resilience against, economic instability, if they do?
>
> Sub-question 3: What are household's perceptions of the ecological importance of agroforestry?
>
> Sub-question 4: What specific types of agroforestry, and specific tree species, are used for what reasons?

The sub-questions are designed to provide more detail into how agroforestry may build livelihood resilience. Economic instability generally refers to disturbances that negatively impact the financial aspects of a household's lives and livelihoods. When this project was first proposed, the research was designed to focus largely on livelihood resilience to the impacts of climate change, mainly floods and droughts. While floods and droughts are still a major focus of this dissertation, other sources of socio-economic and environmental disturbances emerged during field work. Within the first month of field work it became clear that two major sources of economic instability, besides floods and drougths, were violent conflict and wildlife crop raiding. In Burat, conflict is something that people have learned to live with (such as cattle raiding and ethnic tensions), however, a particularly large violent conflict took place in 2012. Households discussed how much that conflict had set them back financially and in their livelihood activities. It therefore seemed appropriate to pursue the economic disturbance of conflict in Burat as a factor causing socio-economic change. Furthermore, wildlife crop raiding was discussed in both study sites as there are protected areas in close proximity to both. Crop raiding seemed to be a menace to agricultural production, causing economic instability through loss of income from crop sales, impacting overall food security for many households. Therefore, violent conflict and wildlife crop raiding where research themes that emerged during field work. These emergent research themes help to advance the understanding of the research questions by providing specific, yet diverse, examples of disturbances to livelihood systems in Isiolo County, Kenya.

Dissertation Overview

This section will provide an outline for understanding how this dissertation is formatted and organized. The Environmental Studies Program at the University of Colorado Boulder encourages students to write their dissertations based on at least three publishable manuscripts, which form the bulk of the dissertation. This is represented in Part 2 of this dissertation, which contains four chapters formatted as manuscripts. However, at the request of my dissertation advisor, Dr. J. Terrence McCabe, I have chosen to also include three chapters which provide a discussion of the theoretical orientations of the research, an in-depth discussion of the research site, and outline the methodological approach of this dissertation. These chapters comprise Part 1 of this dissertation. The first section of this dissertation is Chapter 1, the current chapter, which outlines the research gaps, research questions, and overall layout of this dissertation.

Part 1

The aim of the first part of this dissertation is to provide an in-depth discussion and analysis of the theories that informed this research, the research site of Isiolo County, Kenya, and the research methods utilized. Chapter 2 is titled: Theoretical Orientations: Resilience Thinking, Political Ecology, and the Sustainable Livelihoods Approach. This chapter is divided into three sections. The first provides a brief introduction to agroforestry. This includes both the benefits and challenges of agroforestry practices. The second section of Chapter 2 is titled: Towards Integrating Political Ecology into Resilience-based Resource Management. This section was published in the journal *Resources* (Quandt 2016b) and appears in the same published format here. Overall, this paper provides three key arguments for the integration of political ecology and resilience thinking: it ensures both issues of political power and ecological concerns are highlighted in resource management; using political ecology's multiple analytical lenses is helpful to define and bound the social-ecological system; and political ecology can highlight social surrogates used to measure overall resilience. This dissertation utilized these insights in field work and data analysis. Lastly, Chapter 2 contains a section about utilizing the sustainable livelihoods approach for measuring livelihood resilience. This section provides more specific guidance on measuring resilience and is part of a larger manuscript outlining the advantages of and methods for using the sustainable livelihoods approach to measure livelihood resilience. This innovative methodological approach is relatively unique to this dissertation, and therefore it is important to discuss it in detail so it may be used by others in the future. This section is written as the first half of a publishable manuscript.

Chapter 3 offers a broad overview of the historical, ethnic, and ecological contexts of the research sites of Burat and Kinna, in Isiolo County, Kenya. It includes the history of Isiolo County under British colonial rule to today, with a specific focus on local politics and the development of agriculture. The next section contains a brief description of the five major ethnic groups in Isiolo County, Kenya (Borana, Turkana, Meru, Somali, and Samburu) and their contested claims to land and political control of Isiolo County. These claims have led to interethnic conflict, and one such conflict is the focus of Chapter 7. Chapter 3 concludes with a summary of the ecological conditions in Isiolo, Kenya.

Chapter 4 summarizes the research methods used for this dissertation. This includes the overall approach to research, household case studies, household surveys, key informant interviews, ecological data collection, participant observation and field notes, and archival record research. It also outlines the specific methods utilized to draw from the sustainable livelihoods approach to measure livelihood resilience in this dissertation. Chapters 5 – 8 will include brief summaries of the methods used for each chapter, however the goal of Chapter 4 is to provide an in-depth discussion of the research methods and data analysis processes.

Part 2

Part 2 of this dissertation presents the four research-based chapters which are written in journal manuscript format. The major goal of Part 2 is to provide results and evidence of the research which addresses the research questions outlined above. Chapter 5 is titled: Building General Livelihood Resilience: What Role Does Agroforestry Play? Chapter 5 explores if and how agroforestry is building general livelihood resilience for smallholder farmers. It draws from the sustainable livelihood approach's five livelihood capital assets (financial, human, social, physical, and natural capital) to compare and contrast different groups of survey respondents. Chapter 5 supports the idea that agroforestry improves general livelihood resilience.

Chapter 6 is titled: The Role of Agroforestry in Building Livelihood Resilience to Floods and Droughts in Semi-Arid Kenya. This chapter expands upon Chapter 5 to focus specifically on the disturbances of floods and droughts. Drought is particularly important in semi-arid and drought-prone Isiolo, Kenya. This chapter discusses how agroforestry is providing both livelihood and environmental benefits during floods and droughts and how farmers are purposely planting trees as a coping livelihood during these times. Additionally, simply practicing agroforestry may influence local perceptions of drought. Chapter 6 is currently submitted and under review for publication.

Chapter 7 explores the emerging theme of conflict as a major disturbance to livelihoods in Isiolo County. Chapter 7 is titled: "You Can Steal Livestock But You Can't Steal Trees": The Livelihood Benefits of Agroforestry During and After Violent Conflict. This chapter focuses specifically on if and how agroforestry can increase livelihood resilience and help people cope during episodes of violent conflict. It focuses specifically on a pre-election political and ethnic conflict in 2012 that took place in the research site of Burat, Kenya. Agroforestry did serve as a supplementary source of income during this conflict for some and results suggest that agroforestry can build livelihood resilience both during and after episodes of violent conflict by providing a source of income and food, places to hide from attackers, and construction materials for rebuilding. Chapter 7 is submitted and under review for publication.

Chapter 8 explores the emerging theme of wildlife crop raiding as a major disturbance to livelihoods in Isiolo, County. This chapter is titled: Can Agroforestry Improve Food Security on Farms Impacted by Wildlife Crop Raiding? It takes a specific look at how wildlife crop raiding impacts food security and if and how agroforestry can help farmers cope with wildlife crop raiding. Results focus on two major coping strategies: agroforestry and social networks. Agroforestry was reported to be impacted less by wildlife and therefore sometimes able to provide food and income when other crops are damaged. Chapter 8 is submitted and under review for publication.

Lastly, Chapter 9 provides a conclusion to this dissertation. The aim of Chapter 9 is to connect the results back to the research questions outlined above as well as the policy relevance of the findings. This chapter also includes a discussion of the effectiveness of using the sustainable livelihoods approach to measure resilience. Furthermore, Chapter 9 will outline major limitations of this research and recommendations for further work.

PART 1

CHAPTER 2. THEORETICAL ORIENTATIONS: RESILIENCE THINKING, POLITICAL ECOLOGY, AND THE SUSTAINABLE LIVELIHOODS APPROACH

Introduction

This aim of this chapter is to provide a literature review of the major theoretical concepts used to frame the research. The discussion will build upon the research questions and research gaps presented in the introduction. First, I will present a brief description of agroforestry, including its benefits and challenges. Second, I will focus on the two major theoretical concepts which this research draws from: resilience thinking and political ecology. I will explain each concept separately and then discuss the advantages to using a research approach that integrates resilience thinking and political ecology. This section was published in the journal *Resources* in October 2016 under the title "Towards Integrating Political Ecology into Resilience-based Resource Management." Lastly, I will discuss the sustainable livelihoods approach and how it was used in this research to measure livelihood resilience.

Agroforestry

What is agroforestry?

Agroforestry is a land-use strategy practiced in a wide variety of geographic areas and by many diverse cultures. Almost 1.8 billion people depend on some use of agroforestry products and services for their livelihoods (Leakey et al. 2005), and nearly half of the world's farmlands have at least 10% tree cover (ICRAF 2009). Agroforestry is a multifaceted, ecologically-based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, is believed to diversify and sustain production for increased social, economic, and environmental benefits for land users (Franzel and Scherr 2002; Schroth et al. 2004). Agroforestry involves different combinations of trees, crops, and animals on the landscape over different spatial arrangements or temporal sequences (Sinclair 1999), and Rocheleau et al. (1988) characterize 16 different agroforestry practices. These include the following:

1. Dispersed trees on cropland
2. Contour vegetation strips
3. Alley cropping
4. Trees in home gardens
5. Improved fallows
6. Trees, shrubs and grasses on small earthwork structures
7. Trees and shrubs on terraces
8. Protection and stabilization of waterways and gullies
9. Micro-catchments and water management
10. Living fences
11. Trees and shrubs along waterways and floodplains
12. Trees and shrubs on borderlines and boundaries
13. Windbreaks
14. Trees and shrubs along roads and paths
15. Trees and shrubs around houses and public places
16. Agroforestry in pastures and rangelands

The three most widely used categories to more generally classify agroforestry practices are agrosilvicultural, agrosilvopastoral, and silvopastoral systems (Nair 1993). Agrosilvicultural systems are those agroforestry practices that combine crops and trees. Agrosilvopastoral systems merge all three components of agroforestry – trees, crops, and animals, while silvopastoral involves trees and animals. The association of trees, agricultural crops, and animals in a farming system is an ancient practice, and probably dates back as far as 7000 BC, in the form of shifting cultivation (ICRAF 2006). Many of these traditional indigenous agroforestry practices have been modified and transformed into new techniques throughout the world (Sinclair 1999).

Benefits of agroforestry

Agroforestry provides benefits to people and the environment. Agroforestry benefits include both agroforestry products as well as ecosystem services provided by trees as illustrated in Figure 2.1. The benefits of agroforestry to people include cash income, food supply, energy supply, medicine, construction materials, windbreaks, animal fodder, resources to meet social needs such as shade, and soil and water conservation (Rocheleau et al. 1988; Franzel and Scherr 2002). Timber and non-timber tree products that are sourced from trees cultivated from agroforestry are often called agroforestry tree products (AFTPs) in the literature (Leakey et al.

2005). Examples of AFTPs include fuel wood, lumber, poles for construction, fruit, leaves for fodder, traditional medicines, and spices. Food security is one important benefit of agroforestry because agroforestry trees not only provide food (Belskey 1993; Kwesiga et al. 2003; Mitchell and Hanstad 2004), but can increase soil fertility (Tanzania Agroforestry Research and Dissemination Team 2000) and provide cash for purchasing food. According to the Ching et al. (2011), one sixth of all people on earth suffer from hunger and the issue of food security is becoming increasingly more pressing. Many people in low-income communities suffer from poor nutrition, and promoting edible indigenous fruits and nuts, along with non-native fruit trees, is an attractive option to improve nutrition (UNICEF 2007; Negin et al. 2009). Agroforestry can also help provide health benefits to HIV/AIDS sufferers by providing nutritious fruits and nuts (Leakey et al. 2005).

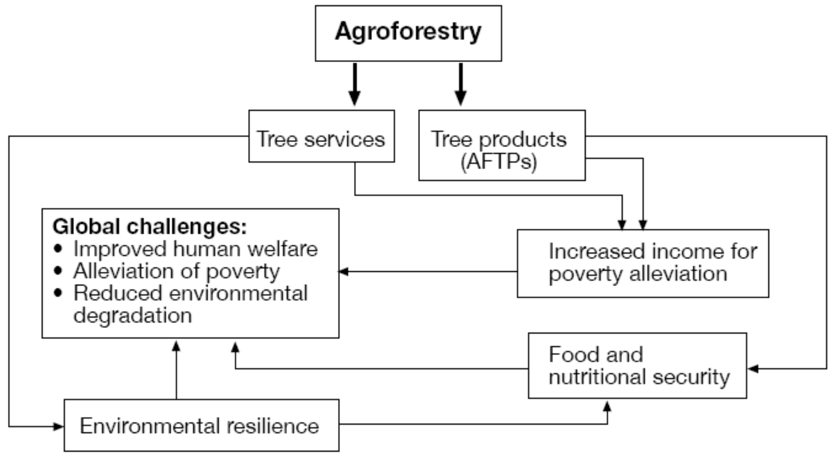


Figure 2.1 The benefits of agroforestry (From: Garrity et al. 2006)

Some of the ecological characteristics of agroforestry tree species makes them well-suited to provide benefits to people and the environment during extreme weather fluctuations (Kandji et al. 2006). For example, trees have some advantages for maintaining production during both wetter and drier years including deep root systems that are able to utilize a greater soil volume for water and nutrients (Verchot et al. 2007). Shade trees also can produce microclimates that buffer temperature fluctuations (Lin 2007), which in turn can reduce the loss of water from crops through evapotranspiration. Further, trees have the ability to buffer crops from storms and storm damage (Philpott et al. 2008). Kandji et al. (2006) found that results from improved fallow trials in Zambia suggested that it was possible to produce an acceptable amount of food in low rainfall years if agroforestry practices such as improved fallows are practiced. However, it is unclear how agroforestry trees themselves will be impacted by climate change and extreme weather-related events (Borland et al. 2015).

Agroforestry has also been touted as having environmental and wildlife conservation benefits. Schroth et al. (2004) provide three main hypotheses for how agroforestry can improve biodiversity conservation. The first is that agroforestry can help reduce pressure to deforest additional land for agriculture if it is adopted as an alternative to less sustainable land use practices, partly by helping people cope with limited availability of tree resources (Schroth et al. 2004). In research conducted in Tanzania, Quandt (2016a) suggested that practicing agroforestry provides tree products that otherwise would likely be collected in a neighboring forest reserve, leading to increased deforestation. Farmers with agroforestry were less likely to collect tree products from the forest reserve than those without trees on their land (Quandt 2016a). Additionally, Murniati et al. (2001) looked at the contribution of agroforestry systems to reducing farmers' dependence on the resources of Kerinci Seblat National Park on the Sumatra Island of Indonesia. The authors indicated that the key factors that propelled households to depend on the extraction of protected forest resources were low farm income, decreased sources of forest products on the farm, and lack of alternative livelihood options. This means that farmers without tree products available on their farms were more likely to harvest more tree products from the protected forest. Murniati et al. (2001) demonstrate that farmers who have a more diversified farming system may be less likely to exploit forest resources.

Schroth et al. (2004) also suggest that agroforestry systems can provide habitat and resources for partially forest dependent native plant and animal species that would not be able to survive in a purely agricultural landscape. In a study by Naidoo (2004), it was found that in Uganda, the value of agroforestry contributions to native wildlife species mostly benefited areas close to existing forest and favored frugivores and larger species. Finally, Schroth et al. (2004) state that agroforestry can serve as a benign matrix land use for fragmented landscapes, such that the biodiversity conservation of the remaining forests will be greater if the agricultural areas are dominated by agroforestry systems. Agroforestry systems can provide a smoother transition between agricultural areas and forests by buffering the edge effects on forest microclimate and wind.

Challenges and limitations of agroforestry

In this section I will focus on a few major challenges to agroforestry that have been documented in the literature including agroforestry adoption, property rights, labor constraints, gender differences, and wealth disparities. Farmers may not adopt an agroforestry practice, regardless of how many benefits the research has shown. Mercer (2004) identified five factors that inhibit agroforestry adoption: risk and uncertainty, household preferences, resource endowments, market incentives, and biophysical factors. Mercer (2004) found that more secure land tenure always had a positive impact on adoption because there was less risk involved and more incentive to invest in practices that may not yield results for years.

Many authors point to the fact that the expected gains from a new agroforestry system must be higher than the alternatives for the use of their land, labor, and capital (see Mercer 2004; Pearce and Mourato 2004). If these gains are not higher than other alternatives people have no incentive to change their land-use practices. Another factor to be considered is labor constraints (McGinty et al. 2008). If the time of year when tree planting would take place is already busy with other farm or off-farm activities a technology may not be adopted for the simple reason that people do not have time to complete the necessary labor. Another often cited reason why agroforestry technologies are not adopted by farmers is a lack of market for agroforestry products (Leakey et al. 2005). If a farmer cannot sell their product, either due to distance from markets, a lack of demand, or other factors, then the farmer will be unlikely to adopt the practice.

Another challenge to agroforestry adoption is that current agroforestry success has been relatively localized while to achieve the ultimate goals of poverty alleviation there is a need to scale-up the benefits of agroforestry (Franzel and Scherr 2002; Kwesiga, et al. 2003; Garrity et al. 2006). It also must be stressed that sustainability is not an intrinsic characteristic of agroforestry (Schroth et al. 2004). While many agroforestry practices, such as improved fallows, aim at improving the sustainability of a farming system, not all agroforestry practices are sustainable or environmentally beneficial (for examples see Schroeder 1997, Rochealeau and Edmunds 1997).

There are a multitude of factors that influence tree planting at the household level including land tenure security, household income, gender of household head, labor availability, and number of household acres, to name a few. According to Belsky (1993) there are two contradicting theories of how wealth influences household tree planting in rural communities. The first is that poor farmers prioritize meeting basic food needs and therefore do not, or cannot, plant trees because they view trees as competing with food crop production, require too many years to produce useful products, and necessitate secure land tenure. The second theory is that tree planting and agroforestry are beneficial to poor households who cannot subsist from their own agricultural production, and who therefore achieve food security through engaging in a diversity of income generating activities, including tree planting. The majority of literature supports the first theory that poorer households are less likely to plant trees and participate in agroforestry activities. For example, a study by Bewket (2005) in Ethiopia found that on average poor households had planted 161.7 trees, medium households 361.3 trees, and rich households 454.5 trees.

The broader topic of land tenure must also be addressed in detail when discussing the challenges of agroforestry. Schlager and Ostrom (1992) describe property as a bundle of rights. The bundle of rights they identify are access rights, withdrawal rights, management rights, exclusion rights, and alienation rights. Different combinations and strengths of these five rights create special types of land tenure systems, which may either promote or hinder the planting of trees. For example, a person may be less likely to plant trees if they are unsure they will continue to manage and control their land in the future. Alternatively, the planting of trees can help create more secure land tenure rights. Tree planting can also be a strategy to claim land rights in areas with open and 'unclaimed' lands (Schroth et al. 2004).

Towards Integrating Political Ecology into Resilience-Based Resource Management*

*This section was published in the journal Resources in October 2016.

Introduction

One of the biggest challenges faced today by both natural resource managers and human development professionals is how to sustainably manage linked social-ecological systems for both ecosystem function and human wellbeing (Berkes et al. 2003; Fabinyi et al 2014). How can we maintain important ecosystem services and natural resources, while also allowing people to maintain their livelihoods? This paper explores two theoretical approaches that attempt to answer this question by informing the management of social-ecological systems: resilience thinking and political ecology.

The concepts of political ecology and resilience thinking have been compared and contrasted by scholars over the past fifteen years (Peterson 2000; Cote and Nightingale 2012; Leslie and McCabe 2013; Brown 2014; Fabinyi et al. 2014; Turner 2014; Stone-Jovicich 2015; Turner 2016). Some continue to argue that they are fundamentally incompatible, largely because political ecologists and resilience scholars often come from different disciplines and schools of thought (Turner 2014). However, in a recent series of articles, Turner (2014; 2016) explored connections between these frameworks and suggested that, despite barriers, resilience scholars and political ecologists maybe should work together in some cases. For example, they hold congruent positions with respect to ecological response to human land use, and political ecologists may be some of the best placed social scientists to cooperate with resilience ecologists in understanding the complex interactions of history, human livelihood practices, and ecological responses (Turner 2014).

This paper contributes to the work of Turner (2014; 2016), Peterson (2000), Brown (2014), and others, by identifying three specific points of synthesis between resilience thinking and political ecology. It aims to provide the theoretical basis for integrating political ecology and resilience thinking into research and resource management. These three insights are outlined in Figure 2.2.

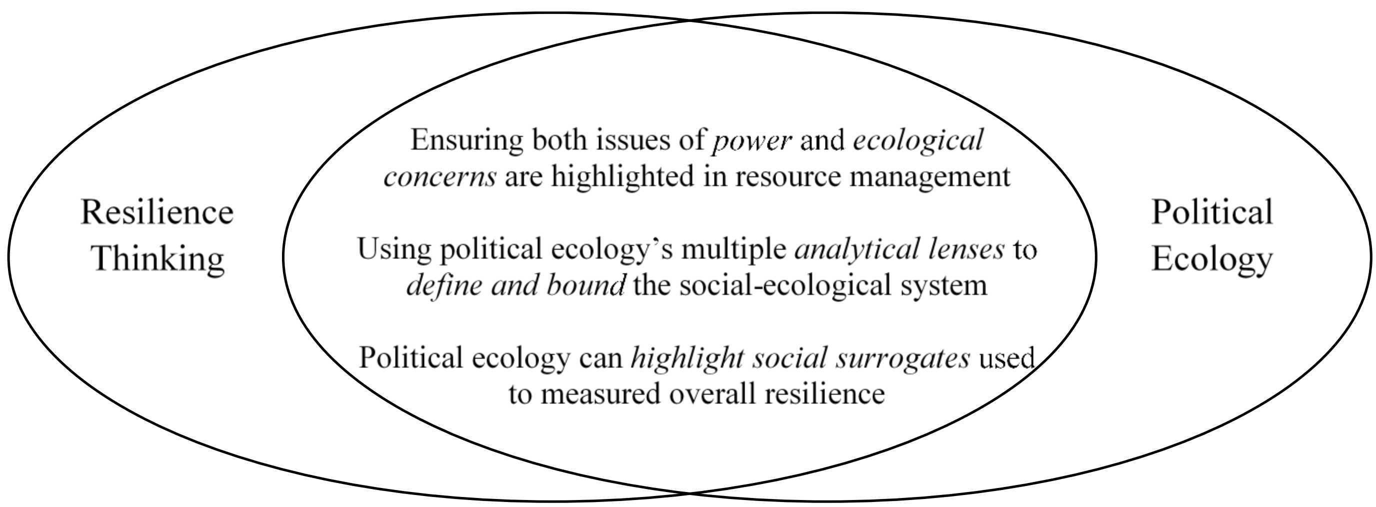


Figure 2.2 Major arguments towards integrating political ecology into resilience-based natural resource management.

Resilience thinking

Before diving into the three insights of this paper, it is important to understand the major concepts embraced by resilience thinking. Resilience thinking has emerged over the last 40 years, originating in the field of ecology (Carpenter 2001). The concept was introduced as a technical ecological term by Holling (1973) in research on spruce forest budworms. Originally, resilience thinking largely built upon insights from non-equilibrium ecology (McIntosh 1987; Turner 2014). Over the years, resilience research has been expanded beyond the confines of its original ecological origins (Beichler et al. 2014; Stone-Jovicich 2015). A resilience approach to social-ecological systems developed after the recognition that management systems based on optimization of a particular good or service (for example timber production) through getting rid of or altering change were not leading to either environmental or social sustainability (Walker and Salt 2006). Instead, resilience embraces change and uncertainty as part of the system in order to achieve sustainability. Resilience is often considered a ‘boundary’ concept that helps to integrate the natural and social aspects of sustainability (Olsson et al. 2015). Resilience thinking has now become popularized within a wide variety of academic disciplines as well as development organizations (Fath et al. 2015).

Resilience connotes multiple meanings that revolve around uncertainty, diversity, connectedness, change, persistence, structure, transformation, and agency (Turner 2014). Resilience is defined by Walker and Salt (2006) as the capacity of a system to absorb disturbance and still retaining its basic function and structure. For social-ecological systems, Cabell and Oelofse (2012) define resilience as the capacity of a system to "maintain the ability to feed and clothe people in the face of shocks while building the natural capital base upon which they depend and provide a livelihood for the people who make it function” (pg. 3). Other scholars include the idea of ‘bouncing back and transforming after a disturbance’ into their thinking of resilience (Olsson et al. 2015). Resilience can also be divided into general or specific resilience, where specified resilience asks the question “resilience of what and to what?” (Walker and Salt 2006). Because this can be a complicated question, the resilience approach requires interdisciplinary analysis and syntheses (Cumming et al. 2005; Turner 2014).

Generally, resilience is associated with the systems’ ability to recover from a disturbance (Fath et al. 2015). Walker and Salt (2006) explain the system as a ball in a basin. The ball is the current state of the system, and the basin is the system. If the ball crosses into another basin (due to fast or slow variables) it signifies that the system has crossed a threshold and entered into an alternative regime. The desired outcome of resilience management is to achieve a system that will provide continued sustainability of the economy, society, and natural resources (Walker et al. 2002). A prominent aspect of the resilience approach to understanding and managing social-ecological systems is the complex adaptive cycle (Gunderson et al. 2002; Folke 2006; Fath et al. 2015). The adaptive cycle explains how the overall system adapts to change and uncertainty and exploits opportunities for growth (Gunderson et al. 2002). The four phases of the adaptive cycle are rapid growth, conservation, release, and reorganization (Walker and Salt 2006). Rapid growth is the phase where species/people exploit new opportunities and available resources, followed by the conservation phase where connectedness of the system components increases and energy/materials accumulate. Next is the release phase where a disturbance or creative destruction causes the system to come undone, which leads to the reorganization phase where uncertainty, novelty, and innovation occur in the aftermath of a disturbance. The adaptive cycle happens at various scales; slower and larger levels set the conditions within which faster and slower ones function in a process called panarchy (Gunderson et al. 2002; Holling et al. 2002). In panarchy, connections between levels can lead to events in faster/smaller cycles overwhelming slower/larger cycles, but it can also create cycles that remember past disturbance and make the system more resilient to disturbance in the future. A key to recovery is system memory where the social-ecological system can store and retrieve knowledge, either through individual recollection, or cultural practices, governments, and institutions (Berkes and Seixas 2005; Hahn 2011; Leslie and McCabe 2013). The resilience of an ecosystem can be increased when the institutions governing that resource make effective decisions and utilize social memory and learning to manage natural resources (Hahn 2011). An organization's or institution's ability to learn from the past is important in making management decisions that allow for change and adaptation. The complex adaptive system will never return to the precise structure and function as before a disturbance, but instead will renew, regenerate, and reorganize (Folke 2006; Fath et al. 2015).

Political ecology

In order to understand how political ecology might be integrated into resilience-based resource management, it is important to understand what political ecology is and its major strengths. Unlike resilience thinking political ecology is rooted in the social sciences. Political ecology began in the 1980s as a framework for understanding the complex interconnections between local people, global political economies, and ecosystems (Blaikie and Brookfield 1987; Schmink and Wood 1987). Political ecology emerged as a result of three convergent factors: cultural ecology, critical theory of many types, and that the apparent contradictions and feedbacks of global ecology appeared to be accelerating (Robbins 2012). It aims to combine the concerns of ecology and political economy to represent the "tension between ecological and human change, and between diverse groups within society at scales from the local individual to the earth as a whole" (Peterson 2000, pg. 24). Political ecology research often focuses on critically examining established explanations for environmental problems and aims to "construct more meaningful and effective forms of explaining environmental problems" (Forsyth 2009, pg. 24). An underlying assumption of political ecology is that politics and the environment are thoroughly interconnected and at the heart of political ecology is the idea that politics should be prioritized in any attempt to understand how human-environment interaction may be linked to environmental degradation (Bryant 1998).

Political ecology utilizes various academic theories, but it would be misleading to call it a theory itself (Robbins 2012). Instead, it draws from a diversity of theories and schools of thought to explain complex environmental-social outcomes. Robbins (2012) groups political ecology research into five dominant narratives: degradation and marginalization, conservation and control, environmental conflict and exclusion, environmental subjects and identity, and political objects and actors. Through these different narratives, political ecology aims to reveal winners and losers, hidden costs, and differential power that exists in social and environmental outcomes (Robbins 2012). Some political ecology 'tools' include common property theory, Marxist political economy, historical materialism, non-equilibrium ecology, traditional ecological knowledge, environmental and social justice, and critical environmental history (Zimmerer and Bassett 2003; Robbins 2012). Additionally, political ecology includes research on the sociology of science and knowledge, the history of institutions and policy dealing with the environment and development, the globalization of environmental discourses, and the power relationships of global environmental governance and management (Adger et al. 2001).

Two of the major strengths of political ecology are the focus on power and power relationships, and its local, case-based approach and ability to analyze human and environment relationships at various scales. Unlike other approaches to environmental problems, political ecology explicitly acknowledges the important role that political power and inequality of power plays in environmental issues. Drawing from the work of Foucault (1972; 1980), political ecology highlights the ways in which the power issues behind political representations, narratives, and discourses shape how people interact with the environment (Agrawal 2005; Fabinyi et al. 2014). Politics and power are explored in political ecology both at the material level and the discursive level. For example, political entities can physically control natural resources (material level), while common narratives about environmental degradation can be used by those in power to maintain that power and control (discursive level). Political ecology research often traces the origins of narratives concerning the environment, with particular attention to identifying power relationships, and how these relationships affect the ecology, economic, and social aspects of an environmental issue (Bryant 1998; Adger et al. 2001). In political ecology these power relationships and hierarchical connections are explored at multi-scalar levels from the local to the global. Political ecology's place-based approach allows for a deep understanding of the historical and political context behind contemporary patterns of resource use and environmental degradation (Turner 2016). It often also aims to connect larger-scale global and regional political, economic, and ecological processes to specific, situated, case studies.

The previous sections have provided brief summaries of both resilience thinking and political ecology (as seen in Table 2.1). In the next section I will outline the major debates and critiques of resilience thinking and political ecology. Drawing from these debates and critiques the remainder of the paper will provide some specific ways that integrating political ecology approaches into resilience thinking potentially creates a more complete, effective understanding of environmental issues and management solutions. I am not saying that these methods are completely compatible or should always used in tandem. According to Turner (2014), political ecologists are some of the first to criticize the management methods of resilience thinking as 'top-down' due to political ecology's commitments to environmental and social justice. However, political ecologists may be some of the best social scientists to collaborate with resilience-based managers because of their emphasis and understanding of complex interactions in history, livelihoods, and ecological responses to these histories and livelihoods (Turner 2014).

Additionally, political ecology is largely an explanatory field (Forsyth 2009), and while it can inform management, it is not a management framework like resilience thinking is.

Table 2.1 Key characteristics for the two approaches for understanding social-ecological systems discussed in this paper.	
Approaches	**Key Characteristics**
Resilience Thinking	Revolves around uncertainty, diversity, connectedness, change, persistence, transformation Complex adaptive cycle: rapid growth, conservation, release, and reorganization Panarchy concept connects cycles at various scales The social-ecological system is a ball in a basin Capacity of a system to absorb disturbance and still retailing its basic function and structure (Walker and Salt 2006)
Political Ecology	Understanding the connections between people, political economies, and ecosystems (Blaikie and Brookfield 1987; Schmink and Wood 1987) Combines concerns of political economy and human ecology (Robbins 2012) Emphasis on historical and political context of resource use and environmental degradation Place-based, focus on case studies Multi-scalar Acknowledges the role power and power relationships play in environmental issues Politics and the environment are thoroughly connected

The debates

While both resilience thinking and political ecology have their strengths in analyzing social-environmental problems, they also have their weaknesses or critiques. Resilience thinking has been criticized for being difficult to operationalize (Cabell and Oelofse 2012), hard to measure (Carpenter et al. 2001), not fully integrating the social dimensions (Folke 2006), not acknowledging the power relationships within a social-ecological system (Lebel et al. 2006; Nelson and Stathers 2009), difficult to define the scales of analysis, and challenging to put boundaries around the system (Brown and Purcell 2005). To manage for resilience it is important to understand the social-ecological system with particular attention to the drivers that cause it to cross thresholds between alternative regimes, and how to enhance aspects of the system that enable it to maintain or build its resilience (Walker and Salt 2006). This is essentially a problem definition exercise which asks the questions: what aspects of the system should be resilient and what kinds of change would we like the system to be resilient to (Bennett et al. 2005)? However, answering these questions is difficult and poses a big hurdle for resilience thinking because resilience is contingent on social values regarding what is deemed important (Turner 2014).

Measuring resilience is also a difficult task, although several authors have put forward ideas about how to empirically measure resilience (Carpenter et al. 2001; Anderies et al. 2004; Bennett et al. 2005; Carpenter et al. 2005;Walker et al. 2006; Lebel et al. 2006; Nadasdy 2007; Nelson and Stathers 2009; Cabel and Oelofse 2012; Leslie and McCabe 2013). Because resilience is not something that can be empirically measured, most researchers have been attempting to define surrogates or indicators of resilience as a proximate measure of resilience. However, there is no standard protocol for determining surrogates of resilience, nor should there be. Instead, a comprehensive strategy for ensuring that major social and ecological aspects of resilience are included for measurement protocols is important. One last major critique of resilience thinking is that it has grown in isolation from social science research on the human dimensions of environmental change, and instead mainly evolved through the application of ecological concepts to society (Cote and Nightingale 2012). This creates problems because it may assume that social and ecological system dynamics are similar (Cote and Nightingale 2012). For example, Cote and Nightingale (2012) state that the “reliance on ecology principles to analyze social dynamics has led to a kind of social analysis that hides the possibility to ask important questions about the role of power and culture in adaptive capacity."

Political ecology has also been debated and critiqued. For example, political ecology has been repeatedly critiqued for being unengaged with ecology and the biophysical world 9Vayda and Walters 1999; Castree 2005; Bakker and Bridge 2006). Vayda and Walters (1999) accuse political ecologists of "only dealing with politics, albeit politics somehow related to the environment" (p. 168). As stated above, dealing with politics and power is a strength of political ecology, nevertheless political ecology research that only focuses on politics and power is critiqued for missing the ecological aspects of environmental change. Even though this critique is not new, in a review of current political ecology research Turner (2016) finds that work actively engaging in ecology is still only a minority of political ecology research. However, this critique is based on the assumption that political ecology should engage directly with ecology in the first place to conduct successful analysis of human-environment interactions.

Using political ecology to complement resilience thinking can help address the critiques of each of these methods for understanding human-environment interaction. There is significant value added to the analysis when political ecology is integrated into resilience-based management because of its ability to understand the interactions of history, livelihoods, and the environment. Specifically, I will focus on three key insights to why integrating political ecology into resilience-based management could lead to more effective resource management. First, the ecological origins of resilience thinking can address the need for political ecology to engage with ecology, while the political focus of political ecology can help integrate social aspects into resilience thinking. Second, political ecology's ability to focus on situated case studies may help define the system, its scale, and boundaries, which is something that challenges resilience thinking. Third, political ecology's explanatory power may help define surrogates or indicators of resilience. Political ecology looks at environmental issues through many lenses (political, social, cultural, economic, etc.) and these various lenses may identify specific measures of resilience in a holistic and effective way.

Where is the ecology? Where is the politics?

The integration of the social dimensions of the social-ecological system in resilience thinking has been a slow process, but is important for understanding change and managing for resilience in social-ecological systems (Perrings 1998; Folke 2006; Brown 2014). Cote and Nightingale (2012) define social resilience as the ability of communities to cope with stresses as a result of social, political, or environmental change. This definition is, however, quite vague and the word 'community' can be a highly contested and misunderstood term. Agrawal and Gibson (1999) assert that 'community' should not be viewed as a small spatial unit with a homogenous population, but instead it should be viewed through a political lens as a heterogeneous group of actors with multiple interests and varied levels of influence on decision-making processes and institutions. Political ecology may provide the proper analytical tools to shed light on power relationships and hierarchies present in communities that are part of social-ecological systems. Power relationships may influence people's ability to adapt to change and manage the system to be more resilient to shocks and disturbances. For example, power inequalities between genders may shape their abilities to adapt to climate risks (Rossi and Lambrou 2008). Power inequalities could include inequalities in participation in decision-making, the division of labor, resource access and control, and knowledge and skills (Nelson and Stathers 2009). Political ecology could help improve the understanding of any power inequalities and their causes, and therefore illustrate how they might be important in social-ecological resilience management (Phadke 2011).

Another question of power when managing for resilience is who gets to decide the resilience of what and to what? Who has power in this process of determining the desired outcomes of resilience management is important for understanding how these decisions are made (Lebel et al. 2006; Nelson and Stathers 2009). For example, as Nadasdy (2005) explains, even though native people may possess rich knowledges about their environment, power to manage the environment often lies in the hands of natural resource managers, and integrating these types of knowledge and different management perspectives is difficult. Political ecology can highlight these challenges: that some people gain while others lose in the process of resilience building, and that resilience for some people or places could lead to the loss of resilience for other social-ecological systems (Stone-Jovicich 2015). This is important in effective resilience-based management. As Haraway (1988) explains all knowledge is situated and there are a multiplicity of knowledges that exist, and therefore each stakeholder may have different knowledge and perspectives about how an area should be managed for resilience. Political ecology could assist natural resource managers make sense of power relationships between stakeholders. By uncovering and highlighting hierarchies of power and suppressed knowledges, it can help uncover the various situated knowledges that exist about a particular social-ecological system and how it functions. Political ecology can help natural resource managers incorporate 'non-scientific' knowledge into management and planning by first showing that they exist, and second illustrating their importance to natural resource management.

Alternatively, utilizing political ecology and resilience thinking in tandem when trying to understand a social-ecological system can help enhance the ecological understanding and analysis of the system. Resilience thinking emerged from the field of ecology (Walker and Salt 2006), often uses ecological terms, and aims for a thorough understanding of the ecosystems involved in management (Gunderson and Holling 2002). For example, resilience thinking explicitly acknowledges that different ecosystem processes occur at different rates, and that both stabilizing and destabilizing forces can be important for ecosystem function (Gunderson and Holling 2002). Taking into account how ecological processes may influence politics, economics, and society is important to integrate into political ecology analyses because it can provide a more thorough understanding. For example, understanding what role a long-term drought and its impacts on the ecosystem (i.e. water availability, vegetation growth, and temperature) might play in local politics or economies would be an important component for understanding the system. In empirical research, drought as an ecological process, has been shown to impact social and political processes, leading to conflict (Harvey 1992). Both resilience thinking and political ecology can benefit from utilizing analytical tools from one another to address critiques in each.

Defining the social-ecological system

Political ecology may assist in defining the social-ecological system for resilience-based management. Resilience practitioners need to define the system they are working with and set boundaries. This is an involved and difficult step in resilience-based management. Cumming et al. (2005) propose a research design for studying resilience which includes defining the current system, defining possible future systems, clarifying change trajectories, assessing likelihoods of alternate futures, and identifying mechanisms for change. In all these steps, understanding the system and its boundaries is incredibly important. While this may sound simple, defining the boundaries of the system is difficult for any theory, including both political ecology and resilience thinking.

However, utilizing political ecology in a resilience-based approach to natural resource management may be able to help answer such questions about how to define the system, where thresholds lie, and what factors cause a social-ecological system to shift to an alternative regime. For example, it may be impossible or unethical to induce a system to cross a threshold in order to understand where the threshold lies and what factors could cause the system to cross a threshold. However, political ecology could help uncover and assess thresholds retrospectively, through a detailed historical analysis of the system and its major components (Carpenter et al. 2005). For example, in a review of empirical research, Forsyth (2009) discusses how some political ecology case studies have shown that historically, some shifting cultivators have increased biodiversity by introducing regular forest disturbance, and thereby *not* caused the system to cross a threshold towards decreased biodiversity. More broadly speaking, Peterson (2000) proposes that a political ecology approach to resilience could help in determining the interconnected dynamics of a system, which would then allow for an assessment of when a system is more vulnerable, or when it is most open for transformation. Here, political ecology may be used to better define the social-ecological system in order to understand what variables are changing and how that might provide opportunity for building resilience, or understanding how the system is vulnerable to change. Additionally, political ecology draws on the field of hazards research, where management systems which may be geared to minimize risk to natural hazards can be altered by political or economic pressure (Robbins 2012). This political ecology tool relates directly to resilience thinking because it examines how social-ecological systems deal with various types of shocks, which could inform how to manage such systems for resilience to hazards.

To effectively define the system, Cote and Nightingale (2012) propose that political ecology, with its focus on the human dimensions of environmental change, can examine the socio-cultural contexts present underlying the heterogeneities across different system dynamics. The context of each social-ecological system is important (Carpenter et al. 2005) and political ecology can help define the social and historical contexts of the system. For example, Goldman (2011) used political ecology to explain how the conservation concept of wildlife corridors is embedded in politics and the history of relations between local people and foreign conservation organizations. In defining the system, it may also be necessary to understand the various scales influencing the system and how to draw boundaries around the social-ecological system of interest. But where should the boundary be drawn? Previous research in both political ecology and resilience draw from case studies, and utilizing and combining the knowledge and experience from these cases could help better inform managers how to define the social-ecological system.

A key for drawing boundaries around a social-ecological system is having an understanding of which factors that influence the system can be controlled and which cannot. This is where a political ecology approach might help determine the more proximate (and controllable) components of the system, giving managers and communities a starting place when thinking about resilience. However, acknowledging components of the system that may lie outside the determined proximate boundaries is important to understanding how 'outside' factors influence the system and could contribute to or degrade social-ecological resilience. Drawing boundaries deals with issues of both temporal and geographic scale and at which scale the system will be defined. Brown and Purcell (2005) discuss how political ecology has been used in analysis of the wider political economy so that the local scale can be analyzed in its wider scalar context. This type of analysis may help manage resilience at a local scale because it can illustrate how the system fits into a wider scalar context. Additionally, temporal scale of disturbances that effect social-ecological systems are important for exploring boundaries. This is particularly prominent in hazards research, where a typhoon can occur in a matter of hours, and a serious drought on the scale of years. Political ecology analysis of previous shocks may help inform future decisions about where the social-ecological boundaries lie when thinking about shocks that happen at different temporal scales. Political economy, culture, and ecology all exist and operate simultaneously at a range of scales, and acknowledging this is important. Identifying the important components for resilience must take into consideration at which scale these components exist and how they interact across scales.

Measuring resilience

The last insight is how political ecology can assist resilience-based managers better measure resilience. Focusing on surrogates or indicators of resilience acknowledges that important aspects of resilience in social-ecological systems may not be directly observed or measured, but instead must be inferred indirectly (Carpenter et al. 2005). This creates a serious challenge to resilience management. Indicators have been used extensively in ecological research but resilience indicators are different because they apply to the entire system, both social and ecological. Indicators also focus on variables that underlie the capacity of the system to provide ecosystem services, and not just the current state of the system (Carpenter et al. 2001). According to Carpenter et al. (2005) there are four general approaches that have been utilized by researchers, and these could benefit from a political ecology approach. The first is stakeholder assessments where aspects of social-ecological resilience are identified through stakeholder workshops aimed at building a common understanding of change in the system. Political ecology would be useful in stakeholder assessments because it could help identify who are the stakeholders in the first place and what are the power relationships between stakeholders. The second approach in determining surrogates is model explorations where models of systems are used to explore the potential thresholds for change, and identify measurable aspects of the system. Political ecology can help develop models of the system by adding to the understanding of the different political, economic, and cultural components and how they are interrelated at various scales. The third approach is historical profiling where a history of the social-ecological system is assessed to classify various alternative system regimes and analyze events in the past that have caused transitions in the system. Political ecology is often used to understand the nuances of the historical context of environmental and/or development issues and it may be able to do the same here in determining surrogates of resilience. Understanding how the social or ecological aspects of the system have changed in the past can help to understand how it might change in the future and what causes these changes. And lastly, the fourth approach to identifying surrogates of resilience are case study comparisons where social-ecological systems that have similarities, but appear to be changing in different ways, are examined to assess properties related to resilience. Comparing case studies allows us to understand how they are different, and therefore what factors might be adding to resilience. The field of political ecology has often focused on case studies to understand human-environment interactions, which makes political ecology particularly useful in this approach. Political ecology has proven insightful when analyzing case studies for what are the drivers of environmental or livelihood degradation (Forsyth 2009).

Conclusions

As this paper has outlined, using a political ecology analysis in resilience-based management may lead to more effective management of social-ecological systems that addresses debates and critiques of both approaches. First, utilizing political ecology and resilience thinking in tandem answers the problem of either approach being too focused on either politics or ecology, and ignoring the other. Second, political ecology's multiple analytical lenses, ability to provide historical context, and case-study nature may help resilience thinking better define and bound the social-ecological system. And, lastly, political ecology can highlight social, political, or livelihood dimensions of the system that should be used as a surrogate of resilience when measuring overall social-ecological resilience.

The world around us is changing at a rapid pace and this may be negatively impacting people around the globe; in particular climate change is expected to have serious consequences (Pahl-Wostl 2007). Understanding the interconnectedness of nature and society is critical to dealing with a changing world and managing for change. Using a political ecology-informed resilience thinking framework for social-ecological system management provides one potential approach for managing resources for change and ensuring that systems can continue to provide ecosystem services and productive livelihoods to the people who depend on them.

A Sustainable Livelihoods Approach for Measuring Livelihood Resilience

The previous section focused on resilience thinking more generally. This section brings the discussion of resilience to focus on livelihood resilience, which is a major concept used in this dissertation research. Some of the discussion about livelihood resilience presented in this section may overlap with topics discussed in the previous section because this section is part of a larger manuscript explaining the sustainable livelihoods approach for measuring livelihood resilience.

Introduction

Over the last few years the concept of resilience has gained prominence in international development and climate change adaptation policy, as well as with environmental conservation agencies, and both government and non-governmental organizations (Jones and Tanner 2015; Walsch-Dilley et al. 2016). The concept of livelihood resilience specifically has been growing as livelihoods are increasingly caught in major global transitions in climatic, economic, and social systems. For example, livelihood resilience is acknowledged both explicitly and implicitly in a range of the United Nation's Sustainable Development Goals for 2030 (Bahadur et al. 2015). This section aims to outline the theory behind one innovative methodological approach for measuring livelihood resilience drawing from the sustainable livelihoods approach. The approach is then utilized for the dissertation research. This section explains the rational and benefits for using the sustainable livelihods approach for measuring resilience, while the detailed mechanics of actually doing this are further explained in Chapter 4. First, I will provide background on livelihood resilience and the sustainable livelihoods approach. A general background on resilience thinking was provided in the previous section. Second, I will discuss how the sustainable livelihoods approach can be used to measure resilience.

Livelihood resilience

While resilience thinking has been praised by some, it has also attracted much criticism as explained earlier. One response to these criticisms has been the development of a livelihood perspective in resilience theory. Tanner et al. (2015; 23) define livelihood resilience as "the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances." Focusing on livelihood resilience places people in the center of analysis and highlights the role of human agency, rights, and capacity to prepare for, and cope with shocks (Tanner et al. 2015). A livelihood resilience approach expands our understanding of resilience beyond "…technical approaches to minimizing harm and loss by bringing issues of people's lives, rights, justice, politics, and power to the fore" (Tanner et al. 2015, 23). Society's ability to manage resilience resides in actors, social networks, and institutions (Lebel et al. 2006). It is also important to note that resilience is inherently neither good nor bad, and often negative regimes are very resilient, while being harmful. In the definition of livelihood resilience, Tanner et al. (2015) state that under livelihood resilience livelihood opportunities are "sustained or improved", which is important because some livelihood strategies may continuously leave people in a cycle of poverty. Livelihood resilience, instead, leaves room for improving upon those livelihoods opportunities and well-being.

Central to livelihood resilience are the coping strategies used by households or individuals during times of stress. These coping strategies can be spontaneous, but often involve planning and preparation for certain shocks. Coping strategies are specific responses or activities used to adjust to changing conditions, both short and long-term, and do not only happen during periods of stress, but are often intensified in such events (Adger 2003; Mosberg and Eriksen 2015). Building livelihood resilience means that a given household's livelihood strategies and activities are better prepared to cope and manage the impacts of shocks, navigate uncertainty, and adapt to changing conditions (Marschke and Berkes 2006). According to Allison and Ellis (2001), the most robust livelihood system is one displaying high resilience and low sensitivity, while the most vulnerable displays the opposite. Shocks to livelihoods can come from the environmental realm, such as climate change, or from the political-economic system, including crop price fluctuations or political instability.

Sustainable livelihoods

The concept of sustainable livelihoods was first introduced by the Brundtland Commission on Environment and Development, advocating sustainable livelihoods as a broad goal for poverty eradication (Krantz 2001). The sustainable livelihoods approach developed as a form of livelihood analysis that has been used by a number of development organizations including the Department for International Development of the United Kingdom, the United Nations Development Program, CARE, and Oxfam (Adato and Meizen-Dick 2002). The sustainable livelihoods approach is methodologically based in participatory research, applied anthropology, and rapid rural appraisal (Chambers 1994; Krantz 2001; Thulstrup 2015). This approach states that livelihoods should be considered in terms of people's access to capital assets (financial, physical, natural, human, and social), the ways in which people combine these capital assets to create livelihoods, and how they are able to enlarge their asset base through interactions with other actors and institutions (Chambers and Conway 1992; Carney 1998; Scoones 1998; Johansson 2015).

At the core of the sustainable livelihoods approach are the five capital assets needed for a sustainable livelihood: financial, physical, natural, human, and social (see Table 2.2). These

Table 2.2 The five livelihood capitals as described by various authors

Type of Capital	Scoones 1998	Tacoli, 1999	Campbell et al. 2001	Adato and Meizen-Dick 2002	Erenstein, Hellin and Chandna 2010
Natural Capital	Environmental services, natural resource stocks such as soil, water, air	Freshwater availability, land management, agricultural space, land	Soil fertility, water resources, forest resources, grazing resources, land quantity and quality	Land, water, forests, marine resources, air quality, erosion protection, and biodiversity	Annual rainfall, soil capability index, farm size, herd size
Financial/ Economic Capital	Capital base including cash, credit, savings and basic infrastructure and production equipment and technologies	Infrastructure and tools /equipment	Credit, savings, remittances	Savings, credit, as well as inflows such as state transfers and remittances	Farm size, herd size, bank facilities, credit societies
Human Capital	Skills, knowledge, ability of labor, and good health	Labor including skills, knowledge, ability to work	Knowledge, sills, health, labor availability	Education, skills, knowledge, health, nutrition, and labor power	Female literacy, immunizations, work participation, population density
Social Capital	Social resources including networks, social claims, affiliations, associations	Access to markets, representation and access to the ‘state’	Adherence to rules, relationships of trust, mutuality of interest, leadership, kin and ethnic networks, social organizations	Networks that increase trust, ability to work together, access to opportunities, reciprocity; informal safety nets; and membership in organizations	Cooperative societies, self-help groups
Physical Capital	Included in financial capital	Included in financial capital	Households assets, agricultural implements, infrastructure	Transportation, roads, buildings, water supply, sanitation, energy, technology and communication	Irrigated area, farm mechanization, distance to nearest town, access to paved roads

capital assets constitute a stock of capital that can be stored, accumulated, exchanged, or allocated to activities to generate an income or means of livelihoods and other benefits (Rakodi 1999; Babulo et al. 2008). Livelihood capitals may be accumulated so that reserves and buffers are created for times of stress or shocks. While these five capitals can, and do, overlap, they encompass different types of assets needed for sustainable livelihoods as described by a variety of authors (Tacoli 1999; Campbell et al. 2001; Adato and Meizen-Dick 2002; Erenstein et al. 2010). Particularly there are overlaps between financial and natural capital as natural capital can create financial capital and vice versa. A household is assumed to need a balance of these five capitals in order to maintain adaptive capacity and well-being (Jacobs et al. 2015). For example, minimum levels of human and social capital are necessary to effectively make use of natural, physical, and financial capital (Jacobs et al. 2015). According to Bebbington (1999), people's assets are not merely a means for which they make a living, but they also give meaning to the person's world, they give people the capability to be and act. The five capital assets are not only inputs into the livelihood system, but are also outputs (Bebbington 1999).

Some of the strengths of the sustainable livelihoods approach is that it draws attention to the multiplicity of assets that people make use of when constructing their livelihoods (Krantz 2001), and seeks to understand changing combinations of livelihood activities in a dynamic and historical context (Serrat 2010). It moves beyond a focus on monetary measures to more adequate multi-dimensional understandings of livelihoods (Rakodi 1999). However, it has been critiqued for not sufficiently accounting for power relationships and politics (Scoones 2009), underplaying macroeconomic trends and conflict (Serrat 2010), and being expert-driven (Jones and Tanner 2015).

Integrating sustainable livelihoods into resilience measurement

Measuring resilience is a difficult task. Several authors have put forward ideas about how to measure resilience, largely using surrogates or indicators of resilience. (Carpenter et al. 2001; Carpenter et al. 2005; Walker and Salt 2006; Nadasdy 2007; Nelson and Stathers 2009; Leslie and McCabe 2013). However, there is no standard protocol for determining surrogates of resilience, nor should there be necessarily. Instead, a comprehensive strategy for ensuring that major social and ecological aspects of resilience are included for measurement protocols is important. Here I propose that using the sustainable livelihoods approach provides one innovative method for determining surrogates of resilience. The five livelihood capitals can be used to organize surrogates or indicators of resilience into these five different categories. As Campbell et al. (2001) state, "the capital assets approach to livelihoods may be an appropriate organizing principal for the selection of indicators of system performance." It serves as a way to ensure that a variety of indicators are considered, including material, social, and natural factors that may help to measure and ultimately build resilience. The sustainable livelihoods approach acknowledges that there are important non-monetary factors to livelihood resilience. Ultimately, resilience is a key component of sustainable livelihoods and vice versa (Thulstrup 2015). Figure 2.3 outlines the conceptual framework used here summarizing how to build livelihood resilience drawing from the sustainable livelihoods approach.

Diversity is also critical for increasing a livelihood's ability to cope with change (Ellis 2000; Hodbod and Eakin 2015). Livelihood diversification can be different in different

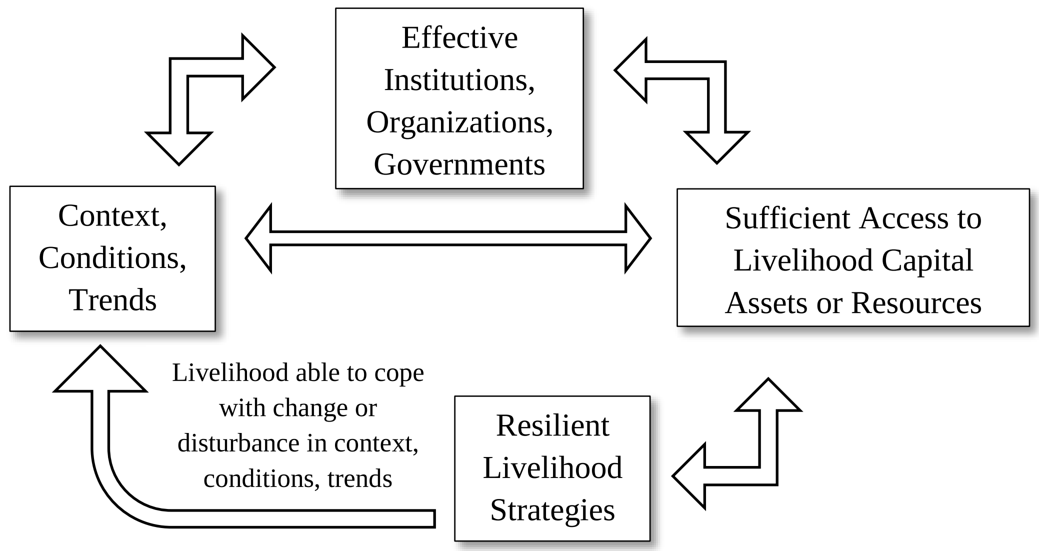


Figure 2.3 Understanding how to build livelihood resilience.

contexts. For example, it is sometimes used to accumulate resources, while others employ diversification to help spread risk or cope with temporary crises, and furthermore others use it as a response to longer-term declines in incomes or resources or due to large scale economic or environmental changes beyond local control (Hussein and Nelson 1998). Using the sustainable livelihoods approach to measuring resilience ensures that a diversity of indicators are used to measure livelihood resilience, instead of indicators focusing just on financial capital. Resilience literature generally focuses on two key types of diversity: functional and response diversity (Hodbod and Eakin 2015; Leslie and McCabe 2013). Functional diversity means that a household may have different types of livelihood activities, therefore decreasing the likelihood that all activities will be seriously disrupted during a shock or disturbance. Thus, diversity is increased if livelihood activities utilize and build different livelihood capitals. Response diversity in coupled human-natural systems includes the heterogeneity of human decisions and actions during and after a disturbance (Leslie and McCabe 2013). The diversity of responses can have different spatial and temporal distributions and be seen at multiple scales (Leslie and

McCabe 2013). Therefore, the accumulation of livelihood capital assets may help increase the ability of households to respond to shocks with a greater diversity of potential decisions and actions.

Most efforts to measure resilience have largely focused on the use of 'objective' frameworks focused on a range of observable socioeconomic variables (Jones and Tanner 2015). Jones and Tanner (2015) advocate for the use of an alternative measurement of 'subjective' resilience which stems from the idea that people generally have a good understanding of the factors that contribute to their ability to plan for and cope with disturbance and change. This is a self-assessment of resilience that focuses on a more bottom-up process than traditional forms of resilience measurement. Jones and Tanner (2015) state that subjective resilience can add value to objective methods because: 1. People have a good understanding of their capacity to deal with disturbance, 2. Subjective measures can help to reduce uncertainty in the selection of indicators, 3. Allows insight to be gained on resilience in contexts where accurate, large datasets are inadequate, and 4. Resilience is heavily shaped by sociocultural and psychological factors including risk perception and personal and cultural values. The idea of subjective resilience was used to develop indicators/surrogates of livelihood resilience for the case study that I will present in Chapter 3 based on my previous work in the case study area of Isiolo County, Kenya (Quandt and Kimathi 2016). I will also utilize the idea of subjective resilience in order to compare and validate using the sustainable livelihoods approach to measuring resilience by comparing the results with self-reported levels of well-being in Chapter 9.

While using a sustainable livelihoods approach to measure resilience has been used in a handful of studies, it has not been widely adopted (Scoones 1998; Campbell et al. 2001; Elasha et al. 2005; Erenstein et al. 2010; Thulstrup 2015). Enns and Bersaglio (2015) report that combining the sustainable livelihood approach with livelihood resilience can help mitigate the risk of downplaying the significance of social capital assets. Thulstrup (2015) used the sustainable livelihoods approach to measure household and community resilience after government programs and interventions in Vietnam. Erenstein et al. (2010) created poverty maps aimed at building resilience using the five capital assets. They found that a solid foundation of all five assets is generally needed for livelihood security and to enable people to rise above the poverty line (Erenstein et al. 2010). Elasha et al. (2005) use the concept of sustainable livelihoods to measure the performance of livelihood interventions in Sudan at building resilience. They concluded that their preliminary results found the sustainable livelihoods framework was useful for measuring a communities' resilience to climate-related stressors from local people's point of view (Elasha et al. 2005). A livelihood approach also strengthens resilience theory by acknowledging that people's circumstances, cultures, values, and perceptions impact their ability to adapt (Enns and Bersaglio 2015), and addresses the often ignored question of 'resilience for whom' (Brown 2014).

CHAPTER 3. ISIOLO COUNTY, KENYA: HISTORICAL, ETHNIC, AND ECOLOGICAL CONTEXT

Introduction

This research was conducted in the two communities of Burat and Kinna in Isiolo County, Kenya. While study area sections are part of Chapters 5 through 8 here I will provide a more in-depth description of the study areas. Understanding the context of the case studies is important because the research questions guiding this study are context specific. The political, economic, ecological, and cultural contexts of this study are inextricably linked to the data, results, and conclusions made in this dissertation.

The first section provides a brief overview of the study area and the two communities where research was conducted. The next two sections focus on both colonial and post-colonial influences, events, and histories of Kenya and Isiolo County. The fourth section focuses on ethnicity and claims to land in Isiolo County. Lastly, I will cover the ecological characteristics and wildlife conservation efforts in Isiolo County. In each section there is a focus on livelihoods and how the subject for that section impacts livelihoods in the area. Additionally, for clarity and consistency I will refer to Isiolo County as Isiolo because before 2010 it was Isiolo District and jumping back and forth between County and District could be confusing. Furthermore, the historical timeline and contextual information provided in this chapter is by no means complete (for example, I do not provide a complete outline of politics in Kenya since Independence). Instead, the information included in this chapter was selected because of its specific relevance to the research questions.

A Brief Introduction to the Study Areas

Figure 3.1 provides maps of where the study areas are located. Isiolo covers an area of 9,782.3 square miles with altitudes that range between 180 and 900 meters (Mati et al. 2005). The climate falls into three agro-climatic zones: semi-arid (5% of the area), arid (30%), and very arid (65%) (Mati et al. 2005). The climate in Burat and Kinna is semi-arid and the median annual rainfall is in the range of 400-600mm (Mati et al. 2005). Isiolo is hot throughout the year with mean annual temperatures ranging from 24 °C to 30 °C (Herlocker et al. 1993). The population of Isiolo is only 143,294 (Acacia

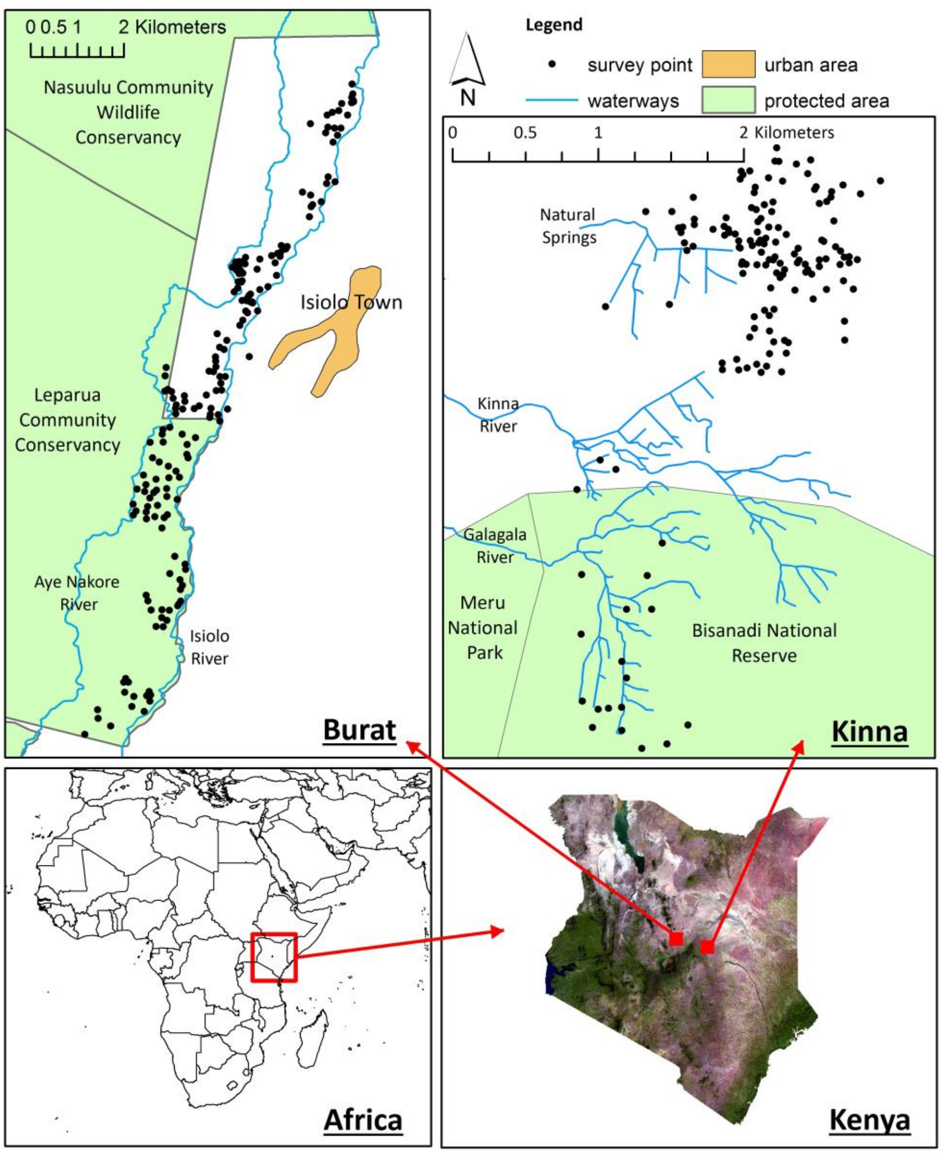


Figure 3.1 Study area map

Consultants Ltd 2011) and the major ethnic groups are Borana, Samburu, Turkana, Somali, and Meru. Isiolo is part of the Ewaso Nyiro North River basin and the Ewaso Nyiro River flows through the middle of the county. Isiolo has several National Parks and wildlife reserves including Samburu, Shaba, Lewa Downs, and Meru. Burat is located only 3km outside of Isiolo Town, while to get to Kinna from Isiolo Town you cross the Nyambene Range and head towards Meru National Park.

It is important to mention that Kinna and Burat are Wards, which is a political and administrative unit. There are 10 Wards in total in Isiolo County. However, the research did not take place over the entirety of Kinna and Burat Wards, and instead was focused on the agricultural areas. There are large stretches of both Kinna and Burat Wards that are dominated by pastoralists and therefore do not fit into the research parameters of practicing agriculture.

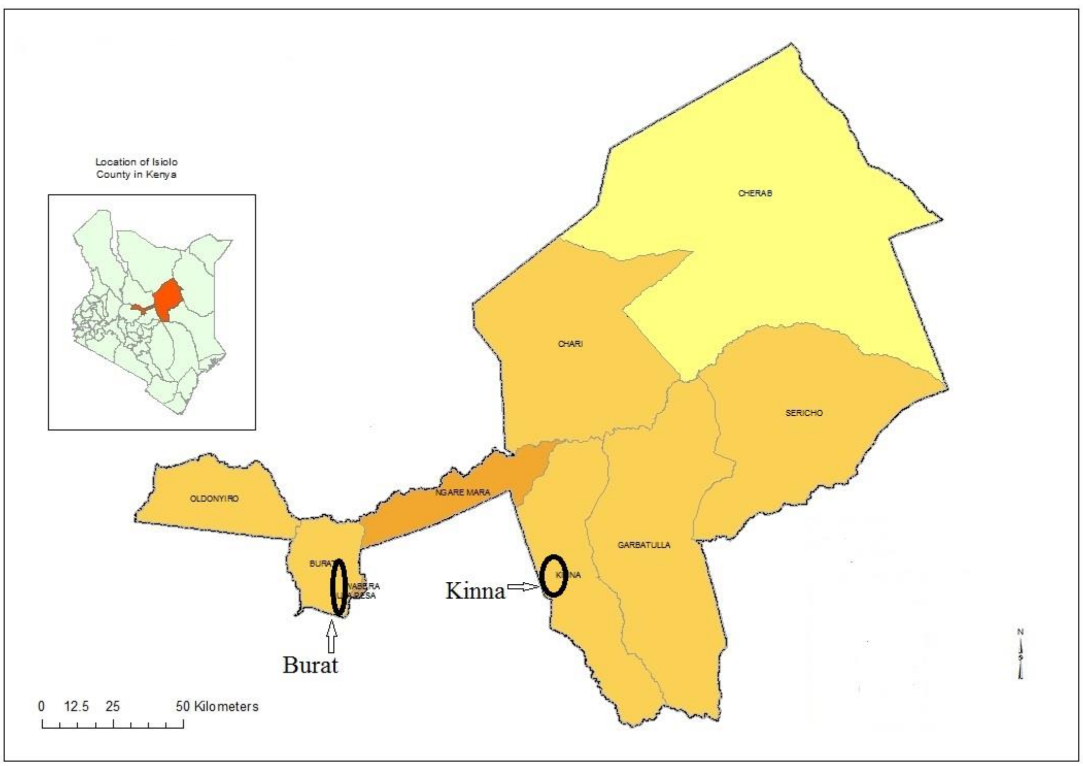


Figure 3.2 Locations of research sites within Isiolo County, Kenya

Figure 3.1 above shows the area of Kinna and Burat where the research took place. Figure 3.2 shows out Burat and Kinna Wards fit into the larger context of Isiolo County and provides the approximate location for the research.

Burat

Burat is a one of the ten Wards that make up Isiolo and had a population of 18,774 in the 2009 census (Republic of Kenya 2013). Burat is a mix of ethnicities including Turkana, Meru, Somali, Borana, and Samburu. Much of the population of Burat lives between the Isiolo and Aye Nakore rivers, where irrigated agriculture is possible. Pastoralism is the predominant livelihood throughout Isiolo, but in some areas of Burat the use of irrigation schemes allows for small-scale farming (Republic of Kenya 2013). Agriculture began in Burat during the colonial period on small-scale experimental farms run by government officials, while the local population did little cultivation (Kenya National Archives). Agriculture began among non-colonial entities in Burat when Meru from neighboring areas moved onto the land near the two rivers in Burat and cleared land for farming (grabbed land) (personal communication).   Tree planting began in earnest in Burat in the early 1970’s but agroforestry wasn’t seriously adopted until the early 1980’s (personal communication). Irrigation in Burat is largely through a system of pipes and generators. Some of the irrigation system was established with the support of international organizations including ActionAid, World Vision, and the Red Cross, while others with irrigation own their own pipes and generators. In Burat, the Isiolo River Water Users Association oversees water sharing by irrigators, pastoralists, and Isiolo Town (Mati 2008).

Within Burat Ward is the Nasuulu Community Wildlife Conservancy and Leparua Community Conservancy. Directly to the south lies Lewa Downs Wildlife Conservancy and Il

Ngwesi Community Trust. Approximately 15km to the north are the internationally renowned Buffalo Springs and Samburu National Reserves, which are separated by the Ewaso Ngiro River and have a combined area of 336 km^2.

Kinna

Like Burat, Kinna is also a ward and is located about 60km from Garbatulla town. The 2009 census reported that the larger Kinna Ward had a population of 14,618. Kinna is largely inhabited by Muslim Borana, with a few Meru as farm help or business owners. Kinna depends on a spring canal and two small rivers that are used for subsistence farming, household use, and watering livestock (Kenya Red Cross Society 2011). Human-wildlife conflict is causing problems with farming in Kinna because Kinna borders Meru National Park (Acacia Consulting Ltd 2011).

Livelihoods in Isiolo have changed in the past 50 years and in Kinna particularly there has been adoption of agriculture by the Borana. This is attributed to livestock losses during the *shifta* conflict at the hands of both the government and *shifta* fighters (Hogg 1983), followed by losses due to droughts in the 1970s and 1980s (Helland 1998), and livestock disease (Hogg 1987). The response of the government after the *shifta* war ended was to establish small-scale irrigation schemes (Dahl 1979; Hogg 1987; Hogg 1989). According to Kinna elders, the Kinna irrigation scheme was dug by the government in 1969 and land was allocated on a first come basis (personal communication). Adopting cultivation was a strategy for livestock poor Borana (Otuoma et al. 2009).

Isiolo History: Colonialism

Land, government, and trade

The British colonial influence on Kenya has a rich history and many impacts of colonialism is still felt today. Kenya was proclaimed to be the British East Africa Protectorate in 1895, and in 1920 a Colony (Fazan 2015). The acquisition of Kenya by the British led to the subordination of existing rules of tenure and property rights of the different ethnicities (Boye and Kaarhus 2011). Under the Crown Lands Ordinance of 1915, all land in Kenya was declared to be Crown Land, including the native reserves (Fazan 2015). Also in 1915, the government introduced a system of registering Africans to control their movement and employment (Sobania 2003). This gave the colonial government the ability to control and manage virtually all land in Kenya, and was an attempt to control the movement of people. As a result of this, in the 1930's the category of 'trust land' was introduced to remedy the native population's feelings of insecurity in their land tenure (Boye and Kaarhus 2011). It was indeed the increasing pressure on resources and scarcity within these trust lands that was an underlying factor behind the Mau Mau revolt that erupted in 1952 (Syagga 2006). This then led to the colonial administration to formulate the Swynnerton Plan of 1954, which was the conversion of some native (agricultural) lands into individually registered land (Boye and Kaarhus 2011).

Isiolo has a long history of British colonial governance. Isiolo Town became the Northern Frontier District headquarters of the British East Africa Protectorate in 1922 (Kenya National Archives). The Northern Frontier District was created in 1909, while Isiolo District was established in 1929 (Boye and Kaarhus 2011). In 1934 the district was reorganized into

Samburu and Isiolo Districts (Kenya National Archives). The area was largely pastoral during the colonial era and there were large movements of people both into and out of the area.

Trade in the district was difficult in the 1930's due to poor roads that were often washed away by rains and floods (Kenya National Archives). As of 1951, colonial records document that livestock, hides, and skins were the only exports from Isiolo, while the importing of Coca-Cola and other amenities was increasing (Kenya National Archives). In 1958, ghee, a type of clarified butter, was added to the export list (Kenya National Archives). Colonial records also document several occurrences of pests and livestock disease in Isiolo. For example, in 1915 rinderpest was reported to have wiped out 60% of the cattle in the district (Kenya National Archives). On top of outbreaks of livestock disease such as rinderpest and foot and mouth disease, the 1940's saw a large locust infestation (Kenya National Archives). Also, wildlife poaching has been a problem in the area since the colonial era. Colonial documents site instances of trade of rhinoceros ivory in 1934, and poaching in the 1950s of giraffe, elephant, and rhinoceros (Kenya National Archives). Overall, the colonial influence aimed at keeping peace and stability instead of the push for development that occurred in other regions of Kenya (Fazan 2015).

Livelihoods and early agriculture

There was virtually no subsistence agriculture practiced in Isiolo before the British (Fazan 2015). As early at the 1930's the colonial government began experimenting with agriculture in the area of Isiolo Town and Burat. In 1933, a good crop of maize was grown for the use of the British government officials (Kenya National Archives). Also in 1933, the government documents recorded a concern over the supply of fuelwood around Isiolo town and stated that they should begin to experiment with tree planting both to preserve natural trees and to assure a future supply of building materials and firewood (Kenya National Archives). The Isiolo River, which runs through Burat, was identified in 1934 as a place of potential agricultural expansion and tree planting experiments began around government housing (Kenya National Archives). According to the colonial government, almost every kind of vegetable could be grown there as well as fruits such as papaya and bananas. The government maize farm was planted using irrigation and in 1936 the government wrote about expanding irrigation in the area (Kenya National Archives).

In 1937, the colonial government began experimental tree plantations along the Isiolo River, planting 3,000 seedlings including Acacia and Eucalyptus (Kenya National Archives). Around the same time an Ethiopian refugee camp was built here and using labor from the camp about 30 acres on the east bank of the Isiolo River was put into irrigated vegetable gardens (Kenya National Archives). However, after the refugees returned to Ethiopia in 1939 this cultivated area was abandoned. In 1944, 1,000 trees were planted, however due to damage by animals and drought condition they did not thrive (Kenya National Archives). The colonial records on agriculture for the last 10 years of colonial rule are very sparse and make short statements about there being no crop production in all of Isiolo (Kenya National Archives). However, these documents do provide evidence that irrigated agriculture and agroforestry began in Burat specifically very early, although if it went beyond the colonial government is unclear.

The first documentation of agriculture in Kinna was recorded by the colonial government in 1940, where they mention that Borana were cultivating crops along the Kinna River and producing good crops (Kenya National Archives). There continues to be documentation of productive farming in 1942-43, when a shortage of maize in Kenya made the government particularly supportive of farming in Kinna (Kenya National Archives). However, in 1944 the farms in Kinna suffered severely from wildlife damage. The colonial government distributed seeds in Kinna in 1946, including bananas, papaya, and onions (Kenya National Archives). Unfortunately, the colonial records indicate that in 1947, the Borana in Kinna had lost interest in farming (Kenya National Archives), however this seems to be accompanied by generally negative comments about the success of farming in the entirety of Isiolo in the documents.

Isiolo History: Post-Colonialism

Independence and the shifta war

Kenya gained its independence from Britain on December 12, 1963 (Sobania 2003). Since Kenyan independence the local authority in Isiolo has been the Isiolo County (or District) Council (Boye and Kaarhus 2011). However, soon after Kenya's independence, insurgency and counter-insurgency wars broke out in the Northern Frontier District (Whittaker 2012). Both Borana and Somali in Isiolo boycotted the first general elections in May 1963 (Boye and Kaarhus 2011). Later that year conflict broke out in Isiolo between secessionist guerilla forces backed by Somalia, also called *shifta*, and the new government and police forces (Dahl 1979; Boye and Kaarhus 2011). *Shifta* bandits used firearms to launch attacks on the Kenyan armed forces, police officers, and administrative units (Branch 2011). For example, there was a raid on the Garba Tulla police post, about 60 km from Kinna, where the *shifta* fired at officers and then took 100 camels that had been taken from pastoralists in the area (Branch 2011). In response, a state of emergency was declared in Isiolo by the central government and the local Borana population was forced to settle into 15 'strategic villages' including Garba Tulla, Merti, and Modagashe. While settled in these villages people were prohibited from grazing their livestock farther than 5km from the villages (Boye and Kaarhus 2011; Khalif and Oba 2013). It was reported that many animals died as a result of concentration in these villages (Kenya National Archives). Hogg (1985) estimated that between 1963 and 1970, the camel population declined by 95% and the small stock population by 90%, while the cattle population only decreased about 7%. The Borana bore the blunt of this conflict, as the Somali moved their herds to Somalia (Hogg 1983; Hogg 1989). Additionally, nearly 2,000 people identified by the Kenyan government as being *shifta* were killed during the conflict (Branch 2011). By 1968 the conflict was largely over (Branch 2011). As the war ended, the local pastoralists were told they could claim compensation for livestock that died or were stolen, though there is no evidence of anyone actually being compensated (Khalif and Oba 2013). In Isiolo the conflict had three major consequences. First, the population shifted from rural areas to local trading centers (Hogg 1980). Second, whatever livestock herds remained had lowered reproductive capacity (Hjort 1979). And lastly, the impoverished population that had lost their livestock became more dependent on external food aid and agriculture (Hogg 1980, Hogg 1985). The response of the government after the *shifta* war ended was to establish small-scale irrigation schemes, and the irrigation system in Kinna is one example of this (Dahl 1979; Hogg 1989).

Impacts of devolution and the 2010 constitution

In 2010 a new Kenyan national constitution was implemented which led to the devolution of the governmental structure in Kenya. Devolution was seen as a mechanism to bring the government closer to the people. Some of the aims of devolving the government was to recognize the rights of communities to manage their own affairs, and the promotion of the interests and rights of marginalized communities (Kirui and Biwott 2013; Steeves 2015).

Chapter 1 of the new constitution, which provides for county governments, emphasizes the sovereignty of the people and that the sovereign power of the people may be exercised directly, or through democratically elected representatives (Kirui and Biwott 2013). The constitution of 2010 also established three distinct categories of land in Kenya: public, community, and private (Boye and Kaarhus 2011). This new category of community land includes land held as trust land by the county governments, as is the case in Isiolo (Boye and Kaarhus 2011).

The 2010 constitution established county governments with elected Governors and Members of County Assemblies (MCAs) (Steeves 2015). The county assembly is made up of members elected from each ward (Steeves 2015). These county governments now were supposed to receive 35% of national revenues (Steeves 2015), including 15% of national development funds to be used in the Constituency Development Fund (CDF) (Omari et al. 2012; Chitere and Ngundo 2015).

Isiolo Today

Isiolo has a total population of only 144,000 people while Isiolo Town has an urban population of 44,154 (Republic of Kenya 2013). Isiolo town is the capital and largest town in Isiolo County. It is the market center for the county and also contains the county government offices. Isiolo remains a relatively underdeveloped area of Kenya. A high 51% of residents have no formal education, while 64.9% cook with firewood and an additional 29.1% cook with charcoal (KNBS and SID 2013). Isiolo suffers high rainfall intensities with poor temporal and spatial distribution, resulting in short-lived excessive flooding (Mati et al. 2005). Poor distribution means that there are a few high intensity rainfall days instead of moderate rainfall days over a greater number of days, which is better suited to agriculture. Spatially, unequal distribution refers to rainfall that includes intensive, localized storms, instead of a more even distribution spatially. Furthermore, in Isiolo 100% of the land is classified as low agricultural potential and since independence about 70% of the land has been classified as trust land (Boye and Kaarhus 2011). In the future, Isiolo has been earmarked for development by the Kenya Vision 2030 program, and is supposed to be developed into a 'resort city' (Auma 2015). Additionally, Isiolo is the site of a future international airport and railway link under the proposed Lamu Port South Sudan-Ethiopia Transport Project (LAPSSET) (Auma 2015). What impacts these development projects will bring are uncertain and many residents are weary (personal observation). There have already been allegations that wealthy elites are grabbing land near where these developments are planned in order to control and capture the benefits (personal communication).

The area suffers from social-ecological shocks and disturbances that include drought, floods, conflicts, human and livestock disease outbreaks, and human-wildlife conflict, with drought being the highest prioritized disaster (Acacia Consultants Ltd 2011). Cattle rustling is a big source of conflict in the area. Additionally, an analysis of the density of vegetation over the last 50 years shows a significant reduction in vegetation (Acacia Consultants Ltd 2011). Most people in Isiolo depend on the river and boreholes for water (Acacia Consultants Ltd 2011). The area of land under irrigation is increasing (Blank et al. 2002). There is some diversification of livelihoods and 62% of families depend on two livelihoods, while some 14% depend on three (Acacia Consultants Ltd 2011). Crop farming was noted to increase resilience to drought (Acacia Consultants Ltd 2011). The adoption of several livelihood options was mainly to cushion the community from the effects of drought (Acacia Consultants Ltd 2011). However, Isiolo is still mainly pastoral with large herds of camels, cattle, goats, and sheep. In the 2009 livestock census there was an estimated camel population of 2.97 million (Dokata 2014).

Ethnicity and Narratives of Land and Conflict in Isiolo

In this section I will first give a brief overview of the five major ethnic groups in Isiolo. Then I will discuss the contested claims over land in Isiolo, and the current state of land tenure.

Borana

The Borana are one of the groups of Oromo migrants who left the southern highlands of Ethiopia in the 1500s (Bilali 2013). Borana today speak their own distinct dialect of Oromo, with elaborate vocabulary that is difficult for some other Oromo groups to understand (Kidane 2002). The Borana in Isiolo retained a complex social institution called the Gada, which is both concerned with relations within and between generations, but also deals with how Borana should live their lives (Helland 1998). The Gada is how the Borana maintain their social and political order and its practice involves many rites of passage and stratification in to generation-sets (Kidane 2002). Time is equally divided up into 5 units of 8 years each, which is a Gada, and the sum of these five eight-year groups makes up a generation or luba (Sobania 2003). According to Borana myth, the Gada law was given by God to a man named Gadayo, who became the first Abba Gada, or 'father of Gada' (Kidane 2002). The Gada councils are headed by the Abba Gada, who is elected and stays in office for eight years, and have important ritual, political, and judicial aspects (Helland 1998).

Traditionally, every male child is given a heifer at an early age that will multiply and supply the son's bride wealth when he is ready for marriage (Kidane 2002). Borana inheritance goes from father to eldest son. Traditionally, a wife's responsibility is to bear children, feed the family, and run all the home affairs (Kidane 2002). A Borana man may marry as many wives as he can afford, and women traditionally married around 16 years of age (Adamson 1967). However, many Borana today have converted to Islam and adopted Muslim traditions.

The Borana are currently the most populous ethnicity in Isiolo and are the majority holders of local administrative and political positions (Boye and Kaarhus 2011). According to the 2009 census, there are 161,000 Borana who reside in Kenya (Bilali 2013). Even as far back as 1900, Borana made up 71% of the population of Isiolo (Costagno 1964). According to many Borana, the colonial government authorized the Borana's exclusive rights to Isiolo to compensate for their loss of land and resources in Wajir (Boye and Kaarhus 2011). According to Hjort (1979), when Isiolo was established as a district in 1929, it was as a "Borana district to prevent further expansion by Somali groups coming from the Northeast." According to Aguilar (1999), in 1932 the colonial police escorted a group of Borana, offering pasture and water, to the area of the Ewaso Ng'iro River, east of Isiolo Town. That group of Borana became administratively cut off from the Borana to the north and are now referred to as the Waso Borana (Aguilar 1999; Jillo et al. 2006). In the 1950s a number of Borana traders had vehicles, which they hired out or used to transport their own goods (Hogg 1986). Overall, livelihoods were still primarily livestock based and in the 1950s only the very poor, whose livestock were not enough to sustain the household, or the very rich, who had the capital and motivation to invest in trade, let their sons leave pastoralism (Hogg 1986).

As stated above, the Borana were heavily involved in the *shifta* war and in the 1960s and 70s their livestock herds were devastated by war, disease, and droughts. The Waso Borana refer to the *shifta* war period as *gaafa dhaaba* or the period of stop (Khalif and Oba 2013). In the wake of the war, irrigated agriculture was actively encouraged by the Kenyan government as an alternative to pastoralism (Hogg 1989). In contrast, Helland (1998) wrote that it was not until around the 1984-85 drought that the local livelihood specialization of pastoralism began to change with some Borana practicing farming. This drought is referred to by Borana as *oolaa katitini* or the drought year when herds moved to Katitini in Kitui District (Khalif and Oba 2013). Jillo et al. (2006) reported that the Borana in Isiolo used to have large, mobile, diverse livestock herds, but since Kenya's independence, years of population growth, drought, and lack of effective policies have altered the situation. They estimate that compared to independence, there has been a 75% loss in cattle populations and a 95% loss of camels and goat populations. Today, many Borana in Isiolo are relatively livestock poor and engaged in a variety of non-pastoral activities to diversity their livelihoods (Jillo et al. 2006).

Turkana

The Turkana are a traditionally pastoral ethnic group in Isiolo and many have settled in Burat. The Turkana are a group of Nilo-Hamites and traditionally occupied arid and semi-arid areas of Northwest Kenya, which is currently called Turkana County (Akabwai 1992). Turkana are believed to have emerged as a distinct ethnic group sometime during the early decades of the 19th century and form one part of a larger linguistic cluster referred to as the Ateker group (McCabe 2004). Evidence suggests that that Ateker group lived in southern Sudan before 1500, after which Turkana expansion south has been very successful (McCabe 2004). Traditional social organization of Turkana differs from other pastoral groups, including the Borana, as the awi (a man, his wives, their children, and sometimes other dependent women) is the basic economic and social unit and there is no hierarchy based on chiefs (Akabwai 1992; McCabe 2004). Turkana manage their natural resources through social relationships. All Turkana have access to open sources of waters, but wells can be individually owned by those who dug the well (McCabe 2004). According to Sobania (2003), the Turkana hold a widespread belief in nature spirits whose world is that of the mountains, rivers, and other natural places. In 2001, the total Turkana population in Kenya was estimated to be around 340,000 (Mburu 2001).

Turkana are not new to Isiolo (Spencer 1973). In 1900, Turkana made up 10% of the population of Isiolo (Costagno 1964). The colonial government appears to have been particularly against the Turkana moving into Isiolo and the colonial records from 1934 even state "the Turkana are, in this district, like rats. One cannot get rid of them" (Kenya National Archives). Turkana were branded by Europeans as being aggressive and hostile because they often resist strangers (Lamphear 1976). Due to this perception of Turkana, beginning in 1928, the British colonial government began disarming Turkana, which had negative impacts as Turkana were defenseless against attacks from neighboring groups (Mburu 2001). The government in Isiolo made several attempts to return Turkana living in Isiolo back to Turkana, including one event in 1957 where about 2000 Turkana were relocated back to Turkana (Kenya National Archives). Despite this, according to Boye and Kaarhus (2011), in the 1940's Turkana were brought to Isiolo by Somali to work as servants, workers, and herders, and even were brought by the district commission to work on road construction. In Burat, after Kenya's independence many Turkana moved into the area that was previously the Livestock Marketing Division (LMD).

Turkana are traditionally nomadic pastoralists and have one of the highest number of livestock in the country (Watson and van Binsbergen 2008). Turkana livestock can consist of goats, sheep, cattle, donkeys and camels. Pastoralism has existed in Turkana for about 9000 years (Blench 2000), however a rapid serious of external developments in the past two centuries have severely compromised long-distance opportunistic movement of livestock (Watson and van Binsbergen 2008). In a study by Watson and van Binsbergen (2008), drought was identified as the principle constraint to livestock-based livelihoods of Turkana. Turkana homesteads can move up to 15 times per year with satellite herds moving more frequently, largely in response to environmental stressors such as drought (McCabe 1985). While many Turkana still rely on livestock herding for their livelihood, some have incorporated agriculture into their livelihood strategies. Many Turkana living in Burat and Isiolo today practice pastoralism along with farming, casual labor, or small business.

Meru

The Meru are another prominent ethnic group in Isiolo and the only group that traditionally practices agriculture. Meru County lies just to the southeast of Isiolo County and the county borders are very near to Isiolo Town and Kinna. Meru are traditionally small-scale farmers in the Nyambene hills and north and eastern slopes of Mount Kenya, just southeast of Isiolo. However, Meru started moving to Isiolo because there was not enough inheritable land for all the children to continue farming there (Boye and Kaarhus 2011; Bilali 2013). The Meru are closely related to the Kikuyu, Kamba, and Embu ethnic groups (Bilali 2013). The Meru are a Bantu speaking ethnic group with oral traditions pointing to a Shungwaya origin, an area north of the Tana River near the coast (Munro 1967). According to Lambert (1950) the Meru did not come to the highlands of Kenya until around 1750. Fadiman (1973) wrote that by the 1730s and 1750s small bands of pre-Meru migrants began to colonize the lowest portions of Mount Kenya and Nyambeni forests. Meru are said to have originally migrated from a place called Mbwa, somewhere to the east of the Tana River (Holiday 1942). Traditionally, Meru were organized into a complex system of age grades, which provided a group of warriors responsible for defense and a group of elders who had administrative power (Holiday 1942). This group of elders is called a Kiama, and the decisions made by these elders traditionally carried the weight of law (Sobania 2003). Before the colonial era, the ethnic group of Meru comprised five sections including the Igembe, Tigania, Imenti, Miutini, and Igoji (Fadiman 1973). However, today there are nine sections after the British administrators also included the Tharaka, Mwimbi, Muthambi, and Chuka (Fadiman 1973).

When Europeans began moving into Meru territory in 1900, they drove Meru off their farms through physical violence (Sobania 2003). Meru land was highly agriculturally productive and thus coveted by European settlers. In 1930, the boundaries ambiguously drawn between Isiolo and Meru Districts by the colonial authorities had 'mistakenly' been drawn so that Isiolo Town was just outside Isiolo District and instead in Meru District (Hjort 1979). This is still claimed to this day as evidence that Meru can claim rights to land and resources in Isiolo Town. During the *shifta* war, many Borana and Somali left Isiolo Town, and the Meru then were able to establish themselves in the trading business (Hjort 1979). As one Borana elder stated "Meru people were not Isiolo residents at all. It was during *shifta* that they took advantage and settled on our land, they were allocated part of Isiolo Town by the Kenyatta government" (Boye and Kaarhus 2011). The Meru were used to individual titles and rights to land in Meru District, and brought the same mentality to Isiolo, where they started owning land in Isiolo Town (Boye and Kaarhus 2011).

In Isiolo Town today, Meru have increasingly dominated the large-scale and long-distance trade (Boye and Kaarhus 2011). Meru also farm in Isiolo County and the Meru in Kinna and Burat are largely farmers and small-business owners (personal observation). Meru are largely Methodist and the Kenya Methodist University is near Meru Town (Sobania 2003). Meru were involved in recent conflicts in October of 2015 over claims to Isiolo Town (Abdille and Abdi 2016).

Somali

The Somali are another prominent pastoral group in Isiolo. While the date of Somali arrival in the Horn of Africa is not known, the first mention of a Somali clan dates all the way back to the 13th century (Castagno 1964). However, the term Somali did not appear in written documents until the 15th century (Castagno 1964). The Somali have six clan-families, and it is the Isaw who migrated south into Kenya (Turton 1974). The Somali language is in the Cushitic group of languages (Spencer 1973).

The majority of Kenyan Somali were pastoralists who migrated south after 1860 (Turton 1972). In 1900, Somali were already prominent in Isiolo and made up 19% of the population (Castagno 1964). Somali achieved limited non-native status in 1919 through the Somali Exemption Ordinance, which allowed them to pay non-native tax and permitted them to be classified as non-natives in all future ordinances (Turton 1974). This only lasted until 1936 however. By 1927 the largest concentrations of Somali in Kenya were in Nairobi and Isiolo. Indeed, Hjort (1979) argues that part of the motives for establishing Isiolo Town in 1929 were to create a place for the British to settle Somali ex-soldiers. Some Somali claim that during colonial times Somali were the sole owners of the central part of Isiolo District, and it was Somali who brought Turkana to Isiolo to work from them (Boye and Kaarhus 2011). In 1948, Isiolo was home to a branch of the Somali Youth League (SYL), but this did not last more than a few months (Kenya National Archives). The SYL was a political party that began in Mogadishu in 1943 with the aim of uniting all Somalis of East Africa within an independent Somalia (Castagno 1964). During 1948, the activities of the SYL threated to bring the colonial administration of the Somali areas to a complete standstill (Turton 1972). However, after the SYL quieted down towards the end of 1948, the Somali resistance was fairly non-existent until independence (Turton 1972).

As seen throughout Somali history in Kenya, Somali had a distrust in the colonial government and the colonial government simply aimed to maintain order and peace in the area (Branch 2011). The British government generally regarded the Somali pastoralists as resisters and by 1919, the pastoral Somali had been largely disarmed and 'pacified' (Turton 1972). At independence Somali accounted for a mere 1% of the Kenyan population, but they inhabited a fifth of Kenya's total land (Branch 2011).

After independence, as discussed above, the Somali were heavily involved in the *shifta* war in Isiolo, when many Somali left Isiolo and moved their herds across the border to Somalia (Boye and Kaarhus 2011). After the *shifta* war ended in 1969, many Somali brought their livestock back from Somalia, Wajir, and Garissa and took control over land that had been left empty as a result of the Borana herds being destroyed during the war (Dahl 1979; Hogg 1983). Somali also settled around Kinna around 1970 after asking the Borana for land because their land to the north was ravaged by drought (Boye and Kaarhus 2011). This same story appears to have been repeated during the 1984 drought, where drought pushed Somali from Garissa into Borana territory in Isiolo, leading to conflict (Schlee 2007). Somali have remained in Borana grazing territory and this has led to several conflicts between the Somali and Borana including conflicts between 1992 and 1995, and from 1997 and 2002 (Boye and Kaarhus 2011). The 1997 to 2002 conflict was largely caused by the drought of 1997, which was followed by severe El Nino floods in 1998, both of which decimated Somali livestock populations (Schlee 2007).

Today, alongside the Meru, Somali heavily dominate business and trade in Isiolo Town (Boye and Kaarhus 2011). Somali traditionally have been averse to farming, but there is evidence that Somali may cultivate crops in hard times (Hogg 1986). In Burat, many Somali cultivate crops and are even involved in tree planting activities. In the Kinna area, heavily armed Somali have been accused of organized wildlife poaching (Khalif and Oba 2013). Most Somali in Isiolo today are Muslim.

Samburu

While not as numerous in current day Isiolo, the Samburu have played an important role in the history of Isiolo. Present day Samburu County is located to the northwest of Isiolo County. Samburu are traditionally semi-nomadic pastoralists closely related to the Maasai (Holtzman 2004). The Samburu language is classified as Nilotic, similar to the Maasai (Fratkin 1996). The social organization of Samburu is characterized by an age-set system and polygamy. There is a period of 7 to 14 years following initiation where young men live as bachelor-warriors distancing themselves from others (Holtzman 2004). Samburu society is also traditionally a gerontocracy in which power rests with the older men, and men under thirty may not marry or assert personal independence (Spencer 1973). The Samburu mainly keep cattle and small stock

(Fratkin 1996). Milk is the major food source of Samburu, which is collected by women (Spencer 1965; Holtzman 2003). Women's role in Samburu society is largely the provisioning of food and cooking (Holtzman 2003). Samburu live in areas of Kenya plentiful with wildlife and there are Samburu traditions about conserving elephants (Kuriyan 2002).

Samburu claim to be the original inhabitants of Isiolo during the pre-colonial area, however after the establishment of Isiolo Town they were pushed west and north out of Isiolo Town (Boye and Kaarhus 2011). However, the legacy of Samburu in Isiolo is still visible as many place names are in the Samburu language (Boye and Kaarhus 2011). Contact between Samburu and Europeans really began in the beginning of the 20th century, with a permanent administrative presence in Samburu District established in the 1920's (Holtzman 2004). The colonial government imposed restrictions on spear ownership by the Samburu in the 1930's (Holtzman 2004). Despite this, Samburu were involved in the Mau Mau conflict, fighting on the side of the British against the Kikuyu Mau Mau. Holtzman (2004) writes that the Samburu warriors were issued spears by the British with a license to kill Mau Mau fighters. To this day, conflict between Samburu and Kikuyu still exists (Holtzman 2004). Since World War II, a large number of Samburu have been involved in Kenyan police and military forces (Holtzman 2004). However, there was some contention between the British administration and the Samburu. Until British land policies were abandoned in 1961, there was contention about grazing control and trespass (Spencer 1973). Such contention came partly because for Samburu there is no explicit ownership of land and in theory every herder has the right to live where they choose, however certain clans may be associated with certain areas (Spencer 1965).

Samburu are traditionally pastoralist, but today many practice cultivation in Burat. In Isiolo, the Samburu, similarly to the Turkana, feel as if they have been victims of historical marginalization and injustices (Boye and Kaarhus 2011). According to Holtzman (2003) the Samburu generally see themselves in a struggle to maintain their identity, culture, and way of life. Samburu are also in conflict with their Turkana neighbors and there have been clashes over land both historically (Spencer 1965) and in recent years.

Contested claims over land

Land is a highly contested issue in Isiolo, Kenya; the five major ethnicities all claim some type of ownership of land and/or use rights of natural resources in Isiolo (Table 3.1; Boye and Kaarhus 2011). In 2005, Isiolo was the 4th most heterogeneous district in Kenya behind Mombasa, Marsabit, and Nairobi, and the largest ethnic group in Isiolo, the Borana, only make up 34.16% of the population (Kimenyi and Ndung'u 2005). These statistics are atypical, and most Kenyan counties are more ethnically homogenous than Isiolo. While there are many explanations for this, according to Kameri-Mbote and Kindiki (2008), it is the Kenya government's inability to manage conflicts that leads citizens to "congregate around their ethnic grouping as a source of security and guaranteed access to resources such as land (pg. 167)." Largely due to these contested claims over the land and ethnic diversity, Isiolo has a long history of ethnic clashes and resistance to both the colonial and independent government. The *shifta* war is the prime example of conflict between the people of Isiolo and the government.

Contested claims over land in Isiolo began pre-colonialism. However, the colonial government played a large role in ongoing conflicts over land. The colonial policies to create "native reserves' based on ethnicity (Boye and Kaarhus 2011) isolated ethnic groups into specific areas. For example, according to a member of the Samburu group, "the colonial government evicted us and put a line to separate us and the Borana" (Boye and Kaarhus 2011).

Table 3.1 Claims to land in Isiolo County by to ethnic group (adapted from Boye and Kaarhus 2011)

Ethnic group	Land claims and perceived rights to land	Sources of legitimation for claims
Borana	Rightful ownership of land in whole district Exclusive claims to grazing land and water points in the Waso area Rights to land management in the district	Pre-colonial occupancy of the area Customary rights confirmed by colonial government Colonial policy of tribal separation and confinement within defined boundaries Traditional Borana tenure rules governing land and resources Trust Land Act
Somali	Access and user rights to key resources (land, pasture, and water) Exclusive ownership rights in Isiolo Central Division (Isiolo Town)	Customary rights to negotiate access and use of resources Agreement between colonial government and ex-soldiers on land rights in Isiolo Central Division/ Isiolo Town Constitutional right of Kenyans to settle and own land anywhere in the country
Samburu	Rightful ownership of land with Borana in Isiolo Indigenous rights in Isiolo Central Division Access and user rights to key resources (land, pasture, and water)	Being the indigenous people of Isiolo during pre-colonial times Samburu place names in the county, indicating the Samburu were the original inhabitants
Turkana	Rightful claims to land and to settle and keep herds in parts of Isiolo County	Presence in the county since early colonial times Constitutional right of Kenyans to settle and own land anywhere in the country
Meru	Rightful ownership to part of Isiolo Central Division/ Isiolo Town Individual titles to land in Isiolo Town	Colonial district boundaries Land allocation by post-colonial government Constitutional right of Kenyans to settle and own land anywhere in the country Registered Land Act

The colonial administration separated ethnic groups in order to eliminate interethnic raiding and warfare (Larick 1986). By providing pastoralists specifically with fixed and secure homelands and grazing area, the colonial government hoped that the institution of warrior-hood and raiding would become irrelevant (Larick 1986). However, even today, more than 50 years after independence, warrior-hood and raiding are still thriving in parts of Kenya. Instead, by reinforcing ethnic identities, the colonial government seems to have exacerbated tensions between ethnic groups.

However, it is important to note that not all conflicts in Isiolo are ethnic or politically related. For example, water scarcity and irrigation can cause conflict. In the north Ewaso Ng'iro River basin, the government has been forced to regulate or ban irrigation activities during drought in order to provide water for household use to downstream users (Ngigi et al. 2015). Police forces have even been brought in to enforce the ban, destroying all irrigation intake structures they came across (Ngigi et al. 2015). During dry periods, when rivers dry out, there can be conflict between farmers who use irrigation and pastoralists who rely on the same rivers to water their livestock. I personally observed this in Burat on the Aye Nakore River during June 2015 when it was necessary to hold meetings between farmers and pastoralists to sort out issues over access and use of water.

According to Menkhaus (2005), present-day Isiolo is "a fault line area where a number of major ethnic groups share uneasy and shifting boundaries…where competition over seats in parliament is acute – one of the most unstable areas of northern Kenya." In Isiolo, conflict is not only over pasture and water, but also resources associated with urban life and politics (Schlee 2007). Tensions have only increased in the past few years as the area has been transformed into a commercial hub. Isiolo will only continue to develop as a focus for Kenya's Vision 2030, with the goal of bringing development to Isiolo County through high profile projects. For example, Isiolo's airstrip is being turned into an international airport, and there are plans to turn an area near Isiolo into a resort city, which has led to much competition over land near the proposed resort city site (Carrier and Kochore 2014). Already, 6,500 acres of land have been set aside for the resort city and a large dam is under construction on the Ewaso Ng'iro River to support the area (Abdille and Abdi 2016). Isiolo also straddles the recently paved Pan-Africa highway that links the horn of Africa to central Kenya and beyond (Abdille and Abdi 2016). These development projects are only exacerbating current tensions and conflict as ethnic groups vie over political power, which then would equate to power over valuable resources and infrastructure (Abdille and Abdi 2016).

The ethnic conflict that took place in Burat before the last election in 2013 is discussed in detail in Chapter 7, however some warn that the 2017 elections could also lead to violence in Isiolo (Abdille and Abdi 2016). The most recent violent ethnic conflict took place in October 2015, between aligned Somali and Borana herders and Meru farmers. Six people were killed along the disputed county border between Isiolo and Meru Counties, which ignited riots in Isiolo Town a few days later following the murder of a motorbike taxi driver in Isiolo Town (Abdille and Abdi 2016). Somali and Borana then looted Meru shops and blocked the road until the 78th Tank Batallion was deployed to restore the peace (Abdille and Abdi 2016). It is because of these ongoing struggles over land and political control that Abdille and Abdi (2016) predict that Isiolo may be one of the most at risk Kenyan counties for violence before and during the 2017 election.

These struggles over politics, rights, and access to land have shaped the insecurity in Isiolo, people's lives, as well as their livelihood opportunities. In Burat and Kinna virtually no one has legal titles to the land, as these areas are still held as trust land. However, the attitudes towards land tenure differed. In Kinna, when asked about land tenure, most respondents seemed fairly confident and secure in their land tenure. Despite not having official titles, respondents spoke as if their farms belonged to them. This secure attitude may be due to the more homogenous ethnic make-up of Kinna, which is predominantly Borana. However, in Burat, land tenure was such a sensitive topic that we avoided it in our household survey. Burat is ethnically diverse and desired territory as one of the only arable areas near Isiolo Town. Residents of Burat have faced ethnic conflict, but also conflict with the neighboring Kenya Army base on the north side of Burat Ward. According to residents, the Kenya Army has threatened to take their land, and has even cut trees and destroyed crops along Isiolo River in order to build a ‘road’. During the time of research, titling was occurring in Isiolo Town, with Burat to follow. This will hopefully lead to more secure land tenure in Burat. However, during field research most people who spoke to us about land tenure security seemed to feel uneasy and unsure about their land tenure security due to both ethnic conflict and conflict with the Kenya Army over the land in the area.

Ecology of Isiolo

In this section I will briefly discuss the ecology of Isiolo with a focus on rainfall and wildlife conservation. This is important because the viability of agriculture and agroforestry in Isiolo is connected to its ecological characteristics. Rainfall amounts and seasonal variability are particularly important for agricultural production. During this research, participants were asked about rainfall, drought, floods, and the ecological benefits they receive from their agroforestry practices. Participants also discussed wildlife disturbance in their communities and on their farms. Therefore, it is important to not only understand the economic, political, and historical context of this research, but the ecological context as well.

Rainfall in Isiolo

Livelihoods in Isiolo County center on livestock keeping and agriculture. These livelihoods are highly dependent on rainfall and overall water availability. Therefore, rainfall amount and seasonal variability were an important aspect of this research. Both Kinna and Burat are located in semi-arid agro-climatic zones as the median annual rainfall is in the range of 400 to 600 mm (Mati et al. 2005). Rainfall is bimodal with the short rains from October to December and long rains from March to May. Farmers in Isiolo County who practice rain-fed agriculture aim to plant their crops on the onset of the short rains. According to Funk et al. (2010), since the 1970s the long rains have declined by more than 100 millimeters and there has been a warming of more than 1°C. River levels in Isiolo County are also on the decline. Isiolo River, in Burat, flows into the larger Ewaso Ng'iro and at the Archer's Post River Gauging Station the river has declined from 4.5 cubic meters per second in the 1970's to 0.5 cubic meters per second recorded in 2000 (Kariuki 2010). Water scarcity and recurrent drought are major constraints to development in Isiolo County (Mati et al. 2005).

In order to fully understand how the climate is changing in Isiolo, I gathered rainfall records from both the Kenya National Archives and the Isiolo Agricultural Office. These records are for Isiolo Town, which means they are most likely accurately reflect the rain levels in Burat, only 3 km outside of town. However, rainfall data for Kinna was unavailable. Rainfall in Kinna may be somewhat different than Isiolo Town since it lies on the opposite site of the Nyambene Mountain Range. In combination, this data spans from 1930 until 2014 (with 13 years missing from 1960 to 1973, and 1982), and is presented in Figures 3.3 and 3.4 (rainfall data). An important point to note is that of all the years with recorded rainfall, 2014, when data collection for this dissertation began, was the lowest recorded rainfall on record with a mere

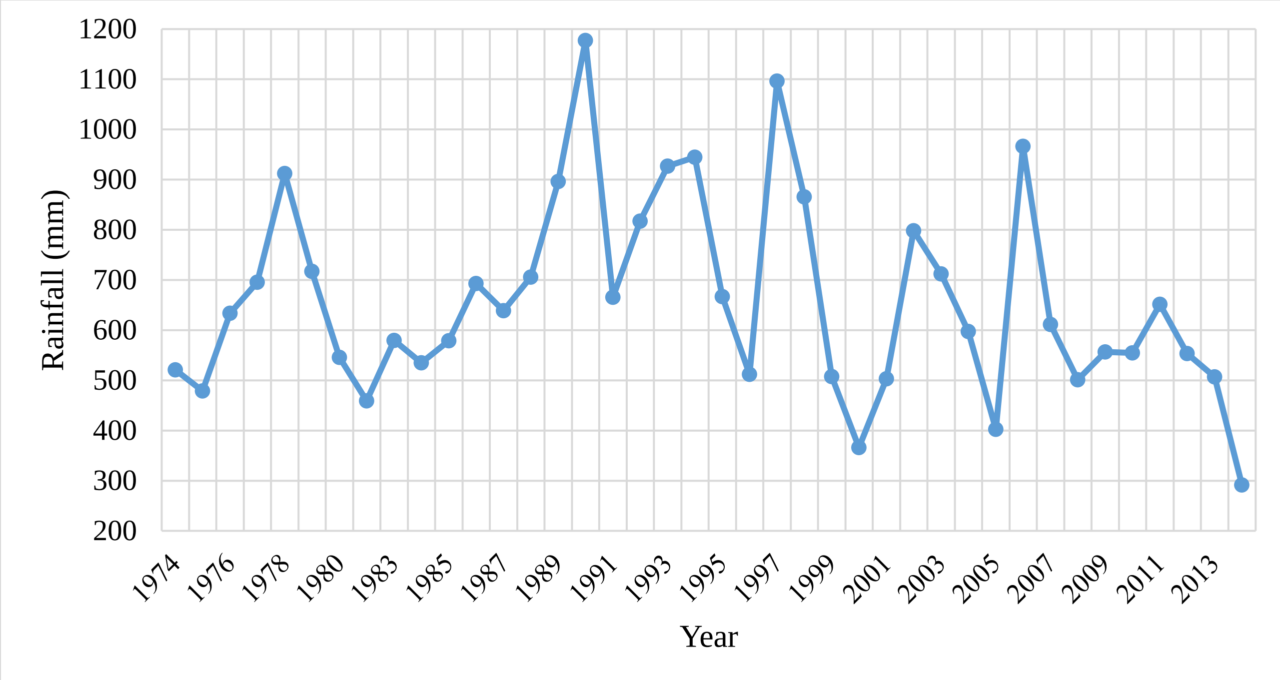


Figure 3.3 Rainfall in Isiolo from 1974 to 2014 from the Isiolo Agriculture Office records. Note that 1984 is missing.

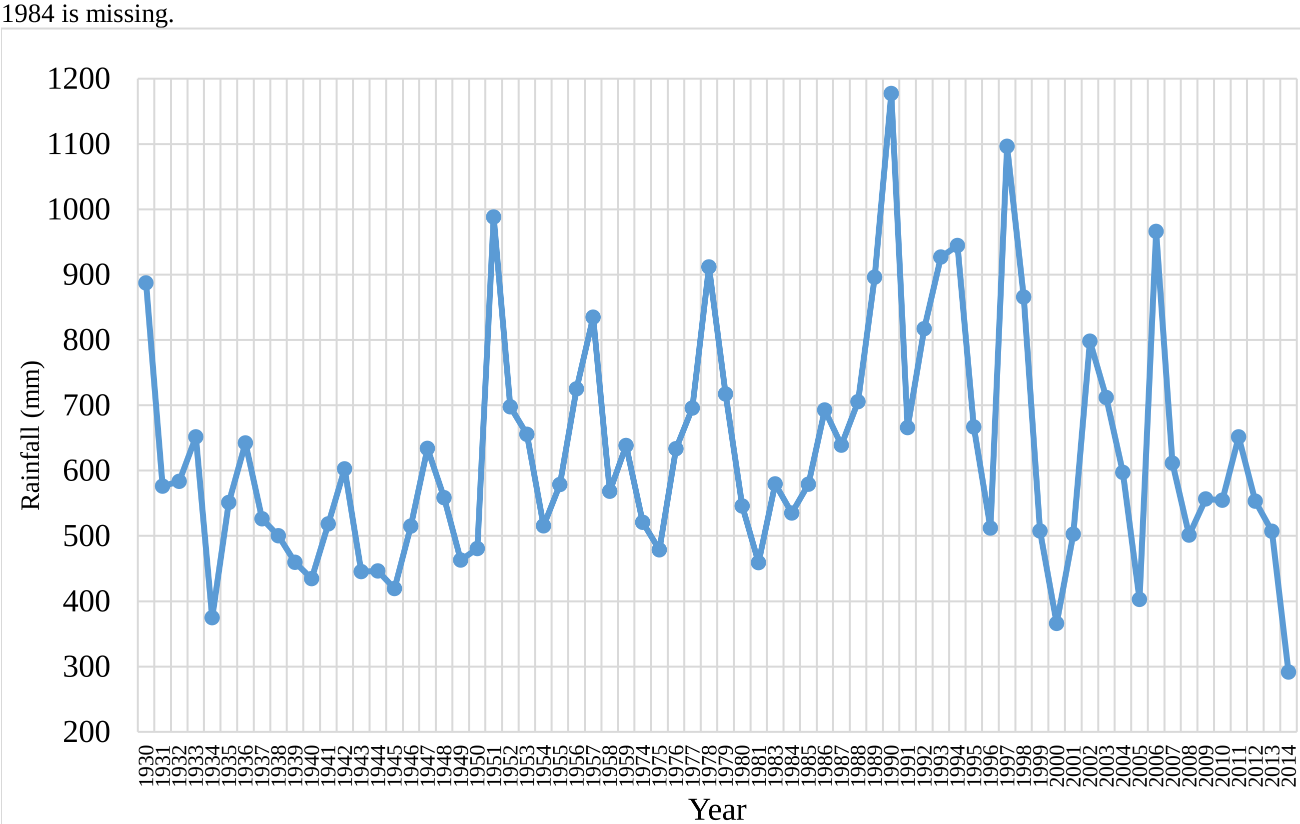


Figure 3.4 Rainfall in Isiolo from 1930 to 2014**.** From 1930 to 1959 is from the Kenya National Archives records of rainfall, while 1974 to 2014 is from the Isiolo Agriculture Office. There is a 15 year gap in data between the two records, from 1959 to 1974.

291.5 mm. However, it is difficult to see rainfall trends in Figure 3.4 particularly and the reliability of archival rain records may be questioned. In contrast, the data recorded by the Isiolo Agricultural Office was incredibly detailed and they had recorded daily rainfall amounts. Figure 3.3 is continuous data and the trend line illustrates that rainfall has decreased in Isiolo since 1974. Decreasing rainfall in Isiolo is a serious issue facing farmers and only adds to the importance of the research questions. Exploring how farmers can build livelihood resilience to decreased rainfall is important.

Due to the importance of water from local rivers for irrigated agriculture in Burat and Kinna, I also wanted to understand how the river levels were changing. As Kariuki (2010) found, the river level in the Ewaso Ng'iro is declining, but is this true in the study areas? Unfortunately, no data was available for Kinna, however there was sporadic river gauge data for the Isiolo River in Burat. Figure 3.5 presents this data from 1976 until 2012 from the Water Resources Management Authority office in Isiolo Town. The reliability of this data is questionable however because it was very sporadically recorded, with some years having the level recorded every day while years at a time were missing. However, if it is assumed that the data which was recorded is fairly accurate, it shows a significant decline in the Isiolo River. If

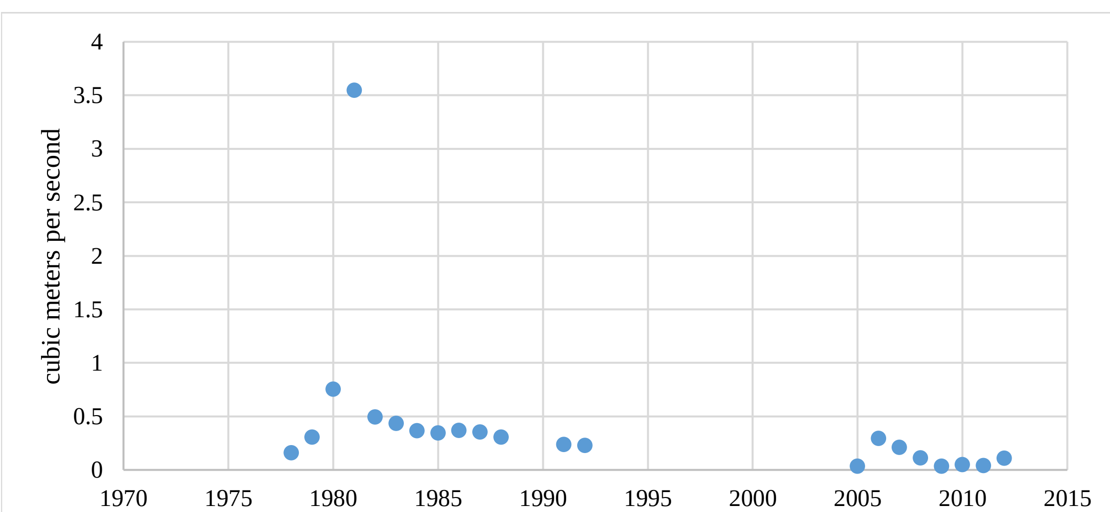


Figure 3.5 Average yearly discharge for Isiolo River.

this trend continues this will have serious consequences for farmers who rely on the Isiolo River. They may have no other choice but to use less water for irrigation in the future.

Wildlife and reserves

Chapter 8 in this dissertation focuses specifically on the impact of wildlife crop raiding on agriculture and the role of agroforestry when other crops are destroyed. Thus, this brief section provides an introduction to wildlife conservation in Kenya, while more specific information about wildlife conservation near Burat and Kinna is found in Chapter 8.

Kenya is world renowned for its rich wildlife and in 2006, wildlife made up 70% of gross tourism earnings in Kenya (Ministry of Tourism and Wildlife 2007). Kenya has 54 national parks and reserves (Owino et al. 2012) with 8% of the land area in national parks (Omondi et al. 2004). However, since the mid- 1970's human encroachment by farming communities in the less agriculturally productive, semi-arid rangelands has increased significantly (Mwale 2000; Okello and Kiringe 2004). Arid and semi-arid areas make up 87% of Kenya's total land area (Pratt and Gwynne 1977), supports 25% of the human population and 90% of the country's wildlife (Maalim 2001; Otuoma 2004). In these areas, vegetation and water are critical natural resources for both people and wildlife, and there can be competition for scarce resources (Herlocker 1999; Otuoma 2004).

Isiolo County is rich in wildlife and contains a variety of protected areas, from national parks to community conservancies. In fact, Laikipia, Samburu, and Isiolo Counties host the largest population of elephants outside of protected areas (Gadd 2005). While the elephants use protected areas as core habitat areas, they utilize the unprotected rangeland to migrate between core areas (Douglas-Hamilton et al. 2005) and elephant population numbers have been on the rise since 1989 (King et al. 2011). Within Burat Ward is the Nasuulu Community Wildlife Conservancy and Leparua Community Conservancy. Directly to the south lies Lewa Downs Wildlife Conservancy and Il Ngwesi Community Trust. Approximately 15km to the north are the internationally renowned Buffalo Springs and Samburu National Reserves. Lewa Downs Wildlife Conservancy is a 40,000 acre ranch privately owned by the Craig family, a white settler family who originally used the land as a cattle ranch.

Kinna Town borders Meru National Park and Bisanadi National Reserve to the south. Meru National Park covers an area of 870 km^2 (Wasonga 2006) and was established in 1966 (Sitienei et al. 2014). These protected areas are part of the larger Meru Conservation Area which also includes Kora National Park, Mwingi National Reserve, and Rahole National Reserve (Wasonga et al. 2006). Meru Conservation Area makes up the second largest protected area in Kenya after Tsavo National Park (Otuoma 2004).

Conclusions

This chapter has covered a wide variety of topics including historical and political context, ethnicity in Isiolo, land tenure, and ecology. Chapters 5 through 8 draw from the information provided in this chapter. Understanding context is critically important to issues surrounding livelihood resilience. Appendix D contains a summary of research field notes and photos and provides further context of the research areas when this research was conducted.

CHAPTER 4. RESEARCH METHODS

Introduction

Summary of research methods

Table 4.1 Data Summary. The phases were not necessarily conducted in sequential order, as many were simultaneous.

Research Phase	Timeline	Summary		
Phase 1: In-Depth Household Case Studies	First interview: Aug – Sept, 2014 Dry season interviews: Sept – Oct, 2014 Wet season interviews: Nov – Dec 2014	Kinna 7 households	Burat 13 households	Total 20 households
Phase 2: Household Survey	March – May 2015	Kinna 152	Burat 187	Total 339
Phase 3: Key Informant Interviews	March – July 2015	- Kinna Water Committees (Chairs of all three committees) - Burat Water Committee Member - Burat Farmer - LMD (Burat) Water Project Chair		
Phase 4: Environmental Data Collection	March – July 2015	- Rain gauge data for Isiolo was obtained from the Isiolo County Agriculture Office - River gauge data for Isiolo River was obtained from the Water Resources Management Authority Office in Isiolo.		
Phase 5: Participant Observation and Field Notes	July 2014 – July 2015	- detailed field journal was kept - observations were recorded at the end of each day of field work		
Phase 6: Archival Records	March – September 2014	- obtained archival records from the Kenya National Archives		

Table 4.1 provides a summary of the data that was collected for this research using a mixed methods approach. Mixed methods is a type of research where the researcher combines quantitative and qualitative research techniques into a single study where the different methods

share the same research questions (Yin 2014). According to Yin (2014), mixed methods allows researchers "to address more complicated research questions and collect a richer and stronger array of evidence than can be accomplished by any single method alone (pg. 66)." Both qualitative and quantitative data were collected, as well as ecological data. The combination of different sources and types of data helped to increase the general understanding of the research questions through iterative triangulation. Iterative triangulation is a theory development process that takes place by using the evidence (household case studies, surveys, ecological data), the existing scholarly literature, and intuition to compare and contrast emerging constructs, ideas, and theories (Lewis 1998). This chapter will go through each phase of the research and discuss data collection and data analysis techniques that were utilized. Please note that the research phases are not necessarily in chronological order.

Before discussing the details of the study, there are overarching aspects of the research that need mentioning. Most importantly, all respondents and interviewees that participated in this study were the household heads for a household that practiced agriculture. Households that did not practice agriculture of any kind were excluded because their livelihood system was outside of the scope of the research questions. However, households that both did and did not practice agroforestry were included. The households without agroforestry could be considered the 'control' households and provided a way to compare and contrast households with and without agroforestry. Comparing households with agroforestry to those without provided an idea of what additional or added benefits agroforestry contributed above and beyond just practicing agriculture. However, agriculture was not necessarily the only or main household livelihood activity and many households also kept livestock, had small businesses, or relied on remittances as their main source of income.

There is no standardized method for measuring agroforestry. Therefore, in this research agroforestry was measured using four different techniques or standards. Using four different standards helped to build a greater body of evidence linking agroforestry with livelihood resilience. First, as mentioned above, agroforestry was measured with a very basic yes or no dichotomy between households who have planted any trees and those with none. However, having only one tree is very different from having 100 and therefore the second way that agroforestry was measured was by asking households to estimate the number of trees that they have on their property. This is important because it can be assumed that the greater number of trees a household has the greater benefits they are receiving from their trees. Third, agroforestry was measured by tree diversity, or the number of different tree species a household has planted. This is important because different tree species are unique ecologically and can provide different benefits to households. Lastly, tree density was also used to measure resilience. Tree density was determined based on the number of trees a household was estimated to have divided by the number of acres. This helped normalize households with many acres and those with smaller farms.

In this research a single household was defined as a group of people who eat from a common pot, share a dwelling, may cultivate the same land, and recognize the authority of one person (Kajembe et al. 2005). This definition helped guide household selection and sampling. The definition of what qualifies as a tree was also important when discussing agroforestry with research participants. According to the Oxford English Dictionary (2016), a tree is defined as a woody perennial plant. This definition was expanded to include other tree-like plants such as bananas and papayas, which are not technically trees, because research participants tended to consider bananas and papaya plants as trees, so they were included as agroforestry trees.

Case studies

Data collection took place in the communities of Burat and Kinna in Isiolo County, Kenya. This research had a multi-case study design, with each community as a separate case study (Figure 4.1). Case studies are a method of empirical inquiry that investigates a research question in-depth and within its real-world context (Yin 2014). Two case studies were chosen for this study because evidence from multiple case studies is often considered more compelling and the study more robust than a single case study, depending on the research questions (Yin 2014). If results from both communities support the hypothesis that agroforestry does in fact increase livelihood resilience to shocks and disturbances, it makes a more compelling case. Here, the same methods were used in each case study location to provide for accurate

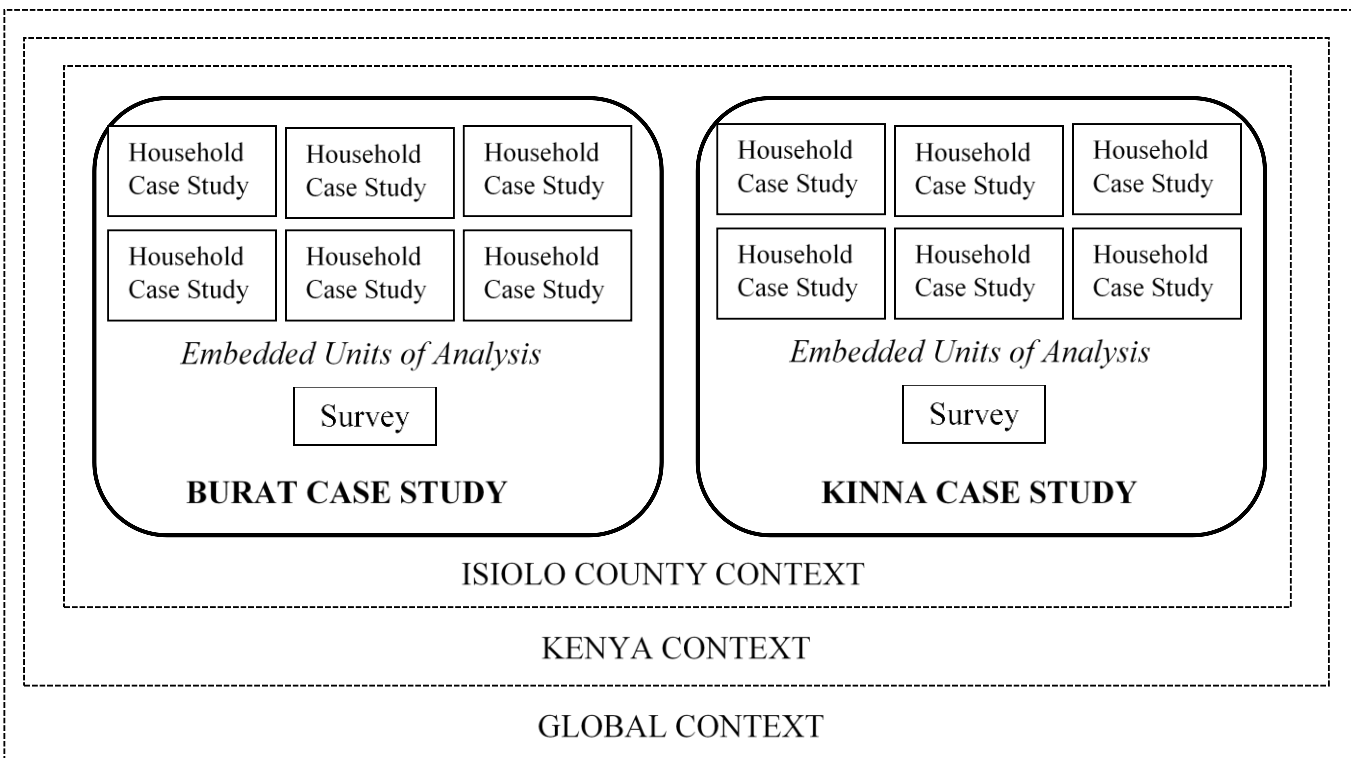


Figure 4.1 Conceptualizing the research design. The number of household case studies illustrated here is not accurate but serves to help visual the research design.

comparisons. Only two case study sites were chosen, and not more, because of limitations in time and financial resources.

The case studies of Burat and Kinna are considered within the larger contexts of Isiolo County and Kenya, as well as the global context of environmental and social change. Within each case study are embedded units of analysis. Embedded units can add opportunities for extensive analysis within the case studies (Yin 2014). Each household case study was considered an embedded unit of analysis, and was analyzed both separately and compared with other household case studies, and survey results. They were called household case studies for convenience during field work, but in the overall research design are really embedded units within a case study. The survey data is also an embedded unit of analysis and provides descriptive information about the case study, comparisons with the household case studies for the same case, and comparisons with the survey data from the other case.

Site selection

The study sites were selected because of my personal experience in the area, the logistical and financial support available, and their suitability to answer the research questions. First, I had previously spent time in both Kenya and Tanzania. This means that I, as a researcher, already had an understanding of cultural norms, issues of gender, the slower pace of life, and rural livelihood systems, as well as advanced Swahili language skills. I had conducted my Master's Thesis research in Tanzania, and thus had practice conducting interviews in a similar setting. Second, in 2013 I worked as a Junior Researcher for the Red Cross/ Red Crescent Climate Centre conducting a climate-smart, ecosystem-friendly livelihoods assessment in 7 communities in Isiolo County, Kenya. During the three months of the livelihoods assessment I became familiar with the various parts of Isiolo County, the ecological problems, and the common livelihood activities. Burat and Kinna were two of the seven communities and during the livelihoods assessment I gathered data in both communities about perceptions of drought and flood, and what community members see as the future of their livelihoods. I also formed a good relationship with the Kenya Red Cross Society – Isiolo Branch Office (KRCS) and KRCS volunteers.

All of this past experience helped me gain entry and access (physically, socially, and culturally) to the study sights. This is critically important to any research project and as DeWalt and DeWalt (2011) explain "gaining entry to a field site and beginning the process of building rapport can be a daunting experience for researchers (p. 41)." Bernard (2011) provides several rules for site selection including using personal contacts to make your entry to a field site, and spending time getting to know the physical and social layout of the field site. During my first trip to Isiolo County I got a sense of what the field sites were like, and then utilized the KRCS to work in these two communities. The KRCS has a great reputation in both Kinna and Burat, where they have conducted development projects such as irrigation and drinking water access, as well as disaster response and provided humanitarian assistance for internally displaced peoples from Burat. This reputation carried over to our research and research participants were generally more than happy to talk to the KRCS volunteers who worked as field assistants and enumerators. Additional logistical support came from the World Agroforestry Centre, based in Nairobi, Kenya. I was able to attain funding for this research from the US Borlaug Fellows in Global Food Security Graduate Research Grant. A requirement of this grant was to have a mentor at an international agricultural research centre. Dr. Henry Neufeldt, Head of the Climate Change Research Unit at the World Agroforestry Centre, not only agreed to serve as my mentor but gave me a Research Fellowship with the World Agroforestry Centre. The World Agroforestry Centre also played a critical role in obtaining visas and the proper paperwork.

Along side the logistical reasons, Burat and Kinna in Isiolo County, Kenya were good field sites for answering the research questions. Kenya provides an excellent opportunity because agricultural production is projected to be severely compromised by climate change, and in the past 30 years the number of food-insecure people in Sub-Saharan Africa has more than doubled (Garrity et al. 2010). The long rains in central Kenya (where Isiolo is located) have declined more than 100 millimetres since the 1970s and there has been a warming of more than 1°C (Funk et al. 2010). Thus, the impacts of drought specifically are very real and will have a large impact on the predominantly natural resource-based livelihood activities in Kenya and Isiolo County. The major ethnicities represented in Isiolo County are almost all traditionally pastoral, and began farming within the past 50 years. However, most households started farming much more recently than this even. This makes Isiolo County interesting because farmers are still in the process of adopting agriculture. Agroforestry is also newer to the area, and it is not the major livelihood or source of income for most farmers in Isiolo County. This provides the opportunity to explore how agroforestry as a supplementary livelihood activity could play a more important, or critical role during shocks or disturbances in semi-arid regions. The fact that agroforestry is a newer livelihood activitiy highlights how farmers are learning and adapting to a changing environment.

Kinna and Burat specifically were chosen because of their diversity and differences, the presence of agriculture, and ease of access. As explained in the study area section, these two communities are different ecologically, culturally, economically, and politically. This provides for a nice comparison and if these two, relatively different case studies show similar results it would provide a more compelling case for the findings of this research. Furthermore, of the seven communities that I visited originally in 2013, Burat and Kinna were the only with significant agricultural areas and agroforestry practices. The other communities were generally more reliant on livestock. Lastly, these two communities were easily accessible with public transportation from Isiolo County. In fact, parts of Burat are within walking distance from Isiolo Town, and I occasionally ran into research participants in town. Kinna was a 2 to 3 hour ride from Isiolo Town in a station wagon that made one trip daily.

Phase 1: In-Depth Household Case Studies

Household selection

Household selection combined convenience and respondent-driven sampling (Bernard 2011). We began by selecting convenient, easily accessible households, and then asked those respondents who they know who might also be willing and able to participate. Respondent-driven sampling is typically used for hard to reach populations (Bernard 2011), however in this study it was a useful method of participant selection because households in the area knew each other well and respondents were able to easily identify households that have significant agroforestry practices. While we aimed to interview both female and male household heads this was not always possible because some household members have employment outside of the farm and therefore were not around to be interviewed. However, if a household member has outside employment then they most probably do not participate significantly in daily farming activities. Additionally, in household selection we strove for a diversity of households practicing a diversity of agroforestry and agricultural practices. Many households in both Kinna and Burat area have at least planted a few trees; therefore we aimed for a diversity of households including those with many trees, a few trees, and no trees. Basically, instead of a simple agroforestry/no agroforestry dichotomy in the household case studies, it was more of a sliding scale from households with an abundance of trees to those with none. It was important to include some households without agroforestry in order to understand how those with agroforestry may cope differently than those without agroforestry when faced with floods, droughts, or other disturbances. Since most agriculture in both Kinna and Burat takes place along water ways the households were generally situated along rivers or canals. Each household that was selected was assigned a number for data collection purposes. Initially, 16 households in Burat and 11 households in Kinna were selected. However, a few households dropped out, refused to be interviewed during the second or third interview, seemed to be not very truthful in their responses, or moved over the course of the study. Therefore, the final number of households was a total of 20; 7 in Kinna and 13 in Burat. Regardless, this was still enough households to see trends in the participants' responses. According to Bernard (2011) there is growing evidence that 10-20 knowledgeable people are enough to uncover and understand the core categories in any study of lived experiences (Table 4.2). Overall, with those 20 household case studies a total of 83 interviews were conducted.

Table 4.2 Household Case Studies. M is male household head and F is female household head. The missing household case study numbers are the households that did not complete all three rounds of interviews, and were therefore dropped from the study.

Household Number	Description of Household (from field notes)	Initial Interview	Dry Season	Wet Season
Burat 2	Entrepreneurial, wealthier, long-time resident, plants significant timber trees, right along Isiolo River	M, F	M	M
Burat 3	Good amount of agroforestry, long-time resident, had to rebuilt their house after 2012 conflicts, diverse livelihoods including miraa and rabbit keeping, right along Isiolo River	M, F	M, F	M, F
Burat 4	Big papaya farm, the male household head sells miraa in town, farm mostly managed by female household head and her sons, right along Isiolo River	M, F	M, F	F
Burat 5	Mature timber trees, small kiosk to sell chai and maandazi, the Bidii Farmers Group uses their land for	M	M	M, F

	projects, located just at the bridge crossing Isiolo River, male household head is also part of Isiolo River water committee			
Burat 6	Single father, adult daughters that have their own part of the farm they work on, few trees, sell homebrewed alcohol, less well off than most households	M, F	M, F	F
Burat 7	Single grandmother runs the household, large farm but not enough labor to farm it all, she sells produce in Isiolo Town which she carries there herself every day, no agroforestry	F	F	F
Burat 10	Male household head is physically disabled. New to agriculture and agroforestry, but learning fast, large variety of vegetables planted as well as papaya and other trees, female household head appears very hard working, part of Kiitos Farmers Group, uses piped irrigation water	F	F	F
Burat 11	Turkana household, female and male household heads speak poor Swahili, children are largely in charge of farming, along Isiolo River, pastoralists, a few trees	M, F	M, F	M
Burat 12	Lots of trees planted and various other vegetable crops, along Isiolo River, have livestock that do not live at home, have their own tree nursery	M, F	M, F	F
Burat 13	Hardworking, lots of fruit trees planted, along Isiolo River, male household head is very talkative, appears to understand a lot about how trees improve his farm ecologically (compost, reduce evapotranspiration), have a tree nursery	M, F	M, F	M
Burat 14	No agroforestry, male household head is a pastor at a local church, young family, farm mostly cash crops such as tomatoes and onions, educated, farm with piped irrigation water from Aye Nakore River	F	F	F
Burat 15	Sub-village chief, very entrepreneurial, large variety of vegetable crops, some timber and fruit trees, has fish pond, modern dairy goat, beehives, farms with water from Aye Nakore River, only cement house in the area	M, F	M	M, F
Burat 16	Small farm, a few mature mango trees, used to own a shop but the male household head was shot in the leg by thieves, still limps a little, very talkative	M, F	M, F	M, F
Kinna 1	Small farm, a few fruit trees, depend on charcoal making, household is along main road between town and Meru National Park	F	M	F
Kinna 2	Single elderly mother, her two sons do most of the hard farming, she cooks and sells maandazi at the local primary school, large mango trees, along main road between town and Meru National Park	F	F	F
Kinna 4	Single, young, divorced mother with one young son, has many young trees/seedlings planted, house well kept, along fence with Meru National Park	F	F	F
Kinna 5	Large amount of trees, sugar cane, large farm, male household head was gored by a buffalo on his farm, limps somewhat, several water canals run through is property, at the intersection of the main road to town and the fence at Meru National Park, long-time resident	M, F	M	M
Kinna 6	Single, female headed household, widow, good number of fruit trees, house burned down a few years ago, canal runs through farm, located along the fence with Meru National	F	F	F

	Park, appears that the husband was entrepreneurial and planted trees, now she has a hard time finding enough labor to work her farm			
Kinna 8	Long-time resident, lots of trees planted, several banana species, miraa, located along fence with Meru National Park near the primary school, brother-in-law does a lot of the farm labor	M	M, F	M
Kinna 10	Entreprenurial, has large farm, lots of fruit and timber trees, fish farm, grows fodder to sell to those with livestock, diverse vegetable crops, tobacco, Borana male household head, Meru female household head, very talkative, close to Kinna Springs	M, F	M	M
Number of Interviews		31	28	24
TOTAL INTERVIEWS = 83				

Initial interview

The next stage was the initial interview, which was conducted at the same time as household selection. The goal of the initial interview was to capture household characteristics including demographics, wealth, livelihood practices, family history, land tenure, and agroforestry practices and crop species planted. This interview was based off of the IMPACTlight survey which was created by the CGIAR Research Program on Climate Change, Agriculture, and Food Security. IMPACTlight is a tool that provides a unifying framework for collecting detailed information on farm resources, farm management strategies, farm productivity, and household economics (Rufino et al. 2012). The IMPACTlight questions used were largely quantitative, and helps to compare and contrast the household case studies. Additionally, using the IMPACTlight survey the data can, in the future, be compared to the Climate Change, Agriculture, and Food Security 15 survey benchmark sites in East Africa, West Africa, and Indo-Gangetic Plains. This may be helpful in the future in broadening the study beyond this specific case study in Isiolo County. See Appendix A for the interview questions.

These interviews also served as an important trust-building exercise so that during later visits the interviewees felt comfortable answering in-depth, personal questions (Rubin and Rubin

2005). The same initial interview was conducted with both the female and male household heads, when possible, in order to corroborate their answers and analyze any differences in answers by genders. Lastly, both the female and male household heads mapped out their household land with an emphasis on the natural resources on their property, livelihoods, and agricultural and agroforestry practices. This information helped to classify land-use practices and specifically different types of agroforestry. The GPS coordinates of each household were also taken. The household selections and initial interviews were conducted in Burat first, followed by Kinna, during the month of September 2014. In Burat, the households were selected and the interviews were conducted with the assistance of research assistants Noor Hussein Noor and Tonny Mwiti. In Kinna, they were conducted with assistance of Abdi Kadir and Noor Hussein Noor. During this stage, a total of 31 interviews were conducted.

Dry and wet season interviews

The next phase focused on interviewing all selected households during both the dry season (August - October) and the wet season (November - December). It was important to conduct interviews in both the dry and wet seasons to capture real time experiences of how agroforestry may be building resilience to climatic and economic issues that arise during both seasons. For example, during the dry season, the challenges that the households face during droughts were most likely more prominent in their minds and memories, regardless if there is a current drought or not.

The dry and wet season interviews were in-depth, unstructured interviews, and the questions asked varied by household and between Burat and Kinna. While different for different households, Appendix A provides examples of both the dry and wet season interviews.

According to Bernard (2011) "unstructured interviews are best in situations when you have lots of time, for example when you are doing long term fieldwork and can interview people on separate occasions." Yin (2014) says that "prolonged case study interviews are interviews that may take place over two or more hours either in a single sitting or over an extended period of time covering multiple sittings." The main purpose of unstructured interviews was to capture what Bernard (2011) calls the 'lived experience' of humans. This is exactly what the research questions aimed to answer: the lived experience of how humans may utilize agroforestry to build livelihood resilience. Unstructured interviews also allow for a nuanced understanding of the research questions. Nuance is important, especially when trying to understand human experiences, because every household may have different experiences and nuance is about showing that things are "not always true or not true, and that they may be true in part, or true in circumstances or at some times" (Rubin and Rubin 2005). The unstructured interviews were based on a clear plan of 6 to 8 topics to be covered in each interview, but also left room for emerging topics that the interviewee may have wished to discuss and may be very relevant to the research questions. The goal was to be able to, over time, understand the livelihood system, what components or factors are critical to building resilience to climate change and economic instability, and what role agroforestry might play.

The dry season interviews took place during the months of September and October, 2014. In Kinna, they were conducted by Abdi Kadir and Noor Hussein Noor and in Burat by Noor Hussein Noor and Tonny Mwiti. In both Kinna and Burat the female household heads seemed to be less interested in being interviewed and several who had participated in the initial interview refused to be interviewed. They typically said that they were too busy, which very well could be true, or they did not want to be interviewed again. Interviews were conducted in

Kiswahili where possible, although a few of the interviews in Kinna were done with some use of the Borana language, which was translated by Abdi Kadir. In Burat, the interviews were conducted between September 17th and September 24th, 2014. Household 9 was left out of this interview because during phase 2 they did not seem to be answering truthfully and sought us out to be interviewed. In Kinna, the interviews were conducted on October 11th and 12th, 2014. Household 3 and household 7 were dropped from the study. Household 3 refused to be interviewed, using the excuse that she did not have the time, and household 7 had moved and was no longer on the same piece of land as before. The recordings for these interviews were transcribed with assistance from Philips SpeechExec Transcribe 7.1 software and a foot pedal. The interviews were transcribed verbatim in Kiswahili. During the dry season a total of 28 interviews were conducted and transcribed.

The wet season interviews were conducted in November and December 2014. The same protocol was used as with the dry season interviews as explained above. However, in Kinna household 11 and 9 were dropped from the study. Household 9 refused to participate again and based on the dry season interview answers household 11 was excluded because they did not seem to be providing honest, open answers during the interview. Household 1 in Burat was excluded from the wet season interviews for the same reason. For these interviews the same male and female household heads were interviewed at each household, if possible, and these interviews were conducted by myself and research assistants in Kiswahili. Interviews were voice recorded and later transcribed verbatim in Kiswahili with assistance from Philips SpeechExec Transcribe 7.1 software. During the wet season interviews a total of 24 interviews were conducted and transcribed.

Data analysis

The case study interviews were transcribed verbatim in Kiswahili and then the text was uploaded into QSR Nvivo 10 for coding. The coding process was done with the text still in Kiswahili to help maintain the original themes and ideas, which could be lost in translation. However, quotes were translated into English if they are were used in presenting examples of the data in written or oral reports, and in this dissertation.

Coding took place in a three step process. The first step was reading through all the interviews and creating the different codes and categories of codes as the reading was taking place. These larger-picture coding categories were based on the research questions and initial findings and included: agroforestry, conflict, drought, flood, historical narratives, institutions and organizations, livelihood capitals, and wildlife. Second, after the first read through of the interviews and initial coding I read through all the codes and categories and re-organized where necessary. All the quotes in all the codes were double checked to ensure that they were in the right place. Codes were reorganized based on emerging categories that came up during the coding process. The last step was to reread all of the interviews to make sure that the codes from the interviews were correct and in the right place. This step also helped make sure that the interviews were properly coded and there were not important quotes left out. The codes are provided in Appendix C. This three step process helped to ensure that the final codes were as thorough and accurate as possible, and inter-coder reliability was not an option because the interview transcripts were in Swahili.

An analytical write-up was conducted for each interview household which aimed to analyze and incorporate all of the findings from that household including the initial interview, dry and wet season interviews, and participatory mapping into one analytical summary document. This assisted with comparisons between households and cross-case comparisons between Isiolo and Kinna.

Informing the household survey

All of the household case study interviews were conducted before the household surveys and were critical in writing an informed survey instrument. Because there was little prior empirical work on how agroforestry may be building livelihood resilience, it was important to first conduct the household case studies in order to gain a basic understanding of this topic. The household case studies helped me and my research team form some ideas about the ways that agroforestry is building livelihood resilience, particularly in the context of floods and droughts. This helped us write appropriate, informed quantitative survey questions. It also helped ensure that we chose appropriate surrogates or indicators of resilience for the survey.

Phase 2: Household Survey

Household selection and generalizability

The purpose of this survey was to collect quantitative, representative data in order to make generalizations, build upon the household case study interview data, and triangulate the research findings. The survey tool was created based on the interviews in phase 1, with surrogates or indicators of resilience organized by livelihood capitals (physical, financial, social, natural, and human). The survey tool went through several iterations and feedback was given by the dissertation committee and Dr. Neufeldt at the World Agroforestry Centre. The survey was translated into Kiswahili with assistance from research assistants Noor Hussein and Tonny

Mwiti. Two practice surveys were conducted March 15, 2015 by the same research assistants, after which revisions were made. A second round of practice surveys were conducted by 6 enumerators on March 20th as part of their training and the survey was finalized after this second round of practice surveys based on enumerator feedback. The questions for the surveys were slightly different between Kinna and Burat. In Burat, we left out question about land tenure because that was, at the time of the survey, a very controversial, hot topic. This was due to ongoing land surveying and titling in Isiolo Town and we did not want the community to think that the research team has alternative motives. Additionally, in Burat there was an additional section focused on the violent conflict that took place in 2011-2012.

In both Burat and Kinna, Kenya Red Cross Volunteers were selected as enumerators for the surveys. Volunteers were selected based on their ability to perform surveys and walk long distances. Unfortunately, in both Kinna and Burat/Isiolo we were not able to have an even number of male and female enumerators because there were not enough female volunteers who were both able and willing to conduct the surveys. In Burat, the enumerators were a mix of ethnicities and ages, all of whom lived in Isiolo town. In Kinna, the enumerators were all Borana living in Kinna because of the necessity to speak Kiborana. All enumerators underwent a two day training. The first day focused on the survey questions and data collection logistics. The second day, practice surveys were conducted followed by a group discussion. All enumerators received a training manual outlining enumerator expectations and survey logistics. Enumerators were used in this research because, as Bernard (2011) states, "if you are studying the experiences of a group of people… then getting more interviews is better than getting fewer. (pg. 197)" Using enumerators made it possible to get more interviews than I would have been able to collect alone. Enumerators were also familiar with the study areas and each other and this made it logistically easier to conduct surveys, not to mention more fun. Noor Hussein Noor and I served as both logistical support and coordination, as well as conducting random spot checks by sitting in on occasional surveys and checking through the surveys at the end of the day.

Additionally, as a white, American, female, there were certain stereotypes that respondents had about me, as well as expectations about aid and development assistance. Utilizing local enumerators helped to minimize these stereotypes and expectations. Because enumerators were generally familiar with the area, they also had a better idea of the truthfulness of the respondents. The enumerators were asked to rate both the willingness and the honesty of the respondent. If either category was given a score of 3 or 4 (on a scale of 1 = honest to 4 = dishonest) the survey was not used for data analysis because the respondent's answers may have been misleading or dishonest. Using local enumerators had many advantages, as mentioned above. The quality of their work was closely supervised by myself, however, their knowledge of the local context was critical in conducting surveys and judging the honestly and accuracy of responses. Further, using Kenya Red Cross Society enumerators was valuable in gaining trust and access to households as the Kenya Red Cross Society is highly respected in both Kinna and Burat.

Before beginning the survey the survey sample size was determined in order to get a statistically representative sample in each community. Determining a suitable sample size was important because I wanted to be able to make generalizations from the data without surveying every agricultural household in Burat and Kinna. The first step was to define the population I wanted to sample (Qualtrics 2011). For this research the population was households that practice agriculture in Burat and Kinna. The formula utilized for calculating sample size was (Qualtrics 2011):

$$n \geq \frac{Np\,(1-p)}{(N-1)D + p\,(1-p)}$$

where,

$$D = \frac{(Margin\ of\ Error)^2}{z^2_{\propto/2}}$$

P is the prior assumption of the population parameter and is assumed to be 0.5. Z represents the number of standard deviations relative to the mean of the standard normal curve corresponding to the level of confidence. The formulas above are used for estimating proportions and are used here because, based on the research questions, I am more interested in percentages than averages or means (Qualtrics 2011). The following parameters inserted into these formulas are given in Table 4.3.

In order to obtain a representative sample size with 95% confidence level and a 5% acceptable margin of error, the appropriate sample size for both Kinna and Isiolo was calculated using the number of households in Kinna and Burat and then estimating the number of households practicing agriculture based on previous work by the Kenya Red Cross Society – Isiolo Branch. A 95% confidence interval is a common standard for quantitative data and means that the sample size is big enough that 95% of the answers would be within the margin of error to the true answer. The remaining 5% of the time, you would expect that the survey response to be more than the margin of error away from the true answer. The margin of error is a statistic expressing the amount of random sampling error in a survey's results. For Kinna there were

4,837 people in Kinna town (Kenya Red Cross Society 2011). If it is assumed that there were 6.1 people per household in Isiolo County (Kenya Decides 2012), then there were 793 households. From previous work of the Kenya Red Cross Society – Isiolo Branch, 31% of households said that they practiced agriculture. Taking 31% of the 793 households I estimated that 246 households in Kinna practice agriculture. Therefore, using the formula, with a 95% confidence level and 5% margin of error, the minimum sample size for Kinna was 150 households. For Burat the population of the agricultural area was approximately 2,500 people according to the Chief of Burat Ward (personal communication). I assumed that there were 6.1 people per household, which means that there were 348 households in this area. From previous work (Quandt and Kimathi 2016), 85% of households said that they practice agriculture. Therefore, I assumed that 2,522 households practice agriculture. From this, with a

Table 4.3 Sample size determination parameters and numbers

Parameter	Kinna	Burat
Total # of households	4,837 total population[1] with an average 6.1 people per household[2] = 793 households	2,500 total population[3] with 6.1 people per household = 410 households
% of households that practice agriculture[4]	31%	85%
Estimate of households practicing agriculture (sample population or N)	246 households	349 households
Confidence level	95%	95%
Margin of error	5%	5%
Standard Deviation	0.5	0.5
Z-score	1.96	1.96
D	0.000651	0.000651
Sample size	150	183

[1] population estimate from the 2009 census (KNBS 2009)
[2] estimated number of people per household is for Isiolo County (Kenya Decides 2012)
[3] personal communication with Chief of Burat Ward for the population in agricultural areas of Burat Ward
[4] these percentages are based off information from the Kenya Red Cross Society.

95% confidence level and 5% margin of error, the sample size for Burat was 183. This means that the total minimum sample size for both communities was 333 surveys.

Data collection

The general field logistics of the survey are described here. The enumerators were split into two teams of three enumerators each. Each team had a team leader, myself or Noor Hussein Noor, whose job was to take GPS points, coordinate their team, and ensure survey quality. A GPS point was taken at every survey point. Each team then followed a path from the designated starting point for that day. The enumerators aimed to survey every other household. If a household did not practice agriculture, they were excluded from participation in the survey. If this occurred, the enumerator would move to the very next household as a replacement household. The enumerators would also move to the very next household if neither the male or female household head were at home. From each household the male or female household head was selected to participate in the survey. Who was selected depended on availability and willingness of the household heads to participate, with the aim to survey males and females as evenly as possible. The breakdown of survey respondents by gender was 123 male and 206 female overall. In Burat, it was 74 male and 107 female and in Kinna it was 49 male and 99 female. Therefore, overall more females were surveyed then males. However, this was due to the fact that females were more often present at the home/farm than their husbands. This suggests that females may be more involved in managing the home and farm than some of their husbands who instead work outside the home as a casual laborer or salaried employee, and this indeed came out during the household case study interviews.

The survey was carried out in Burat between March 23rd and April 2nd. The surveys were conducted in Kiswahili. The research team was able to conduct between 16 and 28 total surveys per day, depending largely on the distance between households (often more than 15 km per day). The surveys in Kinna were conducted between May 3rd and May 11th. In Kinna, the surveys were mostly conducted in Kiborana. During enumerator training in Kinna, we spent several hours discussing how to rephrase the questions into Kiborana so that all enumerators were on the same page. The enumerators in Kinna were all from Kinna, which was helpful overall because they knew the area well and households seemed interested to participate since they knew many of the enumerators. In Kinna, the research team was able to conduct between 19 and 35 surveys a day. The enumerators were generally able to conduct more surveys because the households in Kinna were less spread out than they are in Burat so there was less walking and travel time each day. A total of 153 surveys were conducted in Kinna and 187 in Burat, meeting survey targets; the overall total of surveys was 339. While the issue of land tenure is important to the overarching research questions and the household survey particularly, we did not formally ask about land tenure and instead it was discussed more informally during the household case studies. This decision was made due to the contentious and controversial nature of land tenure during the field work period. I was advised by my research assistants that asking questions about land tenure in Burat specifically might give survey respondents the wrong impression of the research team and the purpose of the research. Therefore, unfortunately, questions focused on land tenure were purposefully left out of the survey.

Data analysis

The quantitative data from the initial interviews and household surveys were entered into Microsoft Excel. Microsoft Excel and Stata IC13 statistical package were both used for quantitative analysis. Descriptive analysis was done to create summary tables of key variables. Regression models were created to better understand what variables contribute most to building livelihood resilience and agroforestry. A logistic regression model was used to examine agroforestry and livelihood capitals. For models comparing livelihood capitals with number of trees, tree density, and tree diversity zero-truncated negative binomial regressions were run. This type of regression model was chosen because the data is count data and the value 0

Table 4.4 Household survey livelihood resilience indicators

Asset	**Quantitative Indicator** (Independent Variables)
Financial Capital	• Salaried job (yes or no) • Access to a bank account (yes or no) • Remittances (yes or no) • Household belongings (# of belongings) • Livestock (# of livestock) • Size of farmland (# of acres) • Ownership of farm equipment (own, rent, borrow pieces of equipment)
Human Capital	• Labor availability (number of household members between 18 – 55) • Education (level of education of respondent) • General health of family (scale of poor to good) • Health problems impact on ability to practice livelihoods (Scale of no to very much)
Social Capital	• Family living nearby (yes, how close) • Political influence or power (scale of none to a lot) • Participation in groups (# of groups) • Participation in agriculture or tree planting group (yes or no) • Strength of relationship with neighbors (# of activities done with neighbors)
Physical Capital	• Normal and rainy season road conditions (scale of good to bad) • Presence of facilities (schools, hospitals, etc.) near home (yes or no) • Access to irrigation schemes (yes or no) • Ownership of farming equipment (own, rent, borrow pieces of equipment)
Natural Capital	• Size of farmland (# of acres) • Own farmland (yes or no) • Diversity of farm crops (# of different crops planted) • Livestock (# of livestock) • Soil erosion (rank of severity of soil erosion on farm)

does not occur in the data. Additionally, further statistical tests, such as one-way ANOVAs, were conducted to test for statistical significance of the data. Chapters 5-8 contain summaries of the specific quantitative analysis conducted for each chapter. The data analysis for the sustainable livelihoods indicators is presented in the next section. Quantitative and qualitative data were compared to triangulate results in an iterative process. Qualitative data was used to support quantitative data and vice versa.

Sustainable livelihoods approach to data analysis

As introduced in Chapter 2, the sustainable livelihoods framework was used to quantify and measure livelihood resilience. The data analysis methods used generally follow Campbell et al. (2001). The sustainable livelihoods framework is divided into five livelihood capitals (natural, social, physical, financial, human) and measurable indicators were developed for each capital (Table 4.4). These indicators were based on a combination of the literature about livelihood capitals (Tacoli 1999; Campbell et al. 2001; Adato and Meizen-Dick 2002; Erenstein et al. 2010), the household case study interviews, and personal previous experience at the research sites (Quandt and Kimathi 2016). Each indicator was then turned into a measurable, quantitative question. For example, under human capital, the survey respondent was asked about household labor availability, which was the number of household members between 18 and 55. These questions were then administered during the household survey described above.

The next step in data analysis was to create simple additive, or composite, indices as outlined in Campbell et al. (2001) and Erenstein et al. (2007). First, the results for each indicator question were converted so that all the questions were on a scale of 0 and 1. The results were assigned a 1 to represent the most desirable response, and 0 to represent the least desirable response. Thus, it was assumed that higher scores should indicate higher levels of livelihood assets and thus greater livelihood resilience. For example, for the question of if any household member has a salaried job, any yes answered was assigned a 1 and any no answer was assigned a 0. Converting the results of each indicator question allowed for proper data analysis. For a full outline of the conversion process for each indicator see Appendix B. Each indicator was given equal weight to aid interpretation and reduce ambiguity, as done by Erenstein et al. (2007). After the results were converted to fit a scale of 0 to 1, composite asset indexes and overall composite asset indexes could be created. Averages were used to calculate both the composite asset indexes and overall composite asset index for each survey respondent (Campbell et al. 2001; Erenstein et al. 2007). This means that for each household, all the results for each livelihood capital asset were averaged. For example, all the results from questions about natural capital assets were averaged to give the overall natural capital score for that household. Next, for each survey respondent the scores for the five capitals were also averaged to give the overall livelihood composite asset index. Averages were used as opposed to adding indicator scores together because different capital assets had different numbers of indicator questions. Also, averages may give a better overall picture of resilience because a solid foundation in all five assets is generally needed for livelihood resilience and security (Erenstein et al. 2010). This overall process is outlined in Figure 4.2. Therefore, each survey respondent's household had one

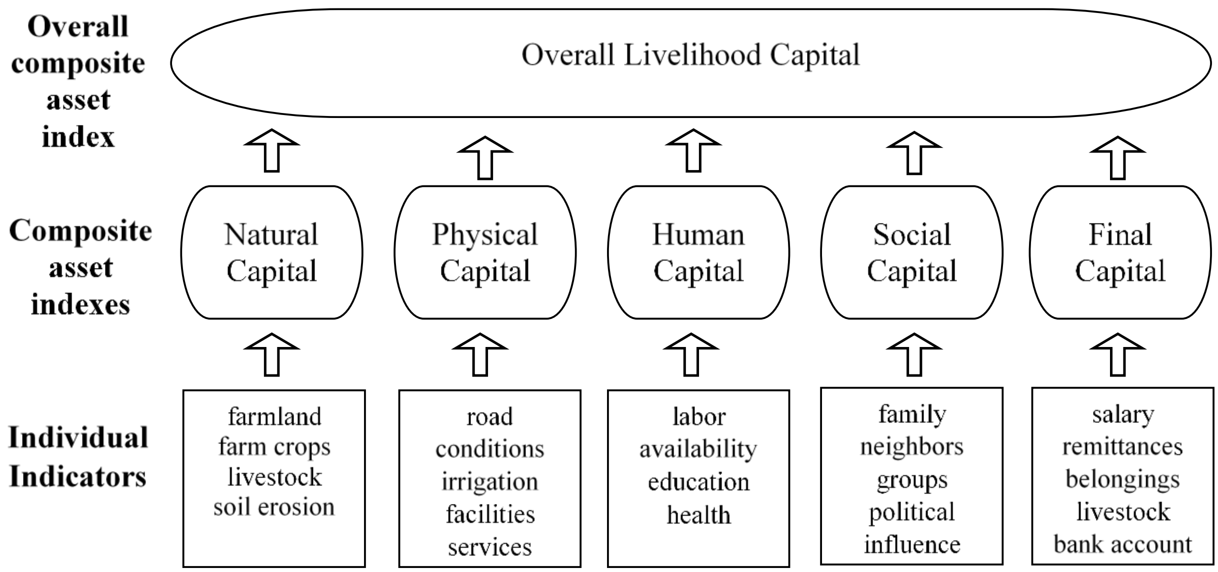


Figure 4.2 Schematic representation of data types and linkages for the sustainable livelihoods framework.

overall livelihood assets score. A higher overall score suggests that the household had greater overall livelihood resilience.

During the data analysis process the composite asset indexes and overall composite asset index were used to compare different groups of survey respondents. This was often done with the use of radar diagrams, or spider charts, to compare and contrast the five capital assets (composite asset indexes) between different groups. For example, in Chapter 5 about general resilience, five capital assets were compared between households with and without agroforestry. This means that the composite asset indexes for each livelihood capital were averaged for all survey respondents that practice agroforestry, and all survey respondents that did not practice agroforestry. One-way ANOVA tests were also conducted at times to determine if the averages for certain livelihood assets were significantly different for different groupings of survey respondents.

Phase 3: Key Informant Interviews

Key informant interviews were completed with chairs of the three Kinna water committees, a member of the Burat Water Committee, a farmer in Burat, and the LMD (Burat) Water Project Chair. These key informant interviews were conducted in order to gain a better understanding of both the history of the irrigation systems and how they function today in both Kinna and Burat. Key informants were chosen based on who both understood the irrigation systems and was willing to share this information (Bernard 2011). Key informant interviews were conducted in Kiswahili. They were voice recorded and then transcribed verbatim. They were not coded as the household case study interviews were. Instead, the texts from these interviews were used during data analysis and report write-up when clarification was needed or to elaborate. They were utilized to gain a better understanding about the context of the study areas and are included in the study area section of this dissertation.

Phase 4: Environmental Data

Environmental data was also obtained to better understand how rainfall patterns in Isiolo County have changed. Rainfall data for Isiolo Town was obtained from the Isiolo County Agricultural Office. This data included daily, weekly, and monthly rainfall records. However, there were gaps in the records including from independence through 1973, and 1982. Besides these gaps, the data included the years between 1973 and 2014. This data was recorded at the Isiolo Meterological Station, and is probably fairly accurate for Burat. Unfortunately, in Kinna, this type of data was not available. Rainfall data was utilized to illustrate long term trends in rainfall, both monthly and yearly. It was also combined with archival rainfall data to illustrate longer term yearly trends in rainfall.

Additionally, I collected river gauge data for Isiolo River from the Isiolo Water Resources Management Authority. The Isiolo River is one of the two rivers that runs through Burat. This data included daily measurements of river discharge from 1977 until 2012. However, there were large gaps in the data including 1989, 1993, and 1995 through 2004. Months or years that did not have at least half of the days recorded were not used in this research. River gauge data was important because the Isiolo River was a major source of water for irrigation, but also a major cause of floods in Burat. Unfortunately, this type of data was not available for any of the rivers in Kinna. River gauge data was used to illustrate how the amount of water in Isiolo River has changed over time and in comparison to the rainfall records.

Phase 5: Participant Observation and Field Notes

Participant observation

Participant observation was used throughout field work. In the words of Bernard (2011), participant observation "produces the kind of experiential knowledge that lets you talk convincingly, from the gut" about your research questions. Participant observation is a strategic data collection method, where most data is qualitative, but it can include quantitative data (Bernard 2011). Participant observation was conducted through field notes taken on things that I saw and heard while conducting the household case study interviews and household surveys. During interviews and surveys I carried around a notebook and would jot down things I observed. For example, during the rainy season case study interviews in Kinna, I observed and wrote down how the mango trees seemed to be producing lots of fruit. I observed people, mostly children, eating mangos at almost every household and could see all the discarded mango seeds littering the road and fields.

Participant observation also took place during my daily life over the year (July 2014 – 2015) that I lived in Isiolo Town. I was friends with my research assistants, enumerators, as well as others in Isiolo Town. Through interacting with them on a daily basis I gained an in-depth understanding of the area and what it is like to live there. I spent many afternoons sitting at a used clothing shop on the main road into town, which was where the KRCS volunteers would hang out. I overheard and participated in many conversations about politics, livelihoods, and life in Isiolo County. Observations and insights from daily life were recorded each evening in the same field notebook that I used during surveys and interviews.

The participant observation notes were not coded or quantified. Instead, in the process of data analysis they were utilized to triangulate the findings. Data triangulation helps to strengthen the validity of research findings, and participant observation is an important part of this (Yin 2014). Most importantly, participant observation helped inform my intuition and reactions to the household case study and survey data. Participant observation helped me determine, based on my own observations and intuitions, if the data seemed accurate, or if something seemed off.

Field notes

Field notes were also recorded throughout this research project. The field notes went one step further than participant observation and included my own analysis and ideas from what I observed or heard during field work. Field notes consisted of bigger picture ideas that formed throughout the period of field work. They were based on larger trends that I observed, through participant observation, but also during the survey or household case study interviews. I also took field notes while transcribing and coding the qualitative interviews, and analyzing the quantitative survey data. For example, if a certain point seemed to come up a lot during the interviews while I was transcribing I would write it down. This process was important for identifying key themes and ideas that deserved in-depth analysis of the household case study and survey data.

Field notes included methodological notes as well as analytical notes. Methodological notes were about techniques or strategies that appeared to work well during data collection (Bernard 2011). They were also about things that we needed to do better or change for the next day or between Burat and Kinna. Bernard (2011) explains analytical notes as where you lay out your ideas about what you think is going on regarding your research questions. These were the larger, big picture notes and ideas, as explained above, and were recorded at all stages of data collection and analysis. Field notes were analyzed in a similar way to the participant observation.

Phase 6: Archival Records

Archival records were useful here in order to understand the historical context of Isiolo County. These archival records included British colonial Provincial and District Annual and Quarterly reports on Isiolo County and the Northern Frontier District from 1919 until independence. The reports were written by various British government officials. The information included in these reports were records of colonial relationships with different ethnicities in Isiolo County, as well as records of agriculture and tree planting in the area.

Importantly, many yearly reports included monthly and yearly rainfall data. Some of the reports were missing or not legible. Archival records were obtained in microfilm format from Syracuse University; which has a large library of Kenya National Archives microfilms.

Archival data was entered into an excel spreadsheet by year, in order to organize key pieces of historical information with a specific focus on rainfall and agriculture. This created a sort of timeline of events and development in Isiolo County pre-independence. I utilized the rainfall data to look at the longer term trends in rainfall in Isiolo County. I combined the archival rainfall data with those obtained from the Isiolo Agricultural Office to illustrate how rainfall has changed over the past almost 100 years. However, as Yin (2014) points out, it was important to also look at the conditions under which the records were produced (colonialism) and its accuracy. The level of detail varied from year to year and with different administrators. This did create some levels of discrepencies in the information from year to year. Also, many of the records contained discriminatory or belittling comments towards various ethnic groups, and overly generalized statements about the region. Therefore, archival records were utilized as a general outline of historical events.

Conclusions

This chapter has outlined in detail the methods used for this dissertation. It illustrates the mixed-methods approach to research and how a variety of research question were utilized to answer the same research questions. The following chapters (5-8) utilized the results of these methods to draw conclusions about the research questions. These chapters also contain a summary of the specific methods used in each chapter.

PART TWO

CHAPTER 5. BUILDING GENERAL LIVELIHOOD RESILIENCE: WHAT ROLE DOES AGROFORESTRY PLAY?

Abstract

Understanding how to build livelihood resilience to an uncertain future is critical as livelihood systems must adapt to local and regional climatic, economic, and political change. Agroforestry, the integration of trees into an agricultural landscape, is one potential solution. However, while many intuitively link agroforestry with livelihood resilience, there is little factual evidence. This paper utilizes data from two communities in semi-arid Isiolo County, Kenya to explore if and how agroforestry is building livelihood resilience for smallholder farmers. This study utilized a mixed methods approach including 20 qualitative case study households, 339 quantitative household surveys, and key informant interviews. In order to measure livelihood resilience, we drew from the five livelihood capital assets of the sustainable livelihoods approach: financial, human, social, physical, and natural capital.

The major benefits of agroforestry were shade and fruit (for sales and consumption); the main tree species planted included mango, papaya, banana, guava, and neem. The average financial capital of households with trees was 36.5% higher than households without. Livelihood capitals were improved by both on-farm diversification and off-farm livelihood diversification. Agroforestry improved the overall quality of life for respondents and conserved environmental resources. The average of all five livelihood capital scores was 10% higher for households practicing agroforestry, indicating that those households may have more resilient livelihoods to future shocks and environmental changes. This paper provides four major findings that may be

applied at regional scales to build livelihood resilience through agroforestry.

Introduction

> "The period when we had not planted trees … it was hard. Now that we have planted, yes, I see that we are on another level. These days, those people who have still not planted they continue to make charcoal, and for us we no longer make charcoal and we no longer work in casual labor. Now we depend upon ourselves. Now I see that there is a difference." – Female farmer in Burat, Kenya

Global issues such as climate change and environmental degradation are creating serious challenges for human populations and international development organizations. Understanding how to build livelihood resilience to global (and local) change is a pressing need as livelihood systems must cope with and adapt to change in order to maintain environmental, political, and economic sustainability. A major challenge is to identify and develop resilient agricultural systems where ecosystem function is maintained and livelihoods are protected (Lin 2011). Agroforestry, the purposeful integration of trees onto farms and agricultural landscapes, is one potential solution. Agroforestry may be able to build livelihood resilience to help farmers adapt to global, regional, or local changes (Kandji et al. 2006). However, while there has been significant research about agroforestry technologies, much less is known about how agroforestry can help farmers build livelihood resilience (Thorlakson and Neufeldt 2012). De Leeuw et al. (2013) reported that "although many people intuitively associate trees with resilience there is very little factual evidence on the roles of trees in building resilience (pg. 3)." Lin (2011) elaborates by saying that "although the idea of resilience has been studied in a broad range of ecosystems, from coral reefs to forests, this idea has not been well studied in an especially important system to human society: the agro-ecosystem (p. 183)." There has been a call from both the academic and development communities for more empirical evidence about the links between agroforestry and resilience (Lin 2011; Maathai 2012; Nair and Garrity 2012; Thorlakson and Neufeldt 2012). In this paper we strive to answer the call for comprehensive empirical evidence by asking the question: if and how agroforestry may build livelihood resilience to help smallholder farmers cope and navigate through an uncertain future?

Literature Review

Theoretical framework

In this paper we draw significantly from resilience thinking. Resilience thinking as it pertains to social-ecological systems was first proposed by Holling in 1973 as the ability of a system to recover and bounce back after shocks and disturbances (Holling 1973). While it arose from ecology, in the past 40 years it has been utilized in a variety of disciplines including engineering, disaster risk reduction, and climate change adaptation (Carpenter 2001; Leslie and McCabe 2013; Fath et al. 2015). Here, we define a resilient social-ecological system, such as a productive agricultural region, as one that has a greater capacity to continue providing the goods and services that support livelihoods and ecosystem services, while being subjected to a variety of shocks and disturbances (Walker and Salt 2006). The resilience of a social-ecological system can be viewed as either specific resilience to a particular disturbance or shock, or general resilience which is the ability of a system to navigate through an uncertain future and the focus of this paper.

Over the last few years the concept of resilience has gained prominence in international development and climate change adaptation policy (Jones and Tanner 2015; Walsch-Dilley et al.

2016). However, resilience thinking has largely focused on natural systems and is often criticized for ignoring the social side of social-ecological systems (Brown 2014). Tanner et al. (2015) propose that the lens of resilience "requires greater attention to human livelihoods if it is to address the limits to adaptation strategies and the development needs of the planet's poorest and most vulnerable people (pg. 23)." One response to this has been the development of a livelihood perspective in resilience theory. Tanner et al. (2015) promote a livelihoods resilience perspective to solving issues of environmental conservation and maintaining livelihoods because it places emphasis on human agency and empowerment. People have the ability to build livelihood resilience to an uncertain future. Tanner et al. (2015; 23) define livelihood resilience as "the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances." Focusing on livelihood resilience places people in the center of analysis and highlights the role of human agency, rights, and capacity to prepare for, and cope with shocks (Tanner et al. 2015). Along with addressing the questions of "resilience of what", a livelihood approach also strengthens resilience thinking by addressing the often ignored question of 'resilience for whom' (Brown 2014). Central to livelihood resilience are the coping strategies used by households during times of stress. These coping strategies can be spontaneous, but often involve planning and preparation for certain shocks. Building livelihood resilience means that a given household's livelihood strategies are better prepared to cope and manage the impacts of shocks, navigate uncertainty, and adapt to changing conditions (Marschke and Berkes 2006). According to Allison and Ellis (2001), the most robust livelihood system is one displaying high resilience and low sensitivity, while the most vulnerable displays the opposite. The concept of livelihood resilience specifically has been growing as livelihoods are increasingly caught in major global transitions in climatic, economic, and social systems. For example, livelihood resilience is acknowledged both explicitly and implicitly in a range of the United Nation's Sustainable Development Goals for 2030 (Bahadur et al. 2015). However, Scoones (2009) does critique a livelihoods perspective because it, 1. Often lacks engagement with the processes of economic globalization, 2. Fails to pay attention to power and politics as they relate to livelihoods, 3. Lack of rigorous attempts to deal with long-term change, and 4. Livelihood studies failed to grapple with the debates about longer-term shifts in rural economies, and agrarian change. Some of these critiques are addressed below.

Agroforestry and livelihood resilience

Agroforestry has been proposed as one livelihood strategy that can help build livelihood resilience to an uncertain future (Kandji et al. 2006; Verchot et al. 2007; Lin 2011; Thorlakson and Neufeldt 2012; Mbow et al. 2014; McCord et al. 2015; Simelton et al. 2015). Agroforestry involves different combinations of trees, crops, and animals on the landscape over different spatial arrangements or temporal sequences (Sinclair 1999). The benefits of agroforestry include cash income, food, energy, medicine, construction materials, windbreaks, animal fodder, and soil and water conservation (Rocheleau et al. 1988; Franzel and Scherr 2002). Of particular importance is agroforestry's ability to enhance food security because agroforestry does not only provide food directly, but also can increase soil fertility (Sanchez 2002), and provide cash to purchase food. Almost 1.8 billion people depend on some use of agroforestry products and services for their livelihoods (Leakey et al. 2005), and nearly half of the world's farmlands have at least 10% tree cover (ICRAF 2009).

While it has been proposed that agroforestry builds livelihood resilience, there are very few studies that address these links in a comprehensive, empirical way. Instead, previous research has indirectly focused on the benefits of agroforestry. Ecologically, shade from agroforestry trees can buffer crops to temperature and precipitation variation (Kandji et al. 2006; Verchot et al. 2007; Lin 2011; Mbow et al. 2014; McCord et al. 2015) and from storm damage (Philpott et al. 2008). During droughts, the deep root systems of some trees are able to help the trees survive while other crops may perish (Verchot et al. 2007). In dryland areas of Africa, where climate variability is normal, farmers have learned to utilize trees to buffer against production risks (Kandji et al. 2006). For example, in Malawi, a study by Garrity et al. (2010) found that during drought farmers who practiced agroforestry obtained modest crop yields, while farmers without agroforestry experienced crop failure.

Furthermore, trees on farms can provide households with fruit and construction materials both for direct household consumption or sales during periods of financial or food deficits, thus increasing livelihood resilience (Neufeldt et al. 2012; Mbow et al. 2014). In their study in western Kenya, Thorlakson and Neufeldt (2012) concluded that agroforestry does have substantial potential to help farmers improve their well-being and environmental sustainability on their farms, thus improving overall livelihood resilience. While providing convincing and important evidence, none of these studies comprehensively address how agroforestry builds livelihood resilience to an uncertain future.

Research Methods

Study area

Research was conducted in the two communities of Burat and Kinna in Isiolo County, Kenya (Figure 5.1). These communities were chosen because they are the two major agricultural areas in Isiolo County, are facing local climatic and economic change, and these two communities are different ecologically, culturally, economically, and politically, providing for two diverse contexts for addressing the research question. Both Kinna and Burat are located in semi-arid agro-climatic zones. Burat is one of the 10 wards which make up Isiolo County but the majority of residents live along the banks of the Isiolo and Aye Nakore Rivers. Burat is a mix of Turkana, Meru, Somali, Borana, and Samburu ethnic groups; each ethnic group having a historical claim to the area (Boye and Kaarhus 2011). Kinna is also one of the 10 wards in Isiolo County and Kinna Town is a small urban center. Kinna is predominantly ethnically Borana with a few Meru households. Kinna Town borders Meru National Park and Bisanadi National Reserve.

Livelihoods in Isiolo County have changed in the past 50 years and in Kinna particularly there has been adoption of agriculture by the Borana. This is attributed to livestock losses during the *Shifta* war of the 1960s (Hogg 1983), followed by losses due to droughts in the 1970s and 1980s (Helland 1998), and livestock disease

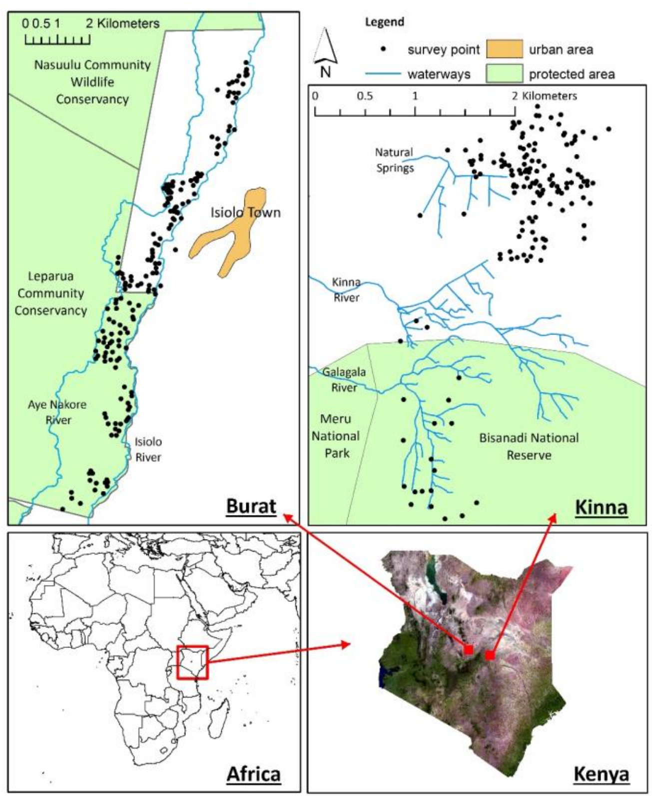


Figure 5.1 Study area map

(Hogg 1987). The response of the government after the shifta war ended was to establish small-scale irrigation schemes (Hogg 1987). According to Kinna elders, the Kinna irrigation scheme was dug by the government in 1969 and agricultural plots were allocated on a first come basis (personal communication). Adopting cultivation was a strategy for livestock poor Borana (Otuoma et al. 2009). Different from Kinna, agriculture began in Burat during the colonial period on small-scale experimental farms run by government officials (Kenya National Archives). Agriculture began in earnest when Meru moved onto the land near the two rivers and claimed farmland. Irrigation in Burat is largely through pipes and generators from the Isiolo and Aye Nakore Rivers. In Burat, the Isiolo River Water Users Association oversees water sharing by irrigators, pastoralists, and Isiolo Town (Mati 2008). Private land in Isiolo County is mainly restricted to Isiolo Town, and the majority of land is administered under the Trust Land Act of 1963 (Boye and Kaarhus 2011). This means that farmers in Burat and Kinna have rights to occupy, use, and inherit land, while they do not have legal property rights such as titles and deeds. Common shocks to livelihoods in Isiolo County include drought, inter-ethnic conflict, wildlife disturbance, livestock disease, livestock theft, crop disease, and political unrest, among others (Auma 2015; Kenya National Archives; personal communications). For example, drought is a common issue, and since the 1970s the long rains have declined by more than 100 millimeters and there has been a warming of more than 1°C (Funk et al. 2010).

Measuring resilience with the sustainable livelihoods approach

Measuring resilience is a difficult task, although several authors have put forward ideas about how to measure resilience (Carpenter et al. 2001; Carpenter et al. 2005; Walker and Salt 2006; Cabell and Oelofse 2012; Leslie and McCabe 2013). Because resilience is not directly measurable, most of the approaches make use of quantifiable indicators of resilience (Jones and Tanner 2015). In this study we utilized the sustainable livelihoods approach to develop indicators of livelihood resilience (Table 5.1), which were then used to measure the overall livelihood resilience of households. The sustainable livelihoods approach states that livelihoods should be considered in terms of people's

Table 5.1 Household survey livelihood resilience indicators

Asset	**Quantitative Indicator** (Independent Variables)
Financial Capital	• Salaried job (yes or no) • Access to a bank account (yes or no) • Remittances (yes or no) • Household belongings (# of belongings) • Livestock (# of livestock) • Size of farmland (# of acres) • Ownership of farm equipment (own, rent, borrow pieces of equipment)
Human Capital	• Labor availability (number of household members between 18 – 55) • Education (level of education of respondent) • General health of family (scale of poor to good) • Health problems impact on ability to practice livelihoods (Scale of no to very much)
Social Capital	• Family living nearby (yes, how close) • Political influence or power (scale of none to a lot) • Participation in groups (# of groups) • Participation in agriculture or tree planting group (yes or no) • Strength of relationship with neighbors (# of activities done with neighbors)
Physical Capital	• Normal and rainy season road conditions (scale of good to bad) • Presence of facilities (schools, hospitals, etc.) near home (yes or no) • Access to irrigation schemes (yes or no) • Ownership of farming equipment (own, rent, borrow pieces of equipment)
Natural Capital	• Size of farmland (# of acres) • Own farmland (yes or no) • Diversity of farm crops (# of different crops planted) • Livestock (# of livestock) • Soil erosion (rank of severity of soil erosion on farm)

access to capital assets (financial, physical, natural, human, and social), the ways in which people combine these capital assets to create livelihoods, and how they are able to enlarge their asset base through interactions with other actors and institutions (Chambers and Conway 1992; Carney 1998; Scoones 1998; Krantz 2001; Thulstrup 2015). At its core are the five capital assets needed for a sustainable livelihood: financial, physical, natural, human, and social. These five livelihood capitals encompass different types of assets needed for sustainable livelihoods (Tacoli 1999; Campbell et al. 2001; Adato and Meizen-Dick 2002; Erenstein et al. 2010). Social capital deals with the realm of social resources including networks, groups, associations, and relationships of trust, reciprocity, and exchange (Adger 2003). Physical capital refers to access to services and infrastructure such as irrigation and roads (Adato and Meizen-Dick 2002). Human capital encompasses the skills, knowledge, education, health, and labor availability of the person or household (Tacoli 1999). Financial capital refers to savings, credit, inflows of state transfers and remittances, as well as size of farm or livestock herd (Campbell et al. 2001; Erenstein et al. 2010). Lastly, natural capital includes access to environmental services and resources including soil, water, air, forest resources, farmland, and grazing areas (Campbell et al. 2001: Erenstein et al. 2010). A household is assumed to need a balance of these five capitals in order to maintain adaptive capacity and well-being (Jacobs et al. 2015). The accumulation of livelihood capital assets may help increase the ability of households to respond to shocks. The sustainable livelihoods approach draws attention to the multiplicity of assets that people make use of when constructing their livelihoods (Krantz 2001), and seeks to understand changing combinations of livelihood activities in a dynamic and historical context (Serrat 2010). However, it has been critiqued for not sufficiently accounting for power relationships (Scoones 2009), and being expert-driven (Jones and Tanner 2015).

Using the sustainable livelihoods approach provides one innovative method for determining indicators of resilience (Table 5.1). As Campbell et al. (2001) state, “the capital assets approach to livelihoods may be an appropriate organizing principal for the selection of indicators of system performance.” It serves as a way to ensure that a variety of indicators are considered, including material, social, and natural factors that may help to measure and ultimately build resilience. Ultimately, resilience is a key component of sustainable livelihoods and vice versa (Thulstrup 2015). The indicators used here were selected through a literature review of livelihood resilience, as well as previous work in the area (Quandt and Kimathi 2016), which focused on local perspectives of the impacts of floods and droughts. Jones and Tanner (2015) point out that measuring resilience is often an ‘objective’, top down process, and instead promote some measures of ‘subjective’ resilience. By drawing on previous work, we were able to address this critique by including local, subjective ideas of livelihood resilience in our indicators (Table 5.1). In order to measure livelihood resilience, the indicators listed in Table 5.1 were turned into quantitative questions to ask research participants. Responses were then aggregated for each household for the five livelihood capitals (composite asset indexes) and overall for each household (overall composite asset indexes). This process is conceptualized in Figure 5.2 and explained in more detail in the data analysis section. The methods used in this paper focus on the diversity and multitude of assets that contribute to livelihood resilience (Ellis 2000; Krantz 2001; Hodbod and Eakin 2015); diversification of livelihoods is widely recognized as a strategy for reducing risk and increasing well-being (Ellis 2000). Using the five livelihood

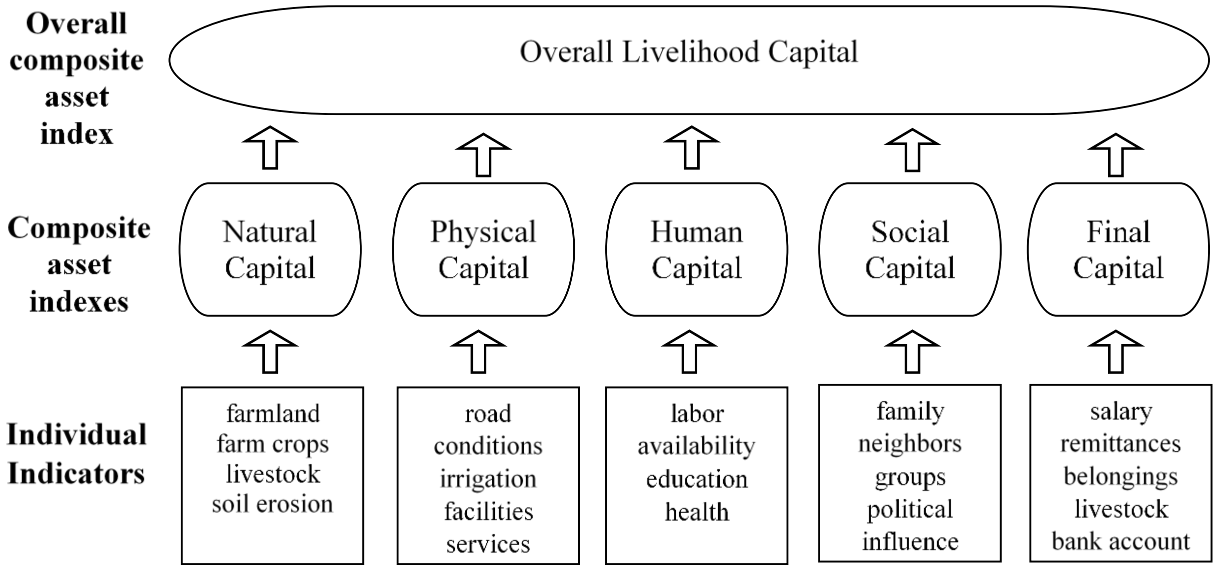


Figure 5.2 Schematic representation of data types and linkages for the sustainable livelihoods

capital assets enabled us to compare and contrast livelihood capitals between households, and measure resilience in a non-monetized approach.

Resilience has been critiqued for leaving out or ignoring power relationships (Nelson and Stathers 2009; Lebel et al. 2016), and we aimed to address this when developing our indicators of livelihood resilience. For example, several of the livelihood resilience indicators focused on issues of power and access to resources. Access to a bank account was included in financial capital, while access to irrigation and public services (schools, hospitals, etc.) were included as indicators of physical capital. Power relationships may impact a household's access to these services, therefore decreasing their overall livelihood resilience. Additionally, a respondent's perceived local political influence and power was included in social capital.

While using a sustainable livelihoods approach to measure resilience has been used in a handful of studies, it has not been widely adopted (Scoones 1998; Campbell et al. 2001; Erenstein et al. 2010; Thulstrup 2015). Thulstrup (2015) used the sustainable livelihoods approach to measure household and community resilience after government programs and interventions in Vietnam. Erenstein et al. (2010) created poverty maps aimed at building resilience using the five capital assets. We draw from these previous examples in this paper.

Data collection

This research utilized a mixed methods approach that included qualitative household case studies and quantitative surveys in both Kinna and Burat. Data collection took place between July 2014 and July 2015. While according to the Oxford English Dictionary (2016), a tree is a woody perennial plant, this definition was expanded for this study to include other tree-like plants such as bananas and papayas, as respondents considered these trees and they are typically included in descriptions of agroforestry in the region (Nair 1993).

A total of 339 quantitative household surveys were conducted from March to May 2015; 152 in Kinna and 187 in Burat. The surveys provide a statistically representative sample size of agricultural households in both Kinna and Burat with a 95% confidence level and a 5% margin of error based on an estimate of the number of households practicing agriculture according to the Kenya Red Cross Society – Isiolo Branch Office. Households that did not practice agriculture were excluded from this research, however households both with and without agroforestry participated in order to provide a comparison. Surveys were conducted by enumerators who all participated in a two day training. Surveys were conducted in either Swahili or Borana based on the language ability of the respondents. At each household either the male or female household head took part in the survey based on who was available and willing to participate, with the goal of a 50/50 gender split. Enumerators surveyed every other household along the given transect (road or path), and if no one was available enumerators surveyed the very next available household. Additionally, GPS points were taken at each survey household.

The qualitative household case studies included 20 households in total, 13 in Burat and 7 in Kinna. These households were selected through combined convenience and respondent-driven sampling (Bernard 2011). Most households selected practiced some level of agroforestry, from many trees to only one; only one household had not planted any trees. The case study households were selected to provide a variety of in-depth opinions, however, they are not necessarily representative of the communities. Each household was interviewed three times, and when possible both male and female household heads were interviewed. The aim of the first interview was to gather basic information about household characteristics, livelihoods, and agricultural practices. Each household was then interviewed two additional times during the rainy season (April-May 2015) and dry season (August-October 2014). These interviews were in-depth, unstructured, and centered around 6 to 8 discussion topics. The main purpose of these unstructured interviews was to capture what Bernard (2011) calls the 'lived experience' of humans. Interviews took place in Swahili, were recorded, and were later transcribed verbatim. Informal interviews were conducted with water committees in both Kinna and Burat to gain a basic understanding of the agricultural and irrigation systems in each community.

Data analysis

The quantitative survey data was analyzed in Microsoft Excel and STATA IC13 software programs. The analytical methods used here were based on previous work by Erenstein et al. (2007) and Campbell et al. (2001), as they provide some of the only examples of measuring resilience by drawing on the sustainable livelihoods approach. For each indicator question, the variety of answers were given a score from 0 (worst, less desirable) to 1 (best, more desirable). Then for each survey household a simple, unweighted, composite index was calculated as the average of the indicator values for each livelihood capital (Figure 5.2). These composite asset indexes can then be compared between households. Regression models were created to better understand what variables contribute most to building livelihood resilience and agroforestry. A logistic regression model was used to examine agroforestry and livelihood capitals. For models comparing livelihood capitals with number of trees, tree density, and tree diversity zero-truncated negative binomial regressions were run. This type of regression model was chosen because the data is count data and the value 0 does not occur in the data. These variables were chosen based on preliminary data analysis which highlighted that the number of trees, tree density, and tree diversity can be important in determining the benefits of agroforestry to a given household. Additionally, further statistical tests, such as one-way ANOVAs, were conducted to test for statistical significance of the data.

The qualitative household case study interviews were coded using QSR NVivo 10. Codes were developed from the academic literature, the discussion topics, and additional themes that emerged during the research and data analysis process. Additionally, an analytical summary was written for each household based on the data collected during all three interviews. The different sources of data (qualitative and quantitative) were compared and contrasted to triangulate results in an iterative process. Where useful, quotes from the household case study interviews are utilized in this paper, however all names are excluded to protect the privacy and confidentiality of participants.

Results

Livelihoods

Table 5.2 provides a summary of survey household characteristics for both Burat and Kinna. It illustrates that in both communities households practicing agroforestry were more likely to have a bank account, access to irrigation, and a greater number of different crops planted. In Burat, households with agroforestry had a significantly greater number of household members and the respondent had been located in the area for longer. Furthermore, in Burat, households with agroforestry reported that the household agricultural crops had fed the family for an average of 5.7 months last year (2014), while for households without agroforestry their crops lasted only 3.9 months (in 2014). In Kinna, farm size was a significant factor and households with agroforestry had on average 4 acres, while those without had 2.5 acres. The top

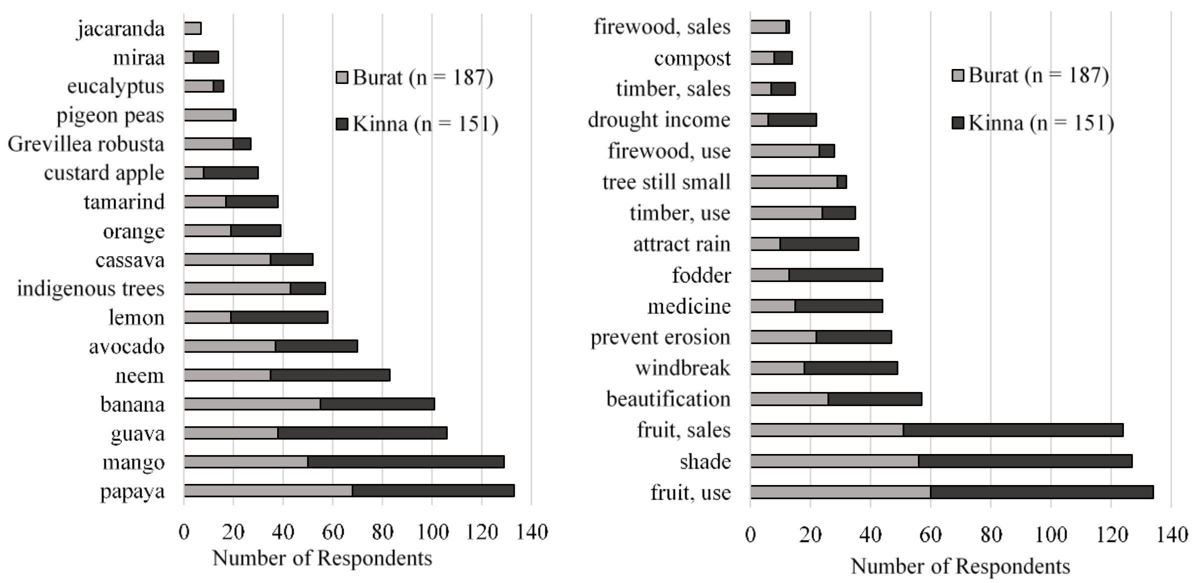
Table 5.2 Summary of household characteristics. The first number provided is the mean and the second is the standard deviation.

	Burat		Kinna		All
	Agroforestry	No Agroforestry	Agroforestry	No Agroforestry	
Household size (# of people)	7.4 (3.9)**	5.9 (2.7)**	6.6 (2.3)	7.2 (2.4)	6.8 (3.1)
Labor force between 18 and 55 years	3.2 (2.2)**	2.3 (1.6)**	2.6 (1.2)	2.9 (1.6)	2.8 (1.8)
Age of respondent (years)	44.5 (16.3)	40.7 (13.4)	45.0 (15.7)	42.8 (15.8)	43.6 (15.5)
Respondent's length of time living in the area (years)	31.7 (15.4)**	22.8 (14.9)**	29.8 (16.6)	28.5 (17.9)	28.8 (16.4)
Bank account (yes =1, no = 0)	0.38 (0.49)**	0.15 (0.43)**	0.41 (0.49)**	0.24 (0.43)**	0.32 (0.47)
Farm size (acres)	2.7 (2.0)	2.8 (2.4)	4.0 (3.5)**	2.5 (1.9)**	3.1 (2.7)
'Own' farm (yes = 1, no = 0)[1]	0.64 (0.48)	0.61 (0.49)	0.69 (0.46)	0.52 (0.50)	0.62 (0.49)
Access to irrigation (yes = 1, no = 0)	0.84 (0.37)*	0.72 (0.45)*	0.97 (0.18)**	0.86 (0.35)**	0.86 (0.35)
Number of different crops planted	8.2 (4.8)**	6.4 (4.1)**	5.2 (2.7)**	3.8 (2.6)**	6.2 (4.1)
Number of livelihood activities practiced	2.7 (1.2)	2.6 (1.1)	2.8 (1.0)	2.6 (0.9)	2.7 (1.1)
Number of months that crops fed the household last year	5.7 (4.5)**	3.9 (3.6)**	3.5 (2.3)	3.3 (3.0)	4.3 (3.7)
N	118	68	93	59	338

* one-way ANOVA test of variance where we can reject the hypothesis that the means are equal between households with and without agroforestry with **$p < 0.1$**
** one-way ANOVA test of variance where we can reject the hypothesis that the means are equal between households with and without agroforestry with **$p < 0.05$**
[1] 'Own' was defined by respondents who answered that they either bought or inherited their land, although no respondents have de jure tenure rights.

three livelihood activities in Burat were, in order, casual labor, livestock keeping, and charcoal production, while in Kinna they were livestock keeping, aid/relief, and small business. Major livelihood differences included an increased dependence on casual labor in Burat (>50% of respondents) and on livestock keeping in Kinna (>60%).

Agroforestry benefits



a b

Figure 5.3 (a) Major trees species planted and (b) Benefits of agroforestry for both Burat and Kinna communities from survey respondents. Households may have planted more than one different tree species. Tree species that had been planted by 5 or fewer households were omitted. Households named all benefits of agroforestry that they receive, both environmental and livelihood related. Benefits of trees that were named by 5 or fewer respondents were omitted.

Figure 5.3 illustrates the major tree species planted and benefits of agroforestry in both Kinna and Burat from the household surveys. The overall top tree species were papaya, mango, guava, banana, and neem (*Azadirachta indica*). The three main benefits of trees were shade and fruit, for both consumption and sales. Of the benefits named in Figure 5.3, it is important to note that 5 are environmental benefits including beautification of the land, windbreaks, prevent erosion, attract rain, and compost. Many farmers in the household case study interviews also discussed the importance of trees for fruit and shade (Table 5.3). Table 5.3 outlines the major tree species and agroforestry benefits listed by the household case study participants and generally mirrors the survey results.

During the household case study interviews with farmers who had not planted many trees we discussed different factors that prevented or hindered tree planting. These factors included insecure land tenure, small farm size, pests and disease, people stealing fruit, lack of water for irrigation, lack of knowledge about how to plant trees, and inaccessibility to tree seeds and seedlings.

Table 5.3 Tree species and benefits of those trees according to the household case study interviews. Household case study participants were asked which trees they grow and what benefits they receive from those trees. Participants could name multiple benefits for each tree species. These results are not statistically significant, but instead serve to provide detail. While 20 households were included, in many households both female and male household heads provided this information separately.

Tree species	Income	Food	Shade	Construction materials	Medicine	Firewood	Wind breaker	Fodder	Drought Income
Papaya	21	26	-	-	-	-	-	-	1
Mango	24	23	4	-	-	1	-	-	-
Banana	10	13	-	-	-	-	-	1	2
Pigeon peas	1	5	-	-	-	-	-	-	1
Avocado	22	19	4	-	-	-	-	-	-
Cassava	2	3	-	-	-	-	-	-	-
Orange	10	11	1	-	-	-	-	-	-
Grevillea robusta	6	-	1	12	-	2	1	1	-
Guava	19	19	1	-	-	1	-	-	-
Custard apple	2	3	-	-	-	-	-	-	-
Neem	1	-	3	1	3	1	-	-	-
Indigenous	3	3	6	9	-	6	2	4	2
Jacaranda	-	-	-	2	-	-	-	-	-
Eucalyptus	4	-	-	7	-	1	1	-	-
Tamarind	1	1	1	-	-	-	-	-	-
Miraa	2	-	-	-	-	-	-	-	-
Lemon	4	2	-	-	-	-	-	-	-
TOTAL	**132**	**128**	21	31	3	12	4	6	6

Livelihood capitals

Figure 5.4 and Figure 5.5 relate the household case study interviews and household surveys, respectively, to the sustainable livelihoods framework and the five livelihood capitals assets. As seen in Figure 5.4, many agroforestry benefits positively impact more than one livelihood capital, illustrating the breadth of agroforestry benefits. For example, fruit does not only provide an income (financial capital), but can also have positive health benefits and provide money for education (human capital).

Figure 5.5 utilizes the composite index of the livelihood indicators to compare livelihood capitals between different groups of survey respondents. The average aggregated score for each

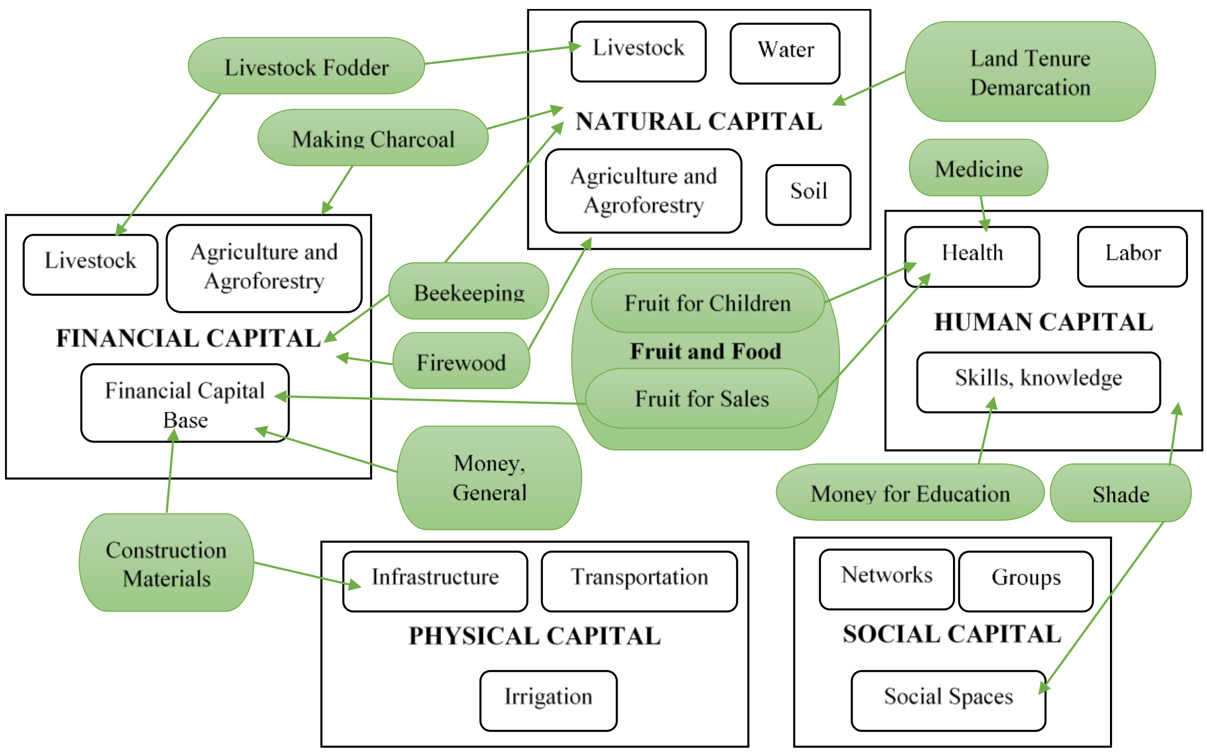


Figure 5.4 Flowchart of the relationships between the benefits of agroforestry and the sustainable livelihoods capital assets. The green ovals and arrows represent different ways that agroforestry can improve livelihood capitals. This flowchart was derived from the coded themes from in-depth case study household interviews. The relationships to livelihood capitals were derived from a mix of the literature on livelihood capitals and agroforestry, and the in-depth case study household interviews themselves.

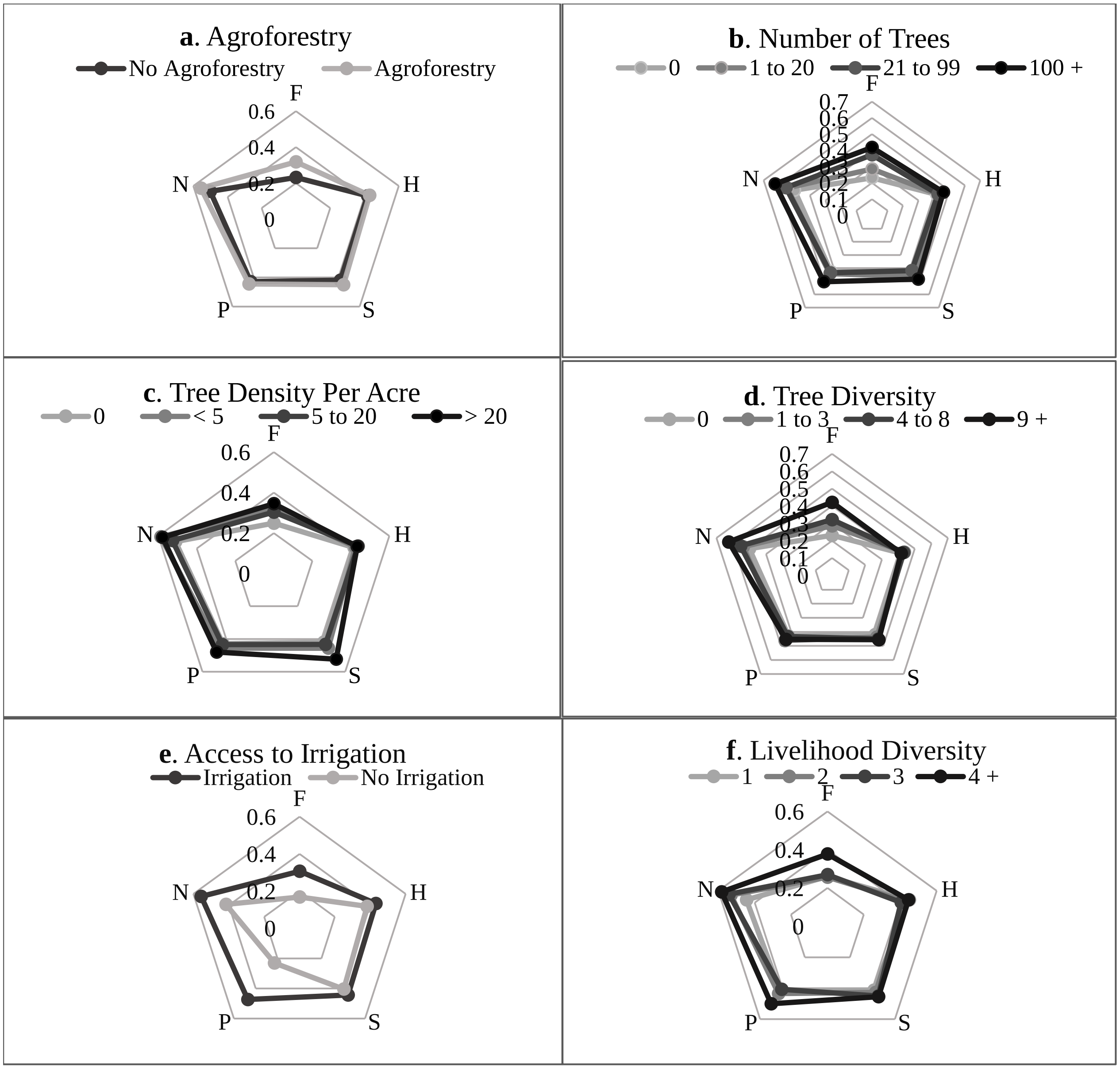


Figure 5.5 Livelihood capitals and different survey household characteristics. These charts illustrate the averaged livelihood capitals on a scale of 0 to 1. The different livelihood capitals are represented here as F = financial capital, H = human capital, S = social capital, P = physical capital, and N = natural capital. All one-way ANOVA tests utilized a scheffe comparison. **a.** The livelihood capitals for survey households with and without agroforestry (yes or no). A one-way ANOVA test of variance found that natural capital (p = 0.0079) and financial capital (p = 0.0000) were significantly different between households with and without agroforestry. **b.** The livelihood capitals for survey households divided into four groups based on number of trees planted. A one-way ANOVA test of variance found the natural capital (p = 0.0236) and financial capital (p = 0.0000) were significantly different between the four groups. **c.** The livelihood capitals for survey households divided into four groups based on number of trees per acre. A one-way ANOVA test of variance found that natural capital (p = 0.0226) and financial capital (p = 0.0154) were significantly different between the four groups. **d.** The livelihood capitals for survey households divided into four groups based on tree diversity (# of tree species). A one-way ANOVA test of variance found that natural capital (p = 0.0097) and financial capital (p = 0.0000) were significantly different between the four groups. **e.** The livelihood capitals for survey households both with and without access to irrigation for agriculture. A one-way ANOVA test of variance found that natural capital (p = 0.0000), physical capital (p = 0.0000), human capital (p = 0.0242), and financial capital (p = 0.0000) were significantly different between those with and without access to irrigation. **f.** The livelihood capitals for survey households divided into four groups based on livelihood diversity (# of livelihood activities). A one-way ANOVA test of variance found that natural capital (p = 0.0031), physical capital (p = 0.0011), and financial capital (p = 0.0001) were significantly different between the four groups.

boxes divided the survey respondents by those with and without agroforestry, the number of trees the household has, the number of trees per acre of land a household has, and the diversity or number of different tree species they have planted. The last two boxes divided the households based on important household characteristics: access to irrigation (yes or no) and livelihood diversity (number of different activities). One-way ANOVA tests of variance found that both natural and financial capital were statistically different between groups for all of the boxes.

Irrigation appears to be an important variable in building livelihood capitals. However from the household surveys, a Spearman's Correlation test shows agroforestry and irrigation are only weakly correlated with a value of only 0.1445 and a p-value of 0.0082. Despite this, according to household case study interviews, irrigation was still important to livelihoods in Isiolo County. A female farmer in Burat commented that "in the times when there is no rain, it [irrigation] will help you. If you water just a little your trees will produce fruit and you will eat."

To further explore the relationships between agroforestry and the five livelihood capitals, four regression models (Table 5.4) were created based on the same four groupings of survey households as in Figure 5.5. Each model includes only the variables that were significant when regressed alone. Number of crop species, or crop diversity, was significantly and positively correlated in models 1, 2, and 4. This means that households that plant a greater number of crop species were more likely to practice agroforestry, have a greater number of trees, and plant a greater diversity of tree species. Ownership and access to farm equipment was also a significantly and positively correlated in models 2 and 3, which means that access to farm equipment can be important for practicing agroforestry.

Lastly, in order to quantify the impact that agroforestry has on livelihood capitals we explored the change in livelihood capitals for households with and without agroforestry (Table

Table 5.4 Four models exploring the effects of key significant variables on four different groupings of survey respondents. Each model by itself includes the variables that were significant when analyzed independently at $p < 0.10$. Model 1 is a logistic regression, while the last three models are zero-truncated negative binomial regressions. The first number given is the coefficient and the second is the standard error.

Independent Variables	Model 1 – Agroforestry (yes/no)[a]	Model 2 – Number of Trees[b]	Model 3 – Tree Density (trees per acre)[c]	Model 4 – Tree Diversity (number of tree species)[d]
Remittances received by household	2.25* (0.94)	_	-0.47** (0.23)	_
Bank account	1.94** (0.61)	0.14 (0.16)	_	0.07 (0.08)
Size of farmland	1.03 (0.05)	0.09** (0.03)	_	0.01 (0.01)
Number of labor-aged household members between 18 and 55	1.07 (0.08)	0.07 (0.048)	0.10* (0.06)	0.03 (0.02)
Education 1 – Primary school	0.91 (0.26)	_	_	_
Education 2 – Secondary school	1.19 (0.55)	_	_	_
Education 3 – Post-secondary school	7.19* (7.80)	_	_	_
Member of agricultural group	1.16 (0.35)	_	_	_
Access to irrigation	1.29 (0.49)	0.09 (0.27)	_	_
Own farmland	1.24 (0.33)	_	_	_
Number of crop species	1.09** (0.4)	0.07** (0.02)	_	0.04** (0.01)
Ownership and access to farm equipment	_	1.45** (0.44)	1.07** (0.47)	0.34 (0.25)
Relationship with neighbors	_	0.02 (0.03)	_	0.04** (0.01)
Adjusted R^2	0.0859	0.0471	0.0106	0.0505
Number of observation	312	183	182	200

* $p < 0.1$
** $p < 0.05$
a. political influence and salary omitted from model. Also, this is an odds ratio.
b. rainy road conditions were omitted from the model.
c. rainy road condition were omitted from the model
d. soil erosion and overall health omitted from model

5.5). The percent change in livelihood capitals is important because it illustrates how much having agroforestry increases that specific livelihood capital. The change in livelihood capitals between households was significant for financial and natural capital. The average of all five livelihood capitals increased by 10% for households practicing agroforestry, and the total of all five capitals increased by 12%, both statistically significant (p-value = 0.000).

Table 5.5 Comparison of livelihood capitals for survey households with and without agroforestry**.** The numbers for livelihood capitals for households with and without trees are averages for all survey households.

Livelihood Capital	Without trees	With trees	Percentage change	p-value
Financial	0.233	0.318	36.5	0.000*
Human	0.415	0.429	3.4	0.352
Social	0.419	0.450	7.4	0.166
Physical	0.428	0.445	4	0.348
Natural	0.500	0.555	11	0.008*
TOTAL[1]	**1.846**	**2.068**	**12**	**0.000***
AVERAGE[2]	**0.400**	**0.440**	**10**	**0.000***

* statistically significant at $p < 0.05$ for a logistic regression between agroforestry and that specific livelihood capital
[1] Total of all livelihood capitals for the household

Trees improve wealth and quality of life

Households were asked if their overall quality of life and household income had improved since planting trees (Table 5.6). Generally, respondents answered that trees had improved both their quality of life and household income. About a third of households reported that agroforestry had improved their income a lot, while in Burat 25.8% and in Kinna 41% of households responded that agroforestry had improved their quality of life a lot. This was supported in the household case study interviews. For example, a male farmer in Burat commented that "now it is better because I earn money every week. Every Tuesday I earn money from this fruit [papaya]." A female farmer in Burat said that "[after planting trees] we are better off, I would have been out making charcoal right now. I used to cut trees instead of growing them." Her husband also added "that there is a difference [between before and after planting trees] because right now if you look at other Turkana that have not planted trees, right now they are struggling. Even yesterday one asked me for some poles from my trees." Lastly, a long-term farmer in Burat told us that trees had improved his finances significantly and that "in that farm I had a hundred trees…and the time when I cut them for timber I was able to pay for my children's school fees." When asked how much his trees had helped him financially he responded "a lot, not just a little."

Table 5.6 Percentage of survey respondents who responded that trees had improved their household income and quality of life. The responses for income were significantly and positively correlated with number of trees ($p = 0.004$), tree diversity ($p = 0.000$), and tree density ($p = 0.039$).The responses for quality of life were significantly and positively correlated with number of trees planted ($p = 0.012$), but not significantly correlated with tree density and tree diversity.

	Burat		**Kinna**	
Amount of improvement	Improved income (n = 91)	Improved quality of life (n = 89)	Improved income (n = 88)	Improved quality of life (n = 87)
None	30.1	22.5	5.7	5.8
A little	18.7	27.0	15.9	12.6
Some	20.9	24.7	44.3	40.2
A lot	29.7	25.8	34.1	41.0

Discussion

The results suggest that agroforestry can and does help farmers build livelihoods resilience to a variety of livelihood shocks in an uncertain future by building financial capital, providing important non-economic benefits such as social and environmental benefits, and increasing both on-farm diversity and the overall diversity of household livelihood activities. In Isiolo County, Kenya livelihood resilience increased on average 10% for households who practiced agroforestry. However, the relationship between agroforestry and livelihood resilience is complex and nuanced.

Benefits of trees and livelihood capitals

Agroforestry plays a particularly important role in building household financial capital as households with agroforestry, and a greater number, density, and diversity of trees had higher financial composite asset scores. Selling fruit was a particularly important source of income for many farmers. Some households in this study utilized their income from fruit sales to improve other livelihood capital assets. For example, income from fruit sales was used to improve human capital by paying school fees and providing healthy food options (fruit and non-fruit) for the family. This in turn helps increase the household's overall resilience because as explained by Jacobs et al. (2015), the balance between the five livelihood capitals may be as important to the ability of a household to cope with shocks and disturbances as the amount of any one type of capital. Indeed, households that reinvest financial capital earned from agroforestry into other types of livelihood capital (physical, human, social, and natural capital) may in the long term be creating more resilient livelihood strategies than households that do not.

Results suggests that in these communities, agroforestry is improving the financial situation of households, and it is not simply that wealthier households are more likely to plant trees. In the household survey, the majority of respondents in both Kinna and Burat answered that trees have improved the household's income; while during the household case study discussions the same sentiments were repeatedly voiced. Additionally, the greater the number of trees a household has planted the greater their score for financial capital and the more likely a household was to respond that trees had greatly improved their household finances. More trees can produce more fruit which can equal greater income. Additionally, farm size needs consideration when exploring financial capital because the size of the farm physically limits the number of trees that can be planted, thus limiting the financial benefits. Farm size was named as a limiting factor for agroforestry in the case study communities.

Thorlakson and Neufeldt (2012) assert that agroforestry can potentially improve household finances, which in turn helps households be more resilient to future shocks and disturbances. Because tree products typically have a higher value than maize or grains, harvesting tree products can buffer against income shocks (Kandji et al. 2006). Tanner et al. (2015) describe livelihood resilience as the ability to sustain, or even improve their livelihood options despite disturbance, and the income provided by fruit sales may assist households to sustain themselves and their livelihoods despite ecological, political, or economic disturbances. Generally, households with fewer financial assets are more vulnerable to shocks or disturbances, particularly the impacts of climate change (Agrawal and Perrin 2008), and therefore increasing financial capital through agroforestry may also reduce vulnerability to environmental and other shocks at a variety of geographical scales.

Non-economic benefits

This research utilized the sustainable livelihoods approach to measure the wide variety of agroforestry benefits, including non-economic benefits. Building livelihood resilience is about more than just building financial capital. Research participants repeatedly mentioned the environmental benefits of trees including preventing soil erosion and providing windbreaks. These types of benefits are difficult to put a monetary value on, but nonetheless important to building livelihood resilience. Additionally, shade from trees was very important in both communities due to the hot climate. Next to the evident benefits on health in a hot climate, shade helps promote social interaction and can help build social capital by providing places for farmers to meet and build relationships, an important aspect of social capital (Adger 2003).

Irrigation

Access to irrigation played an important role in agroforestry practices and agriculture, according to household case study participants. Kinna and Burat are semi-arid areas and rain-fed agriculture often fails, which means that farmers often must rely on irrigation to be successful. Irrigation looks very different in Kinna and Burat; however, irrigation was important in both communities for increasing financial, natural, human, and physical capital. Despite all of this, access to irrigation was not statistically significant in our models (table 4), and only slightly statistically correlated with agroforestry through a Spearman's Correlation test. Therefore, while the results about the importance of irrigation to agroforestry are somewhat mixed, access to irrigation is most likely important in successful farming and tree planting. For example, irrigation was found to be important in poplar agroforestry systems in northern India (Zomer et al. 2007). By providing necessary water for tree planting, irrigation can help build livelihood resilience through agroforestry. Attempting to build livelihood resilience through agroforestry may not succeed in semi-arid and arid parts of Kenya, or even globally, without the support of irrigation schemes.

Diversity

The importance of diversity for building livelihood resilience emerged in this study. Households with a greater diversity of tree species, crop species, and livelihood activities had more resilient livelihood strategies. It is important to note that agroforestry is only one way to diversify livelihood options, and similar benefits could be seen from other supplemental livelihood activities.

Diversification of livelihoods is widely recognized as a strategy for reducing risk and increasing well-being (Ellis 2000). Traditionally pastoral communities in East Africa have been found to be diversifying their livelihood strategies for decades to deal with climate change, increased population, and a shift towards a monetary economy (McCabe et al. 2010). In Kinna, livelihood diversification has been documented as a response by livestock-poor Borana to livestock loss due to conflict and drought (Otuoma et al. 2009). According to Paavola (2008), livelihood diversification involves the "creation of a portfolio of farming and non-farming livelihoods."

On-farm diversity in the form of crop diversity and tree species diversity also played an important role in building livelihood resilience in Isiolo County, Kenya. Tree diversity was significantly and positively correlated with improving household finances and overall wellbeing. Different trees provide different benefits and having a variety of trees may mean that a household is able to capture a greater variety of benefits. For example, while papaya was a popular plant in Kinna and Burat, it really only provides the benefit of fruit. On the other hand, mango was also a popular tree but provides a greater variety of benefits including shade, fruit, firewood, and construction materials.

According to McCord et al. (2015), diversification of on-farm plant species is one strategy that smallholder farmers utilize to reduce their vulnerability in the face of global environmental change. More diversified farming systems have been documented to suffer less from shocks and maintain the household's ability to adapt to changing conditions (Verchot et al. 2007; Thorlakson and Neufeldt 2012). Often, the integration of trees on farms results in a more diversified and sustainable crop production (Kandji et al. 2006). Diversification builds livelihood resilience in a variety of ways. First, diversification expands the number of potential crop types for market (McCord et al. 2015). Many fruit species are seasonal and having a variety of tree crops can spread out the benefits of agroforestry throughout the year. Second, diversification of plant species builds redundancy into the agricultural system, which in turns results in a higher diversity of types of responses to disturbances (response diversity) (Dawson et al. 2013; McCord et al. 2015). Redundancy is an important aspect of resilience (Walker and Salt 2006) and a household with a greater number of crops may therefore have greater livelihood resilience to disturbance than a household with only a few crop types. Redundancy also means that a significant proportion of diversity in an agricultural system could be lost without significant impact on farm production in the short term (Dawson et al 2013). For example, pests might destroy one type of cash crop, but leave others untouched, and therefore the farmer can still rely on the unaffected crop for cash income. Agroforestry provides diversity on the farm and trees may respond very differently to disturbances than traditional crops. Therefore agroforestry may build livelihood resilience to uncertainty by enhancing both livelihood diversity and on-farm diversity.

The importance of diversity in building livelihood resilience goes well beyond the household level (Ellis 2000). Policies that promote regional or country-wide livelihood diversity can help fight against larger-scale shocks including fluctuations in prices for agricultural products and economic recessions. For example, an agricultural region may be more vulnerable to crop disease, pests, or price fluctuations if it relies on one major crop, instead of a diversity of agricultural crops. The concept of redundancy applies not only to the household scale, but larger regional scales.

Conclusion

In this paper we asked the question if and how agroforestry may build livelihood resilience to help smallholder farmers cope and navigate through an uncertain future? Using empirical evidence from two communities in Isiolo County, Kenya we find that agroforestry is building livelihood resilience by using the five livelihood capital assets from the sustainable livelihoods approach as a method for organizing indicators of resilience. Households with agroforestry were on average 10% more resilient than households not practicing agroforestry.

This research aims to answer the call for more comprehensive, empirical evidence about the links between agroforestry and resilience. Four major findings may apply to larger regional or global scales. First, agroforestry improves financial capital, which in turn can be used to improve other capital assets. Building a strong livelihood capital base will help households anywhere deal with a variety of livelihood shocks. Second, agroforestry provides many non-economic benefits that promote livelihood resilience including an improved quality of life, environmental conservation, and shade. Third, in arid regions specifically, irrigation may be an important component not only for promoting agroforestry, but building livelihood resilience. Lastly, agroforestry can promote livelihood and on-farm diversity, thus building redundancy into the agricultural system.

These four findings have broader implications for the development community both in Kenya and elsewhere. Currently, resilience is a hot topic or 'buzz word' in international development. This paper provides four specific findings that development organizations may be able to draw from in their own resilience-building projects. For example, projects could be implemented based around using agroforestry as one method for diversifying livelihood options, thus helping household build their general livelihood resilience. While results may vary in different communities, in our study sites agroforestry was playing an important role in building livelihood resilience to uncertainty. As summarized by a female farmer in Burat, “I planted these trees so that if there is a time when I am lacking something it [trees] will help me. If you are able to plant trees, it will help you.”

CHAPTER 6. THE ROLE OF AGROFORESTRY IN BUILDING LIVELIHOOD RESILIENCE TO FLOODS AND DROUGHTS IN SEMI-ARID KENYA

Abstract

Climate change may create serious problems for farmers by increasing precipitation variability, drought and flood events. Understanding how to build livelihood resilience to these impacts is a pressing need. Agroforestry, the intentional integration of trees into an agricultural landscape, is one potential solution. While many intuitively link agroforestry with livelihood resilience to floods and droughts, little comprehensive, empirical evidence exists. This paper draws on data from two smallholder farming communities in Isiolo County, Kenya to answer this call for more evidence. The study utilized a mixed-methods approach which included 20 qualitative case study households, 339 quantitative household surveys, and rainfall and river level records. The sustainable livelihoods approach was employed to measure livelihood resilience.

Overall, agroforestry helped to build livelihood resilience by providing both livelihood (income, food, fodder), and environmental benefits (shade, erosion prevention, windbreakers) during floods and drought. Agroforestry served as an important source of supplemental income and helped to diversify livelihood strategies. About 74% of respondents planted trees thinking trees would support their livelihoods during drought. Agroforestry also influenced perceptions of drought in these communities. Identifying potential climate change adaptation strategies is crucial for smallholder farmers and, according to this research, agroforestry is one promising option.

Introduction

"We decided to plant trees because they do not dry up fast during times of drought… these times it helps us, the times when there is no rain, it helps us. If you water it a little bit, it produces fruit and you eat." – Burat, Kenya, female farmer

Climate change is creating serious challenges for people globally. It is projected to increase global temperatures which could affect the agricultural growing season, negatively impact human health, and increase drought (Noble et al. 2014). Understanding how to build livelihood resilience to the impacts of climate change, such as floods and droughts, is important as livelihood systems must prepare for and adapt to global and local changes in order to maintain environmental, political, and economic sustainability. Agroforestry, the purposeful integration of trees into farms and agricultural landscapes, may be able to build livelihood resilience to the impacts of climate change for smallholder farmers. However, while there has been significant research about agroforestry technologies, less is known about how agroforestry contributes to building livelihood resilience to floods and droughts (Thorlakson and Neufeldt 2012). There has been a call from the academic and development communities for more empirical evidence about the links between agroforestry and livelihood resilience to climate change (Lin 2011, Thorlakson and Neufeldt 2012). Wangari Maathai (2012: 5), 2004 Nobel Peace Prize Laureate, stated that "trees have an important role to play not only in climate change mitigation but also in reducing vulnerability to climate related risks." In this paper we strive to answer the call for more empirical evidence by drawing on field work in Isiolo County, Kenya to ask if and how agroforestry helps smallholder farmers build livelihood resilience to floods and droughts?

Theoretical framework

This paper is framed using resilience theory and the concept of livelihood resilience. Resilience theory arose out of the field of ecology in 1973 (Holling 1973) and has since been adapted to a variety of disciplines (Fath et al. 2015). Walker and Salt (2006) define resilience as the capacity of a system to absorb disturbance and still retain its basic function and structure. A resilient social-ecological system has the adaptive capacity to face shocks, then learn and recover from them (Walker and Salt 2006). Resilience centers on the questions ‘resilience of what’, ‘resilience to what’, and ‘resilience for whom’ (Brown 2014). We focus on the livelihood resilience of farmers in Isiolo County, Kenya to floods and droughts.

The concept of livelihood resilience is increasingly relevant as households are more involved in global transitions in climatic and social systems (Tanner et al. 2015). Livelihood resilience is defined by Tanner et al. (2015: 23) as “the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances.” Livelihood resilience strengthens people’s ability to prepare and adapt their livelihoods to climate-related events (Ngigi et al. 2015).

Agroforestry and livelihood resilience to climate change

While different for various scenarios, climate models for Africa predict between 3°C and 4°C degree increase in temperatures by the end of the 21st century, roughly 1.5 times the global mean increase (Bryan et al. 2013). With temperature increases at this magnitude, climate change will have negative impacts on agriculture (Porter et al. 2014). Dryland agriculture in the semi-arid regions of the world is particularly vulnerable because of rainfall related production risk and high evapotranspiration (Porter et al. 2014).

Floods and drought form a natural bridge between climate change and climate change adaptation (Brown and Williams 2015). Climate change is expected to cause an increase in the number and strength of natural hazards such as floods and drought (Porter et al. 2014), and these impacts are most severe at the local scale where lives and livelihoods are affected (Shaw 2006). Households must adapt by adjusting their livelihoods to the impacts of climate change (Speranza 2012). Adapting livelihoods to cope with change is nothing new; however, because of the potentially severe impacts climate change is expected to have on food security (Brown and Funk 2008), agriculture (Verchot et al. 2007), and livestock (Nardone et al. 2010), it is important to build livelihood resilience. Adopting agroforestry has been proposed as one livelihood activity that can help build livelihood resilience to floods and droughts (Kandji et al. 2006, Verchot et al. 2007, Garrity et al. 2010, Lin 2011, Thorlakson and Neufeldt 2012, Bryan et al 2013, Simelton et al. 2015).

Agroforestry is a multifaceted, ecologically-based, natural resource management system that, through the integration of trees on farms and within the agricultural landscape, is believed to diversify and sustain production for increased social, economic, and environmental benefits (Franzel and Scherr 2002, Schroth et al. 2004). Agroforestry practices involve combinations of trees, crops, and animals in various spatial arrangements or temporal sequences on the landscape (Rocheleau et al. 1988, Sinclair 1999). The social and ecological benefits of agroforestry include income, food, energy, construction materials, animal fodder, and soil and water conservation (Rocheleau et al. 1988, Franzel and Scherr 2002).

Some of the ecological characteristics of agroforestry species make them more resilient to floods and droughts, including deep root systems that are able to utilize a greater soil volume for water and nutrients (Kandji et al. 2006, Verchot et al. 2007). Shade trees can produce microclimates that buffer temperature fluctuations (Lin 2007), which in turn can reduce evapotranspiration. Further, trees have the ability to buffer crops from storms and storm damage (Philpott et al. 2008).

There is some evidence that agroforestry is already being adopted by farmers to adapt to the impacts of climate change (Thorlakson and Neufeldt 2012, Bryan et al. 2013, Simelton et al. 2015). Thorlakson and Neufeldt (2012) reported that some farmers in Kenya relied on fruit trees for income during floods when other crops were washed away, and during drought farmers sold fuel wood and timber to purchase food. In Kenya, Bryan et al. (2013) found that farmers desired to invest in agroforestry and irrigation to adapt to climate change. Lastly, in Ethiopia, *Enset ventricosum*, a drought resistant, banana-like plant, is utilized as a staple drought food for 10 million people (Brandt et al. 1997). These studies begin to provide evidence of the role of agroforestry in building livelihood resilience to floods and droughts. However, none take a comprehensive livelihood resilience approach to linking agroforestry with resilience to floods and droughts, as done in this paper.

Methods

This study utilized a mixed methods research approach that included 20 in-depth, qualitative, household case studies and 339 quantitative surveys in two communities. All households that participated practiced agriculture, but not all practiced agroforestry. According to the Oxford English Dictionary (2016), a tree is defined as a woody perennial plant. However, this definition was expanded for this study to include other tree-like plants such as bananas and papayas.

Study area

Research was conducted in the communities of Burat and Kinna in Isiolo County, Kenya (Figure 6.1). The population of Burat is about 6,500 (Kariuki 2010), however, the majority of residents live along the banks of the Isiolo and Aye Nakore Rivers approximately 3km from Isiolo Town. Turkana, Meru, Somali, Samburu, and Borana ethnic groups live in Burat and all have historical claims to the land (Boye and Kaarhus 2011). In Kinna research for this study was conducted in Kinna Town, which is ethnically Borana and includes about 900 households (Jillo 2006). The climate in Isiolo County is changing and since the 1970s the long rains have declined by more than 100 millimeters and there has been a warming of more than 1°C (Funk et al. 2010).

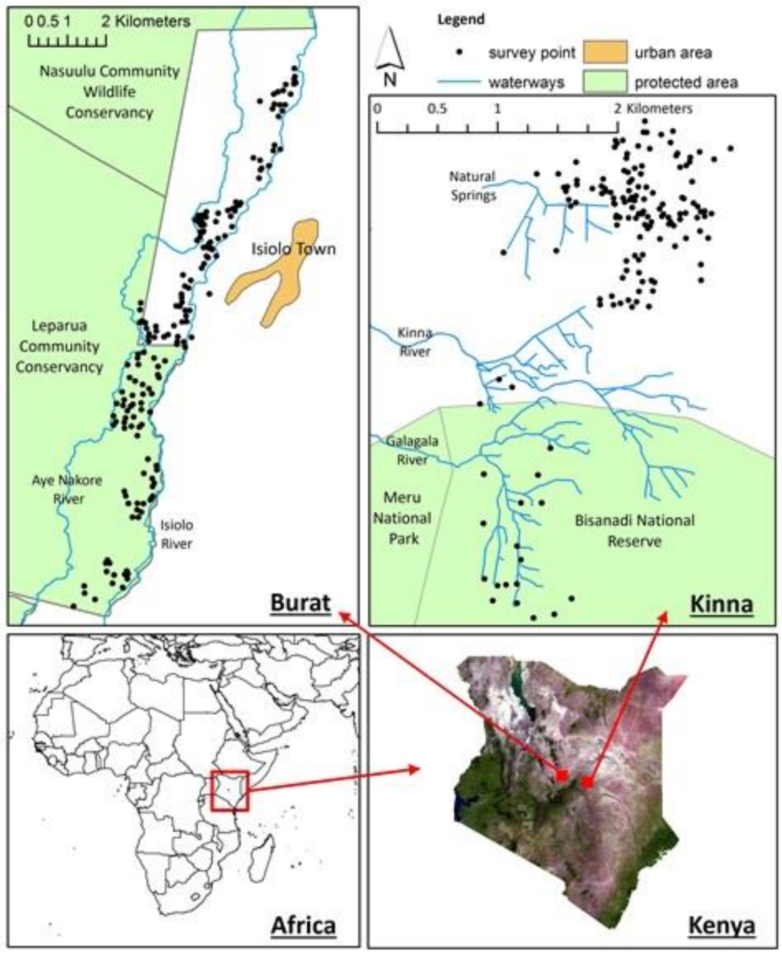


Figure 6.1 Study area map

Livelihoods in Isiolo County have changed in the past 50 years. In Kinna, Borana have been adopting agriculture as a coping strategy for livestock poor households (Otuoma et al. 2009). Massive livestock losses are attributed to the *shifta* war (Hogg 1983), and droughts in the 1970s and 1980s (Helland 1998). The response of the government after the *shifta* war ended was to establish small-scale irrigation schemes (Hogg 1989). According to Kinna elders, the irrigation scheme was dug by the government in 1969 (personal communication). Different from Kinna, agriculture began in Burat during the colonial period on small-scale experimental farms run by government officials (Kenya National Archives). However, agriculture began with native populations when Meru began moving into the area and claiming farmland in the late 1970s (personal communication). Irrigation in Burat is through pipes and generators from the Isiolo and Aye Nakore Rivers. Organizations such as the Kenya Red Cross Society and ActionAid have assisted in providing pipes.

Sustainable livelihoods approach to measuring livelihood resilience to floods and droughts

The sustainable livelihoods approach emphasizes that livelihoods should be considered in terms of people's access to capital assets, the ways in which people combine these capital assets to create livelihoods, and how they are able to enlarge their asset base through interactions with actors and institutions (Chambers and Conway 1992; Carney 1998). At the core of the sustainable livelihoods approach are the five capital assets: financial, physical, natural, human, and social. Social capital includes networks, groups, and associations, and relationships of trust and reciprocity (Adger 2003). Physical capital refers to access to services and infrastructure (Adato and Meizen-Dick 2002). Human capital encompasses the skills, knowledge, education, health, and labor availability of the household (Tacoli 1999). Financial capital refers to savings,

Table 6.1 Household survey livelihood resilience indicators

Asset	**Quantitative Indicator** (Independent Variables)
Financial Capital	• Salaried job (yes or no) • Access to a bank account (yes or no) • Remittances (yes or no) • Household belongings (# of belongings) • Livestock (# of livestock) • Size of farmland (# of acres) • Ownership of farm equipment (own, rent, borrow pieces of equipment)
Human Capital	• Labor availability (number of household members between 18 – 55) • Education (level of education of respondent) • General health of family (scale of poor to good) • Health problems impact on ability to practice livelihoods (Scale of no to very much)
Social Capital	• Family living nearby (yes, how close) • Political influence or power (scale of none to a lot) • Participation in groups (# of groups) • Participation in agriculture or tree planting group (yes or no) • Strength of relationship with neighbors (# of activities done with neighbors)
Physical Capital	• Normal and rainy season road conditions (scale of good to bad) • Presence of facilities (schools, hospitals, etc.) near home (yes or no) • Access to irrigation schemes (yes or no) • Ownership of farming equipment (own, rent, borrow pieces of equipment)
Natural Capital	• Size of farmland (# of acres) • Own farmland (yes or no) • Diversity of farm crops (# of different crops planted) • Livestock (# of livestock) • Soil erosion (rank of severity of soil erosion on farm)

credit, remittances, and financial assets (Campbell et al. 2001, Erenstein et al. 2010). Lastly, natural capital includes access to environmental services and resources (Campbell et al. 2001; Erenstein et al. 2010). In this paper we draw from the five livelihood capital assets to create measurable indicators of livelihood resilience (Table 6.1), since some indicators of resilience are difficult to put a monetary value on. Resilience is a key component of sustainable livelihoods and similar approaches to measuring resilience have been used elsewhere (Erenstein et al. 2010, Thulstrup 2015).

Data collection

Field work took place between July 2014 and July 2015. A total of 339 quantitative household surveys were conducted from March to May 2015; 152 in Kinna and 187 in Burat. The surveys represent a statistically representative sample size of agricultural households in both Kinna and Burat. The survey focused on demographics, livelihood activities, perceptions of floods and droughts, and agroforestry during floods and droughts. Surveys were conducted by enumerators who participated in a two day training. Surveys were conducted in either Swahili or Borana based on the language ability of the respondents. At each household either the male or female household took part in the survey based on who was available and willing to participate. Enumerators surveyed every other household along a transect, and if no one was available enumerators surveyed the very next available household. GPS points were taken at each survey household.

The qualitative household case studies included 20 households in total, 13 in Burat and 7 in Kinna. These households were selected through combined convenience and respondent-driven sampling (Bernard 2011). Each household was interviewed three times, and when possible both male and female households head were interviewed. The aim of the first interview was to gather information about household livelihoods. Each household was then interviewed during the rainy season (April-May 2015) and dry season (August-October 2014). These interviews were in-depth, unstructured, and centered around 6 to 8 discussion topics. The rainy season interviews focused on floods, while the dry season interviews focused on droughts. The purpose of these unstructured interviews was to capture what Bernard (2011) calls the 'lived experience' of humans. Interviews took place in Swahili, were recorded, and transcribed verbatim using Phillips SpeechExec Transcribe 7.1 software.

Rainfall data for Isiolo was obtained from the Isiolo County Agricultural Office, and river gauge data for Isiolo River obtained from the Isiolo Water Resources Management Authority. Informal interviews were conducted with water committees in Kinna and Burat to understand the irrigation system in each community. Historical information was collected through the Kenya National Archives.

Data analysis

The quantitative survey data was analyzed in Microsoft Excel and STATA IC13 software programs. Statistical tests, one-way ANOVAs, and regression analysis were conducted. This research draws on the sustainable livelihoods approach, and while a variety of analytical methods exist to analyze, compare, and contrast livelihood capitals, we drew from previous work by Campbell et al. (2001) and Erenstein et al. (2007). For each indicator, the variety of answers were given a score from 0 (worst, less desirable) to 1 (best, more desirable). Then for each survey household a simple, unweighted, composite index was calculated as the average of the indicator values for each livelihood capital.

The qualitative household case study interviews were coded using QSR NVivo 10. Codes were developed from the academic literature, the discussion topics, and themes that emerged during the research process. An analytical summary was written for each household. The different sources of data (qualitative, quantitative, and ecological) were compared and contrasted to triangulate results in an iterative process. In this paper, names are omitted in all quotes.

Results

Livelihoods and household characteristics

Table 6.2 provides a summary of characteristics for household survey respondents in both communities for households with and without agroforestry. Households practicing agroforestry were significantly more likely to have access to irrigation and plant a greater number of crop

Table 6.2 Summary of household characteristics**.** The first number provided is the mean and the second is the standard deviation. The households are divided up by community and if the household practices agroforestry or not.

	Burat		Kinna		All
	Agroforestry	No Agroforestry	Agroforestr y	No Agroforestry	
Household size (# of people)	7.4 (3.9)**	5.9 (2.7)**	6.6 (2.3)	7.2 (2.4)	6.8 (3.1)
Age of respondent (years)	44.5 (16.3)	40.7 (13.4)	45.0 (15.7)	42.8 (15.8)	43.6 (15.5)
Respondent's length of time living in the area (years)	31.7 (15.4)**	22.8 (14.9)**	29.8 (16.6)	28.5 (17.9)	28.8 (16.4)
Access to irrigation (yes = 1, no = 0)	0.84 (0.37)*	0.72 (0.45)*	0.97 (0.18)**	0.86 (0.35)**	0.86 (0.35)
Importance of irrigation (scale of 1 = not important to 4 = very important)	3.69 (0.82)	3.5 (0.95)	3.94 (0.35)	3.88 (0.43)	3.77 (0.69)
Number of different crops planted	8.2 (4.8)**	6.4 (4.1)**	5.2 (2.7)**	3.8 (2.6)**	6.2 (4.1)
Number of months that crops fed the household last year	5.7 (4.5)**	3.9 (3.6)**	3.5 (2.3)	3.3 (3.0)	4.3 (3.7)
Has your household livelihoods been impacted by floods? (yes = 1, no = 0)	0.54 (0.5)	0.52 (0.5)	0.72 (0.45)**	0.44 (0.5)**	0.57 (0.5)
N	118	68	93	59	338

* one-way ANOVA test of variance where we can reject the hypothesis that the means are equal between households with and without agroforestry with **p < 0.1**
** one-way ANOVA test of variance where we can reject the hypothesis that the means are equal between households with and without agroforestry with **p < 0.05**

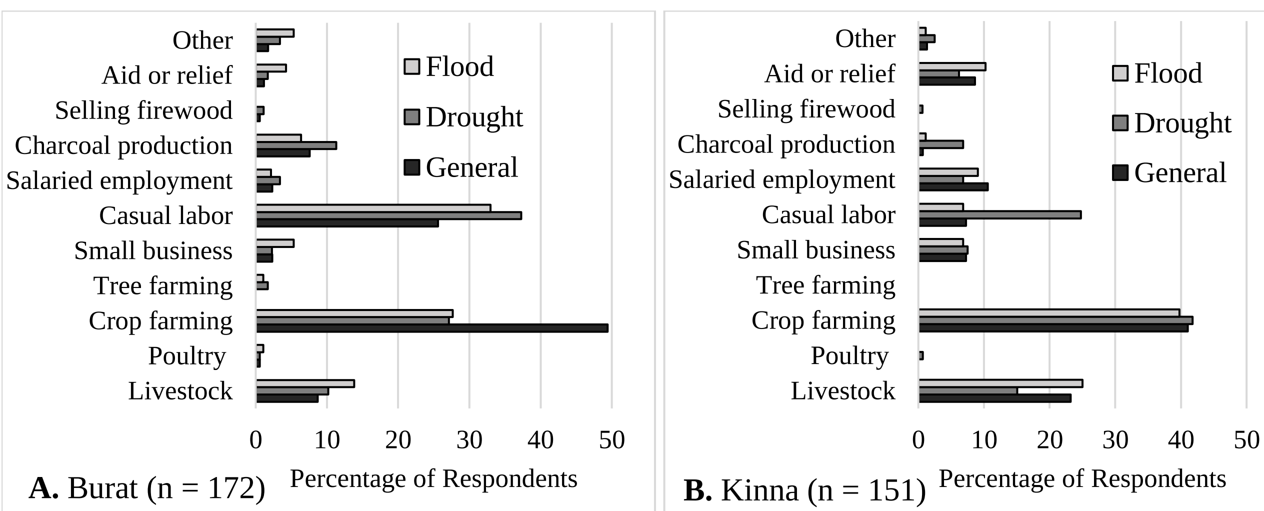
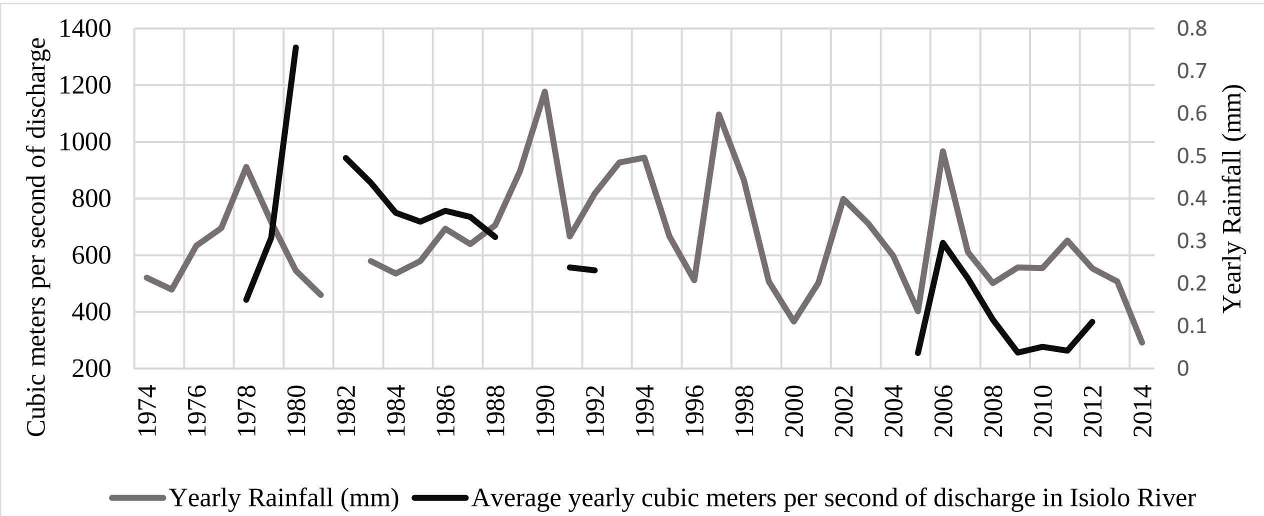
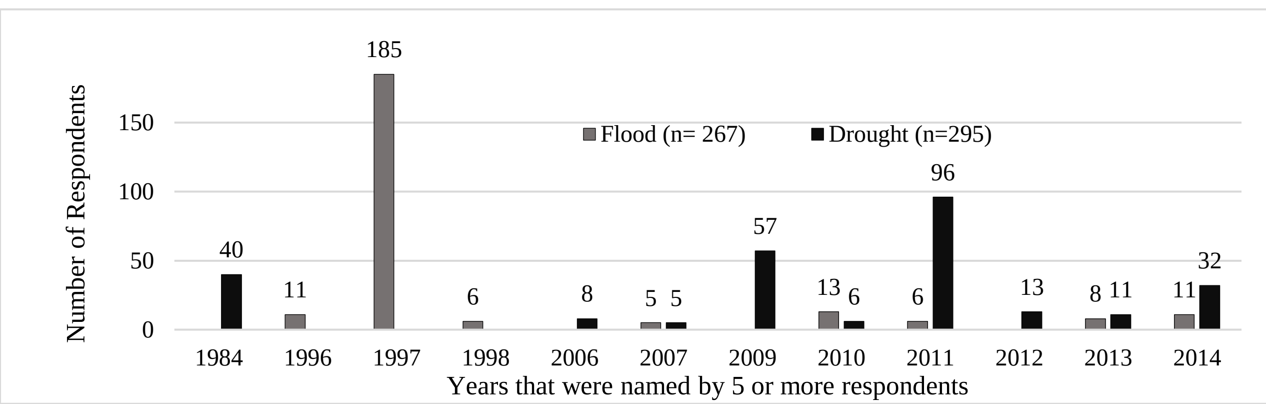


Figure 6.2 Primary livelihood activities generally, and during times of floods and drought for Burat (A) and Kinna (B). This data is from the household survey. Households could only name one primary livelihood generally, and during floods or droughts.

species. However, a spearman's correlation found only a weak positive correlation between access to irrigation and agroforestry (r_s = 0.1445, p = 0.0082). Major livelihood activities in both communities shifted during times of drought and floods (Figure 6.2a and Figure 6.2b). During drought, the livelihood activities of casual labor and charcoal production increased in both communities to help households cope. Results show fewer changes of livelihood activities during floods.



A



B

Figure 6.3 Rainfall and river water data (A) and local perception of the last big floods and droughts (B). Figure 3a is a combination of yearly rainfall gauge data taken in Isiolo Town and yearly average for river discharge on the Isiolo River. These two data sets are not complete but all the years available are presented here. Additionally, there are linear trend lines for both the rainfall amount and river discharge. Figure 3b illustrates the last big flood and drought years named by household survey respondents.

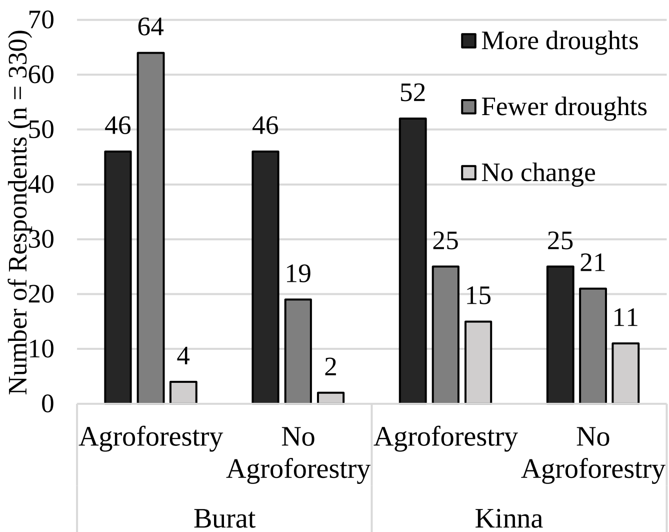
Ecological and rainfall data

Both rainfall and river discharge data for the past 40 years for Isiolo County indicate that rainfall is decreasing in the area (Figure 6.3a). River discharge has particularly decreased, most likely due to the combination of less rainfall and an increase in water use for irrigation upstream as discussed in the household case study interviews. The driest year on record is 2014, when much of this research was conducted. Household survey respondents were asked about the most recent large droughts and floods in the area (Figure 6.3b). The El Nino flood in 1997 was reported by many respondents, while 1984, 2009, 2011 and 2014 were described as drought years.

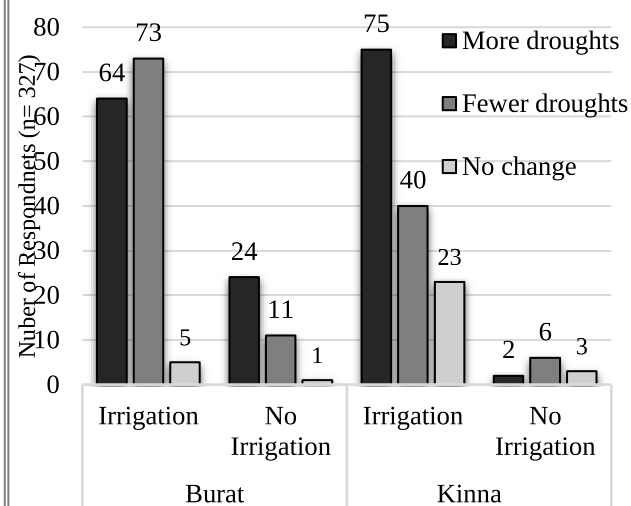
Perceptions of flood and drought

Survey households were asked about the changes in the frequency and severity of flood and drought, along with changes in rainfall predictability over the past 10 years. Households overwhelmingly agreed that floods are becoming less frequent (154 out of 195 respondents impacted by floods), less severe (151 respondents), and that the timing of the rains has become less predictable (171 respondents). However, the perceptions of changes in drought (Figure 6.4a) were very different between communities and households that practiced agroforestry or not.

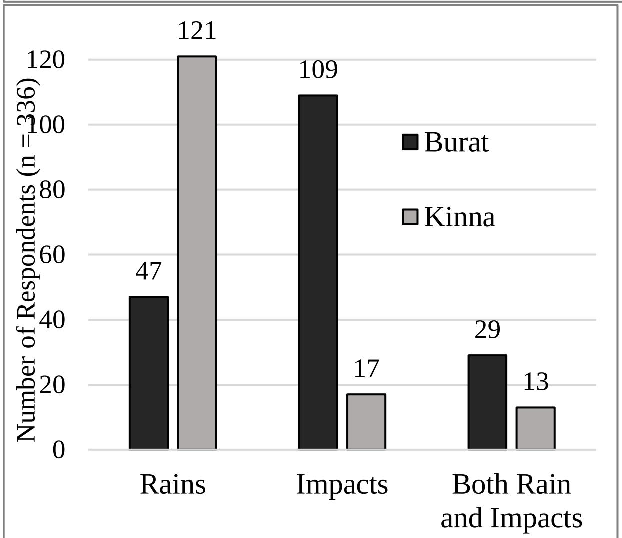
Figures 6.4a and 6.4b show that perceptions of the changes in drought frequency over the past ten years varied between communities and if a household practiced agroforestry and had access to irrigation. In Burat the majority of households with agroforestry and access to irrigation responded that droughts were less frequent; while most households without agroforestry and access to irrigation stated the opposite. Kinna differed from Burat and answers remained consistent regardless of agroforestry and access to irrigation. The fact that households in Burat with agroforestry and access to irrigation found droughts to be less frequent than 10 years ago is both important and interesting. The number of trees, tree diversity, tree density, and livelihood capitals do not explain this trend as they were not significantly correlated with perceptions of drought. Responses were also not correlated with ethnic groups.



A. Change in Frequency of Drought Over 10 Years



B. Change in Frequency of Drought Over 10 Years Based on Access to Irrigation



C. Definitions of Drought by Community

Figure 6.4. Perceptions of the changes in the frequency of drought over the past 10 years. These figures are based on the household survey responses. **(A).** Perceptions of change in frequency of drought over the past ten years between communities and if a survey household practiced agroforestry or not. Overall, this was not statistically significant; while for Burat alone there was a correlation found between agroforestry and perception of drought with a $chi^2 = 13.7896$ and $p = 0.001$. **(B).** Perceptions of change in the frequency of drought over the past ten years between communities and if a survey household had access to irrigation or not. The results for both communities were not statistically significant. **(C).** Definitions of drought based on community. Each survey household was asked to give a brief definition of drought. These responses were coded into if they focused primarily on the rains or water generally, the impacts of droughts, or both. A zero-truncated negative binomial regression model showed that these results were significant with a p-value = 0.00.

From the qualitative data, the most likely explanation is the different histories behind irrigation and agroforestry in Kinna and Burat and the differing definitions of drought in each community. Each survey respondent was asked to define drought. Many respondents in Burat discussed drought in terms of the impacts of drought (i.e. livestock death, food security issues, etc.), while in Kinna respondents discussed drought in terms of a lack of rainfall (Figure 6.4c). Furthermore, the qualitative interviews indicated that the widespread adoption of agroforestry, agriculture, and irrigation in Burat has been much more recent than in Kinna. Thus, when comparing ten years ago to now, survey respondents in Burat may not feel the impacts of drought as much as 10 years ago because of these changes. This is particularly important because in Burat respondents generally defined drought in terms of its impacts and not rainfall directly. As explained by a female farmer in Burat, "… for others [drought] is there. For me,

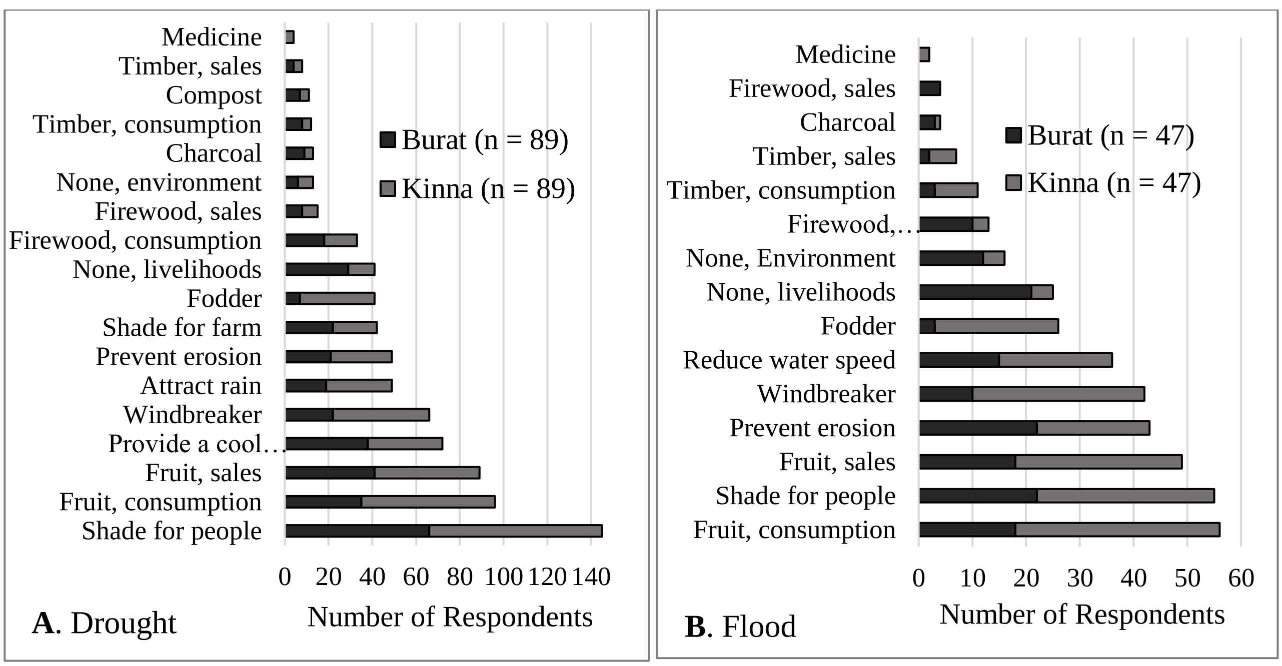


Figure 6.5 Livelihood and environmental benefits of trees during drought (A) and flood (B). This data is taken from the household survey. Households could name multiple benefits of trees for both livelihoods and the environment. This figure shows the total number of respondents that listed each benefit, along with the number of respondents from the two research communities of Burat and Kinna. Households that have not planted trees are not included.

Table 6.3A Tree species and the reason listed for why they do well or their benefits during flood. The numbers in the boxes are the numbers of respondents that named that specific tree and that specific benefit. Survey respondents were allowed to name multiple reasons for why a specific tree does well during floods.

Tree Species	Prevent Erosion	Income	Food	Flood resistant	Windbreaker	Reduce water speed	Shade
Papaya	-	3	5	-	-	-	-
Mango	**-**	**24**	**23**	**13**	**10**	**7**	**9**
Banana	1	3	2	-	-	-	-
Orange	1	1	1	1	1	1	1
Grevillea robusta	1	-	-	1	1	1	1
Guava	3	2	2	3	2	1	-
Neem (*Azadirachta indica*)	3	-	-	5	3	1	1
Indigenous	-	-	1	**6**	2	-	2
Acacia sp.	-	-	-	3	1	-	-
Euphobia	-	-	-	2	1	2	1
Tamarind	-	2	2	4	2	0	3
Total	9	**35**	**36**	**38**	23	13	18

Table 6.3B Tree species and the reasons listed for why they do well or their benefits during drought. The numbers in the boxes are the numbers of respondents that named that specific tree and that specific benefit. Survey respondents were allowed to name multiple reasons for why a specific tree does well during droughts.

Tree Species	Uses less water	Drought resistant	Income	Food	Shade	Fast production	No pesticides	Fodder
Papaya	4	6	**16**	**27**	5	6	1	-
Mango	**16**	**25**	**39**	**31**	**32**	3	6	**5**
Banana	1	4	**8**	**13**	1	3	2	2
Avocado	-	-	2	2	-	-	1	-
Cassava	1	2	1	1	-	-	-	-
Orange	1	2	2	2	2	1	1	-
Grevillea robusta	-	-	1	0	-	-	-	-
Guava	2	2	4	4	4	1	1	2
Custard apple	-	-	-	1	-	-	-	-
Neem (*Azadirachta indica*)	1	5	-	-	**7**	-	2	1
Indigenous	1	6	-	-	**7**	-	-	2
Acacia sp.	2	4	-	-	4	-	2	**4**
Euphobia	1	3	-	-	2	-	1	1
Jacaranda	-	1	-	-	1	-	1	1
Eucalyptus	1	-	-	-	-	-	-	-
Tamarind	4	5	3	2	7	-	-	**4**
Miraa	-	-	1	-	-	-	-	-
Lemon	-	-	-	1	1	-	-	-
TOTAL	35	**65**	**77**	**84**	**73**	14	18	22

not bad like it used to be. You see, now I harvest at least a little, it is not that bad. But for others there is drought."

Benefits of trees during flood and drought

According to survey respondents, agroforestry provided livelihood and environmental benefits during floods and drought; the top benefits for both were shade and fruit for sales and household consumption (Figure 6.5). Many environmental benefits were named; for example, a male farmer in Burat said that by "planting trees in a line, it prevents the soil from being swept away by water." Table 6.3 breaks down the benefits of agroforestry during floods and droughts by specific tree species as discussed by the household case study participants. For floods, mango trees were named repeatedly as trees that provide multiple benefits including income and food. During drought, mango, papaya, and banana were listed as being important tree species. As a male farmer from Burat explained about mango trees, "their roots travel far, trees are able to get water from deep down." However, mango often take a long time to grow. Papaya and banana were repeatedly listed as trees that are helpful in drought because they produce fruit year round. However, they do need to be watered occasionally and may dry up during severe droughts.

Household survey respondents were asked how important trees were to their livelihoods during floods and droughts, and during the 1997 El Nino flood (Table 6.4). Agroforestry was very important during drought to just over half of household survey respondents practicing agroforestry. Households with more trees ($p = 0.021$) and a greater diversity of tree species ($p = 0.028$) were more likely to say that trees were important during drought. During floods the majority of survey households in both Burat and Kinna said that trees were important both generally, and during the El Nino of 1997 specifically. However, these answers were not

Table 6.4 Percentage of survey respondents who listed agroforestry as being important for the household livelihood during drought, floods, and the El Nino flooding of 1997. The sample sizes vary because not all respondents were asked all questions. For example, these figures leave out all households without agroforestry. Additionally, households who had never experienced flooding were not asked flood questions.

	Drought			Flood			El Nino 1997		
	Burat (n = 91)	Kinna (n = 89)	Total (n = 180)	Burat (n = 48)	Kinna (n = 45)	Total (n = 93)	Burat (n = 42)	Kinna (n = 45)	Total (n = 88)
Not important	22	2.3	12.2	14.6	2.2	8.6	19.1	4.4	11.4
A little important	9.9	24.7	17.2	14. 6	28.9	21.5	11.9	30.4	21. 6
Somewhat important	8.8	18	13.3	10. 4	8.9	9.7	11.9	15.2	13.6
Very Important	59.3	55.1	55.1	60.4	60	60.2	57.1	50	53.4
Pearson chi^2			23.0689			6.3924			8.0526
p-value			0.000			0.094			0.045

statistically significant with the number of trees or tree diversity. An elderly female farmer in Kinna reported "I depend on selling these mangos for food during floods."

Households that were able to sell fruit during flood or drought events were more likely to rank agroforestry as very important (Table 6.5). This highlights the importance of fruit sales in

Table 6.5 Importance of fruit sales and agroforestry during drought and flood. This figure shows the percentage of household survey respondents' ranking of the importance of agroforestry during drought or floods based on if they can sell fruit or not during drought or flood. The importance of drought was on a four point scale from not important to very important. Rankings of the importance of agroforestry are statistically significantly correlated to if a household is able to utilize their agroforestry to sell fruit during floods or droughts.

Importance of Agroforestry		**Not Important**	**A Little Important**	**Somewhat Important**	**Very Important**
Sell fruit during drought?*	**Yes** (n = 89)	4.55	37.93	62.50	62.00
	No (n = 86)	95.45	62.07	37.50	38.00
Sell fruit during floods?**	**Yes** (n = 48)	12.50	36.84	33.33	67.27
	No (n = 43)	87.50	63.16	66.67	32.73

* Logistic regression models found this to be statistically significant with p = 0.000. In Burat only p = 0.000, in Kinna only p = 0.016.

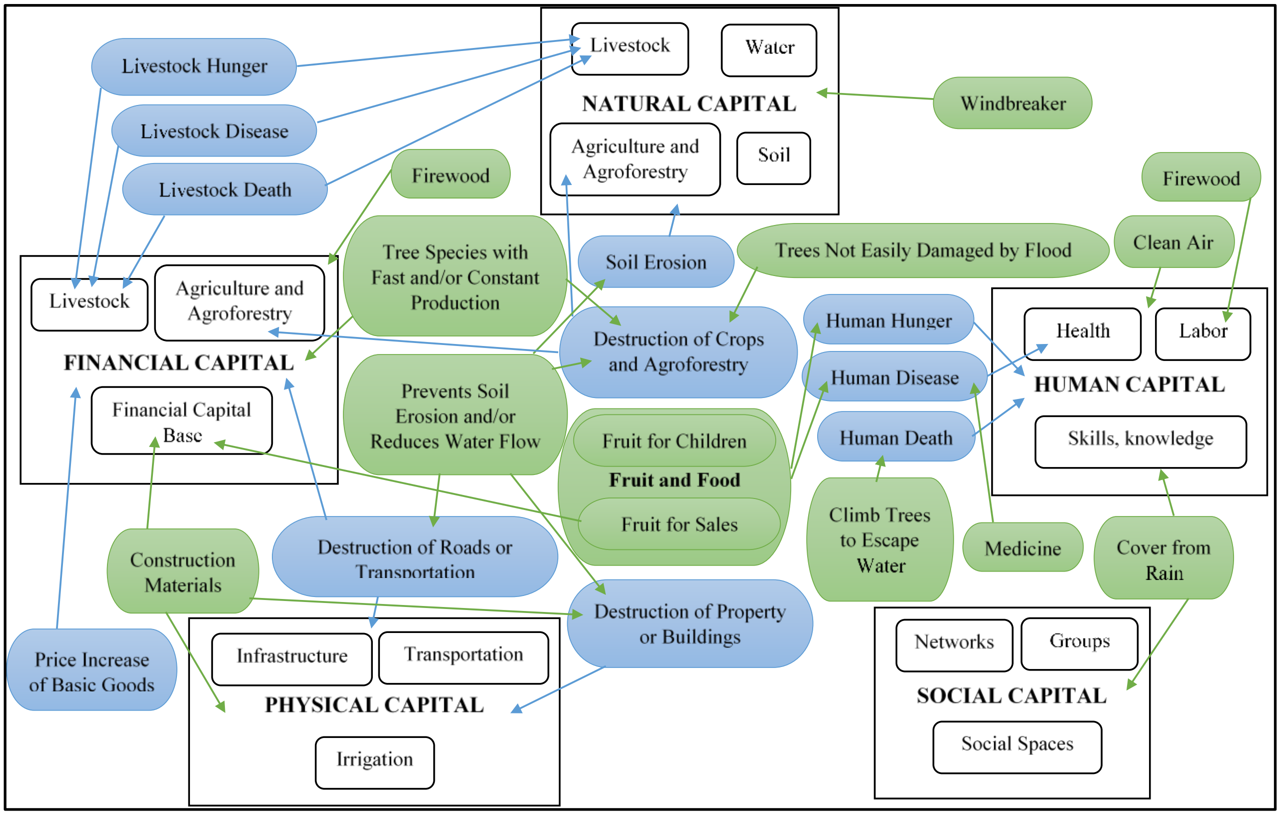
** Logistic regression models found this to be statistically significant with p = 0.001. In Burat only p = 0.011, in Kinna only p = 0.086.

building livelihood resilience. Lastly, survey households were asked if they had planted trees thinking that it would help them cope during either floods or droughts. In both Burat and Kinna, about 74% of respondents said that they had planted trees with drought in mind. For floods, 65% of respondents in Burat and 43% of respondents in Kinna said that they had planted trees with floods in mind.

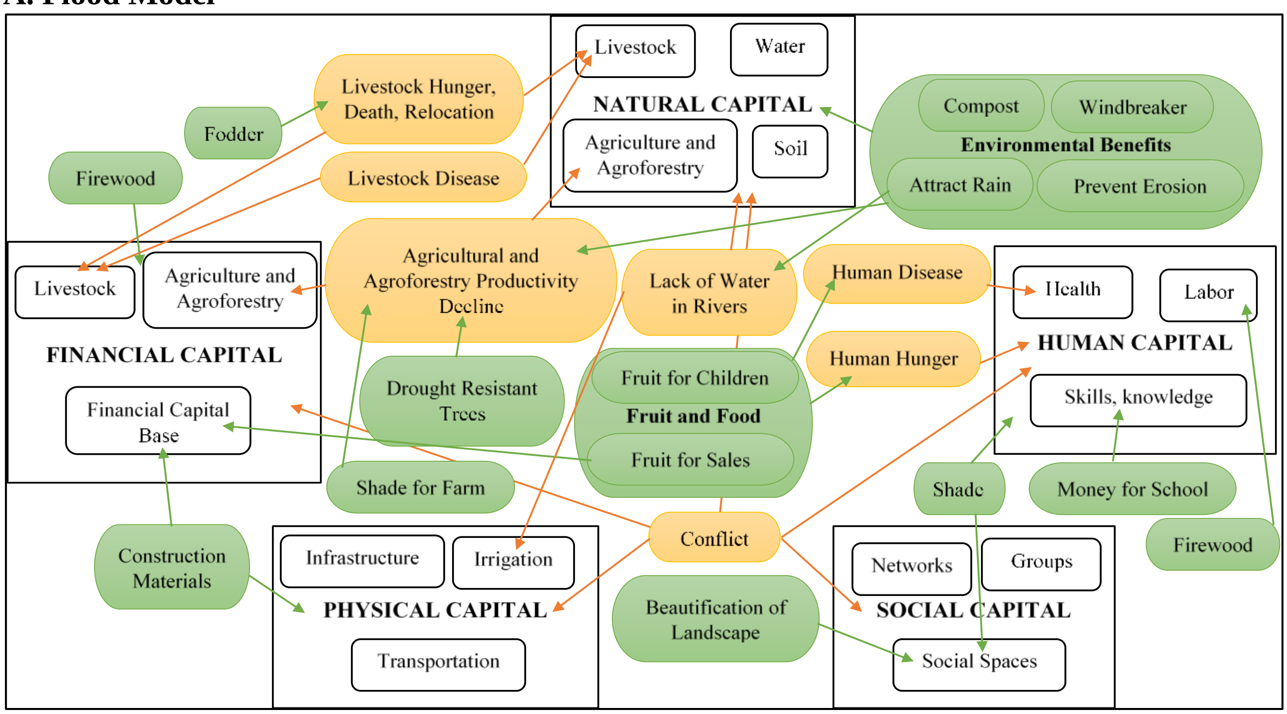
Agroforestry and livelihood capitals

Household case study participants discussed how their livelihoods have been impacted by floods and droughts and how trees mitigate those impacts, both directly and indirectly (Figure 6.6). These flowcharts utilize the five livelihood capital assets of the sustainable livelihoods framework to conceptualize these relationships and impacts. Some of the benefits of agroforestry are the same for both flood and drought including fruit for sales and consumption, firewood, construction materials, and preventing soil erosion. However, as floods and droughts have some different impacts on the five livelihood capital assets, trees also have different roles to play in mitigating and helping households cope with these impacts. For example, floods can lead to various water and insect borne diseases and trees were cited to provide traditional medicine during flood. During droughts, household case study participants discussed how trees provide shade on their farms which helps to retain soil moisture for their crops.

To complement Figure 6.6, the livelihood capital asset scores of each survey respondent (financial, human, social, physical, and natural) were divided into households that ranked agroforestry as being important, a little important, somewhat important, or very important during floods and droughts. Only financial capital showed significant differences between the households for floods and the 1997 El Nino, but not drought (Figure 6.7). Those survey



A. Flood Model



B. Drought Model

Figure 6.6 Flow charts of the impacts of floods (A) and droughts (B) on livelihood capitals and the benefits of trees. These flow charts were derived from the household case study interviews. The bubbles represent different themes that arose during the interviews. Figure 6A illustrates the impacts of floods on livelihood capitals (blue) and how trees benefit households during floods both directly and indirectly (green). Figure 6B illustrates the impacts of droughts on livelihood capitals (orange) and how trees benefit households during droughts both directly and indirectly (green).

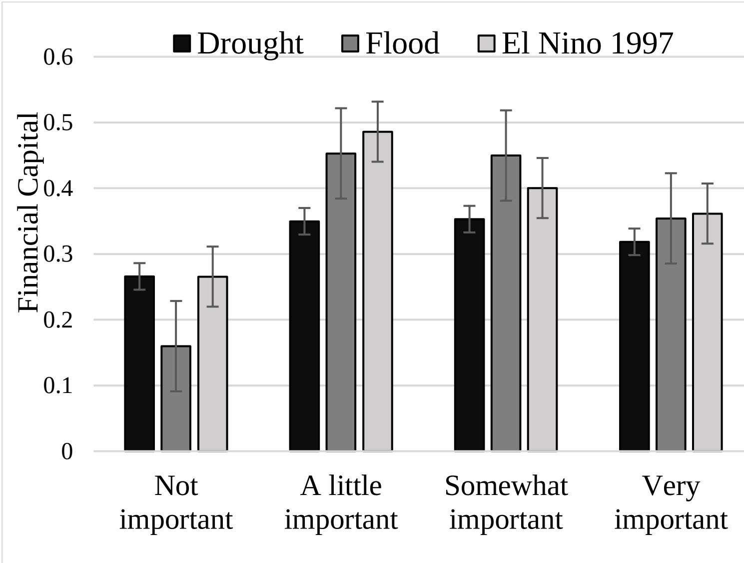


Figure 6.7 Financial capital based on the rankings of the importance of trees by survey households during drought, flood, and the 1997 El Nino. Respondents were asked to rank the importance of agroforestry during drought/flood/El Nino on a four point scale from not important to very important. The household financial capital is based on the average of all financial indicators for reach survey household. The four other financial capitals (social, human, physical, and natural) were also tested but were not significant. One-way ANOVA test of variance found we could reject the hypothesis of equal means for the importance of agroforestry during floods ($p = 0.0113$) and El Nino ($p = 0.0344$), but not drought ($p = 0.4310$).

Nino had the lowest financial capital scores. For floods, those who ranked agroforestry as not important had on average 12 trees, while all other households had on average 74 trees, providing further evidence that the number of trees is important in linking agroforestry to livelihood resilience. For El Nino similar trends existed. Households that ranked agroforestry as very important during drought, flood, and the 1997 El Nino had overall lower financial capital scores than households that stated that it was a little or somewhat important. Households who ranked trees as very important during flood and the 1997 El Nino had, on average, the most trees with 96 and 105, respectively.

Discussion

In answering the question if and how agroforestry can build livelihood resilience to floods and droughts, the results highlight three major findings. First, agroforestry can and does provide livelihood and environmental benefits during both flood and drought events. Second, perceptions of drought severity and frequency may be influenced by practicing agroforestry and irrigated agriculture. Lastly, agroforestry can and does help build livelihood resilience to floods and droughts; the benefits of agroforestry providing supplemental income and a diversified livelihood strategy.

Agroforestry benefits during flood and drought

In order to help farmers prepare for and cope with flood and drought events, agroforestry needs to still provide both environmental and livelihood benefits during such events. Farmers recognized the scientifically documented environmental benefits of trees during floods (for example see Rocheleau et al. 1988, Franzel and Scherr 2002) including preventing soil erosion, providing windbreaks, and reducing water speed during floods. Environmental benefits were so important to farmers that they comprised half of the benefits of trees during floods reported by survey respondents. Environmental benefits during drought were also important, particularly shade for both people, the farm, and livestock, which supports scientific research (Lin 2007). These environmental benefits are critically important for improving and maintaining farm productivity and livelihood activities. The benefits of trees are enhanced by the ecological characteristics of agroforestry trees. Some tree species can maintain production during drier years because their deep root systems are able to utilize a greater soil volume for water and nutrients (Verchot et al. 2007). This characteristic makes certain species more resilient to droughts than cash crops with shallow roots.

The major livelihood benefits during both flood and droughts were fruit for sales and consumption. Research in Kenya by Thorlakson and Neufeldt (2012) reported that some farmers relied on fruit trees for income during floods when other crops were washed away and our results support the use of fruit sales as an alternative income source. Households who could sell fruit during floods reported that agroforestry was more important to their livelihoods during floods than households who could not or did not sell fruit.

During drought mangos were important because they use less water than other crops and are drought resistant. Banana and papaya were also named as being important because they are able to produce fruit year round. These trees were important sources of food and income during drought when other tree species may not be in season or able to produce fruit.

Agroforestry and perceptions of drought and floods

According to ecological data, surveys, and household case studies, floods appear to have much less impact on farmers in Isiolo County than droughts, which means that households spend less time planning for floods. However, survey respondents reported that the timing of the rains was less predictable than in the past. The predictability of the rains is critically important for rain-fed agriculture in Kenya as farmers must time the planting of their crops with the onset of the rains; therefore this may have far reaching impacts on the agricultural sector in Kenya (Mburu et al. 2015).

Drought has been a chronic problem in Isiolo County, Kenya and as households are gaining access to irrigation and more experience farming, many are preparing for and coping with drought by planting trees. However, climate change may push the boundaries of previous local experience with drought and livelihoods may have to cope in new ways, including expanding agroforestry practices and technologies.

Agroforestry does not only provide environmental and livelihood benefits that help households prepare and cope with droughts and floods, but results here show that agroforestry may even change how drought is perceived and felt by households. Perceptions of drought are important because households often act on their perceptions, regardless of scientific data (see Meze-Hausken 2004 for an example from Ethiopia). Rao et al. (2011) found that farmers' ability to discern long-term trends in climate is often subjective because of the complex interactions between climate and other factors including soil fertility, land use change, and local economic conditions. Perception and definitions of drought can be influenced by local biophysical, social, cultural, economic, and political conditions (Slegers 2008). Farmers in Burat had different perceptions of drought frequency than farmers in Kinna. The differences in perceptions are complex, but may be attributed to how the different communities define and measure drought. In Burat, farmers with agroforestry and access to irrigation perceived drought to be less frequent than 10 years ago. The benefits of agroforestry may have played a role in these changed perceptions of drought. For example, before planting trees a farmer might have struggled to produce crops during drought; while after planting trees they now are able to sell papaya fruit and firewood. Where they used to not have an income during drought, now they have at least something small to fall back on, causing drought to seem less severe and its impacts less severe.

Irrigation may also play a role in shifting perceptions of drought, as Burat adopted wide-spread irrigation more recently than Kinna. Irrigation may lessen the impact of drought for some households, helping them cope with drought, supporting research in Kenya by Bryan et al. (2013). However, irrigation is costly and making larger investments in irrigation can be financially difficult for smallholder farmers (Bryan et al. 2013). There is also a limit to the benefits of irrigation because the rivers and canals used for irrigation can and have dried up drought events.

Agroforestry and livelihood resilience

According to Tanner et al. (2015) a resilient livelihood sustains well-being despite environmental, economic, social, and political disturbances. Results show that, for some, agroforestry can and does help build livelihood resilience to floods and drought. Agroforestry is not the main livelihood activity for virtually any household in Isiolo County, Kenya, however, during times of floods and drought it can and often does become an important source of food, income, and ecosystem services. The importance of agroforestry is dependent upon both total number of trees a household has on their farm along with the diversity of tree species. Results show that different tree species provide different benefits during floods and drought.

Agroforestry is a form of on-farm crop diversification. Crop diversification provides redundancy within the agricultural system and smallholder farmers may rely on tree crops when others fail (McCord et al. 2015). Redundancy means that a significant proportion of the diversity of plants could be lost on the farm without having a significant impact on farm production in the short term (Kindt et al. 2006, Dawson et al. 2013). The use of trees as an alternative source of income and food during drought and flood has also been documented in Kenya by Thorlakson and Neufeldt (2012) and Mbow et al. (2014a). This type of crop diversification is a purposeful livelihood strategy for many residents in Isiolo County, Kenya. Households are planting trees expecting that they will help them during floods and drought; many understanding the importance in practicing a diversity of livelihoods and planting a diversity of crops.

The five livelihood capital assets of the sustainable livelihoods framework can be negatively impacted by flood and drought. However, results illustrate the various ways that agroforestry can mitigate these impacts and help households cope. The models in Figure 6.6 illustrate both direct and indirect benefits of agroforestry for building livelihood resilience. Sendzimir et al. (2011) used similar, though more complex, models in order to examine patterns of causal relationships in the Nigerian Sahel and analyze the various interactions that occurred in both forest decline and then forest growth over the last few decades. Models such as these which visually depict qualitative data are helpful tools in conceptualizing complex relationships and interactions. Livelihood systems are complex and models can illustrate this complexity.

Livelihood capital assets are also important for quantitative comparisons. Primarily, the survey data highlighted that agroforestry was most important during drought and floods for households with medium levels of financial capital. Wealthier households may have other financial resources to draw from during floods, such as outside employment, remittances, businesses, etc, while those with lower financial capitals may not have the resources to invest in agroforestry in the first place. This is particularly interesting and important in the context of building resilience because it shows that agroforestry can be one activity helping middle-range income households prepare for and cope with floods and drought.

Conclusion

This study aimed to answer the call for more comprehensive, empirical research exploring the relationships between agroforestry and livelihood resilience to floods and droughts. Results from two different communities in Isiolo County, Kenya indicate that agroforestry can and does build livelihood resilience to flood and drought events. First, agroforestry provides livelihood and environmental benefits during both flood and drought events. Second, perceptions of drought severity and frequency may be influenced by practicing agroforestry. Lastly, agroforestry helps build livelihood resilience to floods and droughts; the benefits of agroforestry providing supplemental income and a diversified livelihood strategy.

While more research on the subject is needed, the findings presented here may be useful to both academic and development professionals. The three major findings above can be utilized in projects that aim to build livelihood resilience to floods and droughts. This research identifies specific ways that farmers are integrating trees into their agricultural system, many of whom are purposefully doing this to help their households cope with future floods or drought events. Policies and/or development projects that scale up these results could have significant and beneficial impacts on communities struggling to cope with floods and droughts. Identifying potential climate change adaptation strategies is crucial for smallholder farmers and, according to this research, agroforestry is one promising option. As stated by a male farmer in Burat, "I planted these trees because I knew that [during drought] I would eat this fruit… I knew that they would provide fodder for our livestock during drought."

CHAPTER 7. "YOU CAN STEAL LIVESTOCK BUT YOU CAN'T STEAL TREES": THE LIVELIHOOD BENEFITS OF AGROFORESTRY DURING AND AFTER VIOLENT CONFLICT

Abstract

While violent conflict affects the lives of 1.5 billion people globally, little is known about how people in areas of conflict support and feed themselves. This paper explores one livelihood strategy, agroforestry, and asks how it may be used to build livelihood resilience during and immediately after violent conflict. Research was conducted in Burat, Kenya which faced a violent conflict in 2012 before the 2013 elections. Broadly, the conflict was over local ethnic politics and control. Research included 13 qualitative case study households and 187 quantitative household surveys. Major livelihood coping strategies during the conflict included aid, help from relatives, and casual labor, with agroforestry as a supplementary livelihood activity for some. The results are context-specific, but suggest that agroforestry can build livelihood resilience during and after conflict by providing income and food, places to hide from attackers, and construction materials for rebuilding homes afterward.

Introduction

"You can steal livestock but you can't steal trees." – Female farmer in Burat

Violent conflict affects the lives and livelihoods of almost 1.5 billion people (Tilman 2004; World Bank 2011). However, we generally have little knowledge about how people in areas of violent conflict support themselves and, most importantly, feed themselves both during and immediately after conflict. The few articles that have been written on this topic include Korf (2004) and Munas and Lokuge (2016) in Sri Lanka, and Verpoorten (2009) in Rwanda, while Justino (2012) provides a broad overview of coping strategies during conflict. This paper seeks to explore one livelihood strategy, agroforestry, and asks if and how it may be used as a coping mechanism and help build livelihood resilience both during and after times of violent conflict. This research also provides some comparison of non-conflict vs. conflict livelihood activities to highlight the importance of agroforestry. As the quote above suggests, trees may provide a viable source of income and food while other livelihood activities are not possible during conflict. This paper provides some of the first research efforts aimed at understanding the potential uses of agroforestry during and immediately after violent conflict through empirical research on the experiences of households in the small community of Burat, Kenya during and after a year-long conflict from 2011 to 2012. The conflict was generally over political control of the area along ethnic lines to gain an ethnic majority before the 2013 national elections.

Livelihood resilience, political ecology, and household coping during times of conflict

Traditionally, conflict was thought to arise from opposing interests involving scarce resources and/or incompatible goals; however, not every conflict involves divergence of interests or goals (Tjosvold 2006). Conflict also does not just happen, it is driven by people who make choices to either escalate conflicts or find more constructive outcomes. Conflict and livelihoods are inextricably linked as livelihood activities can create conflict and are also disrupted during conflict (Young et al. 2005). Livelihoods during times of conflicts may be defined as how people access and use resources in order to increase their financial security, reducing the vulnerability created and/or exacerbated by conflict (Jacobsen 2003). Conflict can also lead to institutional breakdowns resulting in a loss of social capital and trust within a community, dysfunctional markets, and poor government institutions (Jaspars and Maxwell 2009).

Resilience has become a popular research and policy concept within international development contexts and is often based on the ability of a system to bounce back to normality after a shock or disturbance (Folke 2006). Resilience thinking grew out of the natural sciences but is often used in linked social-ecological systems. However, there are many challenges in using resilience thinking for development, and Tanner et al. (2015) argue that focusing on livelihood resilience can help to overcome these challenges because it focuses on an issue of high priority: human livelihoods. Therefore, this research is framed using Tanner et al.'s (2015) concept of livelihood resilience. Livelihood resilience is defined by Tanner et al. (2015, 23) as "the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances." Thus, livelihood resilience is an approach that strengthens people's ability to cope with a breakdown of their typical livelihood activities during violent conflict. Here, we seek to understand the role of agroforestry in strengthening a household's ability to sustain their well-being during and after violent conflict.

This paper also uses political ecology to understand how conflict arises, by critically analyzing the history of power and control over land in Burat, and understanding the available livelihood strategies available during conflict. Political ecology encompasses the body of work that connects ecological concerns to a broadly defined political economy (Robbins 2012).

Political ecology often focuses on power relationships that influence environmental access, management, and change (Robbins 2012). Political ecology has been used in the past to study conflict (Robbins 2012). For example, Okoli and Atelhe (2014) used a political ecology perspective to explore the herder/farmer conflicts in Nasarawa State, Nigera.

While much has been written about household coping strategies in times of peace, much less is known about how households cope during times of conflict (Verpoorten 2007). People living in conflict areas show various degrees of resilience, and often a household's economic position before a conflict may help determine their ability to cope (Justino 2012). The livelihood coping strategies practiced during conflict have been shown to influence the household welfare after conflict (Tilman 2004). An important part of any coping mechanism is the ability to combat food insecurity (Justino 2012). Justino (2006), suggests that during violence some households may return to subsistence agriculture and low-risk activities to feed themselves. For example, in post-war Sri Lanka, Korf (2004) found that livelihood coping strategies utilized were casual labor and focusing on key income activities due to a reduction in opportunities. In Mozambique, Tilman (2004) reported that farmers who did better post-war generally focused on known and low-risk activities. So casual labor, subsistence agriculture, and generally low-risk activities can be used as coping mechanisms, but what about agroforestry?

The potential of agroforestry

Agroforestry is a multifaceted, ecologically-based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, is believed to diversify and sustain production for increased social, economic, and environmental benefits (Franzel and Scherr 2002; Schroth et al. 2004). Agroforestry involves the combination of trees, crops, and animals in various spatial arrangements or temporal sequences on the landscape (Rocheleau et al. 1988; Sinclair 1999). The benefits include income, food, energy, construction materials, medicine, and the conservation of water, soil, and vegetation (Rocheleau et al. 1988). Globally, almost 1.2 billion people depend on agroforestry products and services for their livelihoods (ICRAF 2006).

So how could agroforestry potentially serve as a coping mechanism during or after violent conflict? First, there may be connections between agroforestry and political stability according to the United Nations Drylands Ambassador Dennis Garrity, who said the planting of trees has "improved the region's ability to cope with drought shocks, contributing toward more political stability over the past 20 to 30 years" (Hall 2013). Additionally, people in dryland regions of Africa have been using both naturally growing and planted trees to cope with other stressors that impact their livelihoods (Barrow and Mlenge 2003; Thorlakson and Neufeldt 2012). For example, in Ethiopia, *Enset ventricosum*, a drought resistant, banana-like plant, is utilized as a staple food crop during drought for 10 million people (Brandt et al. 1997). A study in Uganda by Sanginga et al. (2007) found a positive association between natural resource-based conflicts and the planting of trees. Trees were planted as a method to resolve boundary disputes by claiming and securing ownership and access to land and its associated resources such as water and pasture (Sanginga et al. 2007). This research by Sanginga et al. (2007) supports previous research about the planting of trees as a means to secure land tenure (Schroth et al. 2004) and goes against conventional wisdom that conflict is a barrier to the adoption of natural resource management technologies. Agroforestry trees can provide food and income, and if people have access to these benefits during violent conflict they may continue to benefit from them. For example, 25% of urban residents in two towns in Darfur still had access to their farms during conflict (Buchanan-Smith and Jaspars 2006). The issue of access to farms and agroforestry trees will vary depending on the type of conflict; and Burat, Kenya is an example of a localized conflict where farmers did have limited access to their farms and associated resources during the violent conflict. Most people were temporarily displaced, however, their land and farms were not stolen. Furthermore, most displaced households temporarily relocated within 10 km of their farms, meaning they could still easily access their farms for periods of time.

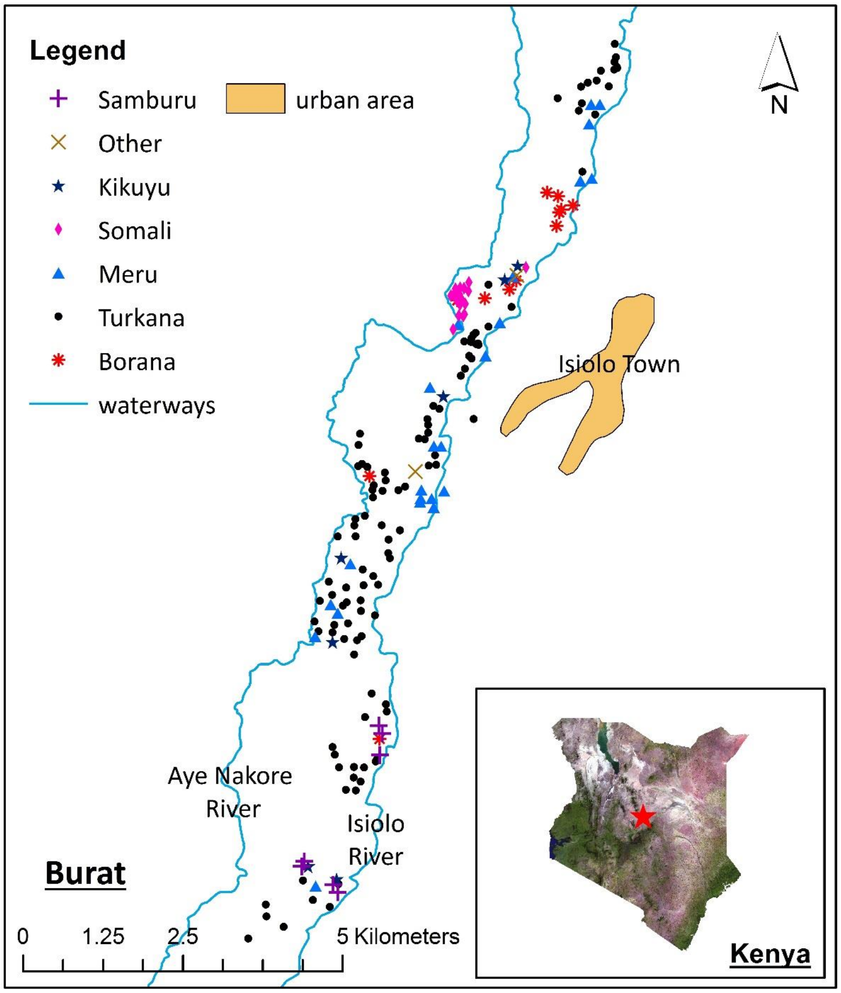


Figure 7.1 Study Area Map. This map shows the study area including all the household survey points by ethnicity. The ethnicity and its corresponding symbol is provided in the legend.

Burat and the 2012 Violent Conflict

It is important to understand the geographic, ecological, and political context of this study. Figure 7.1 provides a map of Burat and the survey respondents. Burat is located about 5 km outside Isiolo Town, the capital of Isiolo County, with an urban population of 44,154 in the

2009 census (Republic of Kenya 2013). Burat had a population of 18,774 in the 2009 census (Republic of Kenya 2013). Much of the population of Burat lives between the Isiolo and Aye Nakore rivers. Pastoralism is the predominant livelihood throughout Isiolo County, but in some areas, including Burat, irrigation schemes have allowed for small-scale farming (Republic of Kenya 2013). The ecology of the area, which includes access to water for irrigation, has helped to draw a variety of ethnic groups to farm in Burat. Meru were the first to farm in the area and many migrated to Burat and cleared and claimed land 40-50 years ago, gaining a recognized *de facto* ownership of the land (personal communication). Most residents in Burat are traditionally pastoralists, but many of these pastoralists turned to agriculture after their livestock herds were decimated by the *shifta* war in the 1960s (Hogg 1983), and droughts in the 1970s and 80s (Helland 1998).

The major ethnicities in the area around Burat are the Somali, Borana, Turkana, Samburu, and Meru (Figure 7.1). These five ethnic groups all lay claim to the land, which are used to also claim political control or representation (Table 7.1). Largely due to these claims, Isiolo has a long history of ethnic clashes. Additionally, virtually no residents in Burat and Isiolo County have a legal title to their land. According to Dida Golicha, chair of the Isiolo Peace Committee, the lack of proper land tenure policy is the major factor fueling conflict in Isiolo County (Sharamo 2014). Additionally, a long history of cattle rustling, road banditry, and border/grazing disputes between ethnic groups in Isiolo continue to be major sources of conflict in the area, contributing to distrust and dislike between ethnic groups, and are becoming more politicized (Ruto et al. 2010).

According to Menkhaus (2005), Isiolo is "a fault line area where a number of major ethnic groups share uneasy and shifting boundaries…where competition over seats in parliament

Table 7.1 Claims to land in Isiolo County (adapted from Boye and Kaarhus 2011). The rows provide general perceived and legitimate claims to land in Isiolo County organized by ethnic group. The legitimate claims are not meant to respond or correspond to the perceived claims.

Ethnic group	Land claims and perceived rights to land	Sources of legitimation for claims
Borana	Rightful ownership of land in whole district Exclusive claims to grazing land and water points in the Waso area Rights to land management	Pre-colonial occupancy of the area Customary rights confirmed by colonial government Colonial policy of tribal separation and confinement within defined boundaries Traditional Borana tenure rules governing land and resources Trust Land Act Constitutional right of Kenyans to settle and own land anywhere in the country
Somali	Access and user rights to resources (land, pasture, water) Exclusive ownership rights in Isiolo Central Division (Isiolo Town)	Customary rights to negotiate access and use of resources Agreement between colonial government and ex-soldiers on land rights in Isiolo Central Division Constitutional right of Kenyans to settle and own land anywhere in the country
Samburu	Rightful ownership of land with Borana in Isiolo Indigenous rights in Isiolo Central Division Access and user rights to resources (land, pasture, water)	Being the indigenous people of Isiolo during pre-colonial times Samburu place names in the county, indicating the Samburu were the original inhabitants Constitutional right of Kenyans to settle and own land anywhere in the country
Turkana	Rightful claims to land and to settle and keep herds in parts of Isiolo County	Presence in the county since early colonial times Constitutional right of Kenyans to settle and own land anywhere in the country
Meru	Rightful ownership to part of Isiolo Central Division/ Isiolo Town Individual titles to land in Isiolo Town	Colonial district boundaries Land allocation by post-colonial government Constitutional right of Kenyans to settle and own land anywhere in the country Registered Land Act

is acute – one of the most unstable areas of northern Kenya." Tensions have only increased in the past few years as the area is a focus for Kenya's Vision 2030 initiative, with the goal of bringing development to Isiolo County through high profile projects. There are plans to turn an area near Isiolo into a resort city, leading to competition over land near the proposed resort city site (Carrier and Kochore 2014).

While many violent conflicts have occurred in Isiolo County, this paper focuses on what I will call the pre-election conflict that took place before the March 2013 elections. From mid-

October 2011 to December 2012, 122 houses were burned, approximately 165 people were killed, 9,000 cattle were stolen, and over 2,900 people displaced in organized violence as the Borana and Somali communities fought with their Turkana neighbors (AlterNet 2011; Huka 2013; IRIN News 2012; Sharamo 2014). Burat, which has a large Turkana population, was one of the areas most affected by the fighting and most residents fled to Isiolo town (IRIN News 2011).

Most sources argue that the pre-election conflict in Burat was not traditional pastoral competition but instead was driven by local political and economic interests tied to Burat (*Capital FM* 2012; Sharamo 2014; IRIN News 2011). Different ethnic communities were competing over power and political control of the Isiolo County Government (Sharamo 2014). The Borana community claims that Isiolo County belongs to them, and therefore they should retain control of the government (Ndeta 2012). However, the Turkana community proposed that the elective positions should be shared by the ethnic communities, including theirs (Ndeta 2012). The Turkana are an ethnic minority in Isiolo County (although the predominant ethnicity in Burat), and after decades of marginalization beginning during the colonial period were searching for a voice and representation in government. A Turkana candidate lost a close race for a Parliamentary seat in the 2007 elections, which shocked the Borana community that they could potentially lose 'their' parliamentary seat (Ruto et al. 2010).

The elections in 2013 were particularly important to the local community because of the new constitution in 2010 and the devolution of the Kenyan government. The 2010 constitution established County governments with elected Governors and Members of County Assemblies (MCA) (Steeves 2015). Each ward has their own MCA, and Burat is a ward. Also, County governments now were supposed to receive 35% of national revenues (Steeves 2015), including

15% of national development funds in the form of a Constituency Development Fund (CDF) (Omari et al. 2012; Chitere and Ngundo 2015).

Therefore, before the 2013 elections both Turkana and aligned Borana and Somali ethnic communities were attempting to place themselves in a strategic position to win in Burat. This was important because some of the devolved government's aim was to recognize the rights of communities to manage their own affairs, and the promotion of the interests and rights of marginalized communities (Kirui and Biwott 2013; Steeves 2015). Ruto et al. (2010) predicted that in Isiolo the political alliances will do their best to ensure that come 2013 they will have the upper hand in the elections, which could include inciting violence. It appears that this prediction came to fruition in 2011-12 as media sources attributed the violence in Burat to the 2013 elections; agreeing that politicians were fueling the flames (Carrier and Kochore 2014). For example, the acting permanent secretary for provincial administration and internal security, Mutea Iringo, ordered all nomadic pastoralist to leave Isiolo, while at the same time these herders were asked by local politicians to remain in Isiolo County to allow them to register to vote in Isiolo for the 2013 elections (IRIN News 2012). Many of these nomadic pastoralists were Turkana or Somali (Carrier and Kochore 2014). In the end, a member of the Turkana community was elected in 2013. The conflict was entrenched in a deep political history of ethnic claims over land and a desire of marginalized people for self-governance and legitimization. A political ecology lens helps to highlight how the violent conflict in Burat, Kenya was largely tied to historical influences over land and political/ethnic control, and that the violence was not necessarily focused on traditional narratives of access and ownership of natural resources.

Methods

Data collection

This research utilized a mixed- methods approach including qualitative household case studies and quantitative household surveys. All households in this study practiced agriculture, however households with and without agroforestry were both included for comparison. While there is no universally recognized definition of a tree, in its broadest sense, a tree is any plant with an elongated stem, or trunk, which supports leaves or branches at some distance above the ground (Tokuhisa 2013). In this research we draw from this broad definition in order include plants such as bananas and papayas. This was done for three reasons: 1. Research participants consider these types of plants trees, 2. Banana and papaya are typically included in descriptions of agroforestry systems in East Africa (Nair 1993), and 3. Some botanical definitions of trees include these types of plants (Tokuhisa 2013). Field research took place between July 2014 and July 2015. Because field work occurred two years after the conflict, responses were based on the memories of the respondents about the conflict.

A total of 187 quantitative household surveys were conducted. An appropriate sample size for Burat (183 households) was calculated using an estimate of the number of households practicing agriculture (349 households) according to information from the Kenya Red Cross Society – Isiolo Branch Office. Enumerators conducted surveys in Burat, in Swahili, after receiving a two day training. Enumerators surveyed every other household along a transect (road or path), and if no one was available at a household enumerators surveyed the very next available household. At each household, either the male or female household head was surveyed depending on who was available and willing to participate. GPS points were taken at each survey household.

The qualitative household case studies included 13 households in Burat. Each household was interviewed three times to build trust and create a dialogue. Both male and female household heads were interviewed when possible. These households were selected through combined convenience and respondent-driven sampling (Bernard 2011). The case study households provided the in-depth lived experiences of households in Burat during and after the conflict. All interviews were conducted in Swahili by the lead author, who is fluent in Swahili, working with local research assistants. Swahili was used, instead of the languages of the ethnic groups, in order to avoid any loss of meaning that can happen with translations or using a translator. Recorded interviews were transcribed verbatim with help from Phillips SpeechExec Transcribe 7.1 software.

Data analysis

Quantitative household survey data was analyzed with Microsoft Excel and STATA IC13 software programs. Statistical analysis included summary statistics and correlation tests. All qualitative household case study interviews were coded using QSR NVivo 10 software. The interviews were coded in Swahili in order to maintain their original themes, which could potentially be lost in translation. Codes were developed from the interview discussion topics and academic literature. Qualitative and quantitative data was compared and contrasted to triangulate results in an iterative process. Additionally, to provide insight into how interview participants talked about relevant issues some Swahili words are included in italics.

Results

Local narratives of conflict

The conflict in Burat was largely considered to be politically-motivated along ethnic lines, with many ethnic groups represented in Burat (Figure 7.1, Figure 7.2). Out of the 186 households surveyed, all but 10 households were directly impacted by the violent conflict; for example, they had livestock stolen, their homes looted/burned, or they had to relocate (Table 7.2). The 10 households not impacted were not present in Burat in 2011-2012.

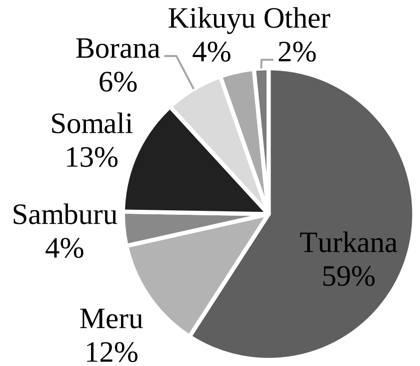


Figure 7.2 Ethnic make-up of agricultural households in Burat. Survey respondents were asked to identify their ethnicity (n = 187).

Table 7.2 Impacts of the pre-election violent conflict in Burat by ethnicity. The numbers are the percentages of each ethnicity that experienced that specific impact of violent conflict. Household survey respondents listed all the ways their households were impacted. They were able to list more than one impact.

Impacts of Conflict	All respondents	Borana (n = 11)	Turkana (n = 106)	Meru (n = 19)	Samburu (n = 6)	Somali (n = 23)	Kikuyu (n = 7)
House looted	70.5	63.6	71.7	63.2	50	87	28.6
Relocate for > 1 month	54.6	63.6	56.6	47.4	0	52.2	71.4
House destroyed	50	45.5	51.9	47.4	16.7	56.5	28.6
Livestock stolen	50	50	46.2	42.1	66.7	65.2	42.9
Crops destroyed/stolen	42.3	60	39.6	52.6	33.3	30.4	85.7
House burned	27.3	27.3	29.3	26.3	0	21.7	42.9
Relocate for < 1 month	22.7	9.1	25.5	10.5	66.7	21.7	0
Family member killed	16.5	27.3	16	5.3	16.7	21.7	14.3
Family member injured	10.8	9.1	12.3	10.5	0	8.7	0
Trees destroyed/ cut	6.8	0	4.7	5.3	0	13	14.3
No access to farm	1.1	0	0	5.3	16.7	0	0
Farm equipment stolen	1.1	0	0	4.4	0	0	14.3
Family member raped	0.6	0	0	5.3	0	0	0

Over fifty percent of survey respondents had their house looted (*tuliibiwa*), had to relocate for over a month (*tulihama*), had their house destroyed (*waliharibu nyuma*), and/or their livestock stolen (*waliiba mifugo*) (Table 7.2). This had devastating impacts on the community that is still felt today as people continue to rebuild their lives and livelihoods. However, it is important to note that land was not seized or permanently stolen during the conflict. Consistent with media reports, it appears that the intent was not to steal or destroy the physical land, but instead to gain local political control along ethnic lines of the Burat area. Looting and thievery was largely opportunistic. Trees may have been largely left alone because the heart of the conflict was not natural resources, livelihoods or use of the land, but political power and control. In many household case study discussions farmers told us they were able to return to their farms occasionally to farm. A Meru male farmer said that during the conflict he "was still farming on my farm. But I was scared. I was able to come in the morning, do some farming, and around 2pm I would hear gun shots and I would run away."

During the household case study interviews, interviewees discussed with us their experiences with the conflict. Each person had their own unique story and experience. While talking to a Turkana man, he pointed to a small path and told us, "a man was shot there" (*walimpigia pale* in Swahili). During all our interviews everyone spoke like a victim of the conflict, and no one discussed being an instigator or attacker. One of the Meru case study households was caught in the middle of the violent conflict and their family home was burned (*nyumba ilichomeka*). In the male household head's words:

> "Our family, before our house was burned down, we lived well. We had everything we wanted. We worked on the farm, irrigated our crops, things were good. But after our house was burned, we have not lived well since. [When the fighting started] we moved. Very few people stayed here because there were gun shots all the time. It was very bad here. During that time, we went to town, we worked as casual laborers. The Turkana that burned our house are age mates with my

children. They know each other. I told my children to just be quiet because we do not want to move. Do not tell on those who burned our home. But they know who they are. When we see each other we feel shame."

Coping mechanisms during conflict

Table 7.3 compares survey responses for the major livelihood activities both during the conflict and during 'normal' or non-conflict periods. Many livelihood activities were less frequently practiced during conflict such as charcoal production, business, livestock keeping, or crop farming. Other livelihoods became more prominent during conflict, including relying on help or *msaada* from family or organizations such as the Kenya Red Cross Society for basic necessities such as food, soap and hygiene products, and cooking utensils (Table 7.3). As one Turkana woman explained "I thank god for the Red Cross… you can even see here now that there are things such as blankets, soap, that they gave to us during that time." However, some farmers reported being able to still rely on their farm or trees. While the percentage of households practicing agroforestry decreased from 63.4% during non-conflict periods to 21.4% during the conflict, this was not as drastic a decrease as other major livelihood activities. While 42.3% of

Table 7.3 Major livelihood activities in Burat during conflict compared to non-conflict major livelihoods. Household survey respondents were asked to select the major coping strategies they used to support themselves during the conflict and non-conflict periods. All the activities here were mentioned by more than 10% of respondents during either conflict or non-conflict. Respondents could select more than one livelihood activity.

Livelihood Activity	**Conflict** Percentage of household survey respondents (n=169)	**Non-Conflict** Percentage of survey respondents (n = 187)
Agroforestry	21.4	63.4
Aid	53	15.5
Help from relatives	37.3	-
Casual labor	25.4	53.5
Crop farming	6.5	100
Livestock	4.7	36.9
Small business	2.4	13.4
Charcoal production	1.8	17.1
Poultry	0.6	16.6

household survey respondents reported that their crops were stolen or destroyed (*kuiba* and *kuharibu* in Swahili), only 6.8% of survey respondents reported that their trees were destroyed or cut (Table 7.2). Thus, many households were still receiving the same benefits from their agroforestry trees during conflict as during non-conflict periods as will be explained in the next section.

Agroforestry as a coping mechanism

Agroforestry, while not one of the major coping mechanisms, did help some households support themselves both during and after the violent conflict as a supplemental coping strategy The most commonly planted trees by household survey respondents in were papaya (68 of 187 households), banana (55), mango (50), indigenous trees (43), guava (38), avocado (37), and neem (*Azadirachta indica*) (35). When asked specifically if trees helped their family, 21.4%

A. Benefits during conflict **B**. Benefits after conflict

Figure 7.3 The benefits of agroforestry both during and after the Burat conflict. Household survey respondents were asked if trees benefited their household during or after the conflict. If they answered yes, they were asked to explain all the ways that trees benefited their household.

Table 7.4 Quotes from interview participants about the benefits of agroforestry during and after the violent conflict in Burat in 2011-12

During or After Conflict	Interviewee	Quote
During	Female Turkana	Trees helped us a lot. It helped especially our children for food.
	Male Turkana	Trees helped because it made my farm look like the bush. Indeed, I would find that during that time, I would find many people hiding on my farm. A person is able to hide themselves and save themselves because even if a bullet is fired here, trees will stop it.
	Female Meru	Even trees… we would eat and we would sell fruit. Like these mangos and avocados, we were able to get a little bit at least.
	Male Meru	It helps us a lot. Trees helped us a lot. Sometimes it helped with firewood, or we would cut firewood to sell in town.
After	Female Turkana	When we returned, these trees helped me because they had produced fruit. I sold mangos and it helped me.
	Male Turkana	These trees, you know I found that some had dried up, but others were still doing well. I cut poles from these trees to build a house.

responded that trees helped support them during the conflict and 47.4% immediately after the conflict (Figure 7.3). During conflict some farmers could return to their farm and harvest fruit, firewood, or construction materials, as seen in Figure 7.3 and Table 7.4. During non-conflict periods the major benefits of agroforestry were fruit for household consumption and fruit for sales. This remained similar during the violent conflict. Some survey respondents and household case study participants discussed being able to hide and take refuge behind trees, a unique benefit of agroforestry during times of conflict. While hiding behind trees for safety is extreme, it was nonetheless an important benefit of trees during violent conflict. If the people described in the quote in Table 7.4 were not able to hide behind the trees on this man's farm they may have lost their lives.

Many research participants (both household surveys and household case studies) said that trees also provided important benefits after the conflict. Trees helped households rebuild their houses (*kujenga nyumba)*, provided food (*chakula*), and provided a source of income through the sales of construction materials and fruit (*pesa*) (Table 7.4; Figure 7.3b). The most common benefit was helping to rebuild houses after they were looted, destroyed, or burned.

Survey respondents were also asked to rank the importance of their trees to their livelihoods during and after the conflict from not important (*si muhimu*) to very important (*muhimu sana*). Overall, almost a quarter of survey respondents ranked agroforestry as very important for supporting their household during the conflict. Furthermore, 81.8% of respondents who could harvest fruit, 100% who could harvest firewood, and 100% who hide behind trees during the conflict ranked agroforestry as very important. After conflict, 73.3% of respondents who could harvest food, 35% who used trees to rebuild their home, and 78.6 % who sold fruit for income ranked agroforestry as very important to them after the conflict. This highlights that for households who were able to benefit from their agroforestry trees during and after the conflict, agroforestry was an important livelihood activity for their household.

Notably, the number of trees a household had was significant for how important they ranked agroforestry. Those who ranked agroforestry as not important had on average 20 trees, while those who ranked agroforestry as very important had on average 57 trees (one-way ANOVA, p-value = 0.0178). Therefore, not only do the benefits received matter, but also the number of trees a household had. The importance of trees during conflict was not significantly correlated with either ethnicity or any of the direct impacts of the conflict outlined in Table 7.2.

Discussion

Agroforestry was one of several livelihood activities (such as aid and help from family members) that helped build livelihood resilience for some households both during and immediately after violent conflict in 2012 in Burat, Kenya. Agroforestry helped provide food, income, physical security, and materials for rebuilding homes. As highlighted in the introductory quote to this paper, as well as results section, some non-conflict livelihood activities, such as livestock keeping, were disrupted during the conflict due to livestock theft and raiding. The major livelihood activities changed drastically when comparing non-conflict to conflict livelihoods. Agroforestry also decreased to an extent (63.4% to 21.4%), but not on the scale of crop farming, livestock keeping, charcoal making, or small business. To the households who could still rely on agroforestry somewhat as a livelihood activity, it was very important.

Agroforestry was an important source of food and income as households who could access their trees for fruit emphasized the importance of agroforestry during/after conflict. This has many implications for development agencies as well as governmental and non-governmental interventions at post-conflict recovery. The empirical results here illustrate how such organizations/interventions can promote supplemental livelihood activities, such as agroforestry, that can become an important source of food and income during conflict. The greater the number of trees a household had the more important of a livelihood strategy it was for them. If a household has more trees they are likely to receive more benefits from their trees (i.e. more fruit, firewood, fodder, income etc.). Food security is a critical issue during violent conflict and studies have found that during conflict some households may return to subsistence agriculture when other livelihoods are no longer viable to feed themselves (Brück 2004; McKay and

Loveridge 2005; Justino 2006). Income from fruit sales was also an important source of money that allowed households to purchase staple foods. However, agroforestry served as a supplemental livelihood activity in Burat, and for most, was not the major coping strategy used. It was one of several activities that households used to build livelihood resilience. For most households, the main source of support during the conflict was aid, relatives, or casual labor. The use of casual labor as a coping strategy has also been documented in post-war Sri Lanka (Korf 2004). Any additional source of income, such as agroforestry, could be important to households who are mostly relying on outside help from their family or aid organizations for survival. Post-conflict, Tilman (2004) found that households in Mozambique did better based on their coping strategies during the conflict and those that focused on known and low-risk activities also fared better. In Burat, agroforestry was a low-risk activity. For larger, established trees, little to no work was needed for the tree to produce fruit, firewood, or construction materials, and these agroforestry products could be harvested during calmer periods of the violent conflict.

A surprising result of this study was the importance of agroforestry for personal safety and security. Hiding behind trees for protection was mentioned by both survey respondents and household case study participants. In Burat, farms with many trees provided cover and security for people in emergency situations when fighting broke out suddenly. This is potentially the most important benefit of agroforestry during conflict because without your life you have no livelihood.

Households in Burat have been rebuilding their lives and livelihoods in the 4 years since the conflict ended. Agroforestry has helped some households in Burat rebuild by providing construction materials and income through fruit sales while struggling to return to their normal lives and livelihood activities. Many households had their houses looted, burned, or destroyed during the conflict, and construction materials from agroforestry lessened the financial burden of rebuilding. This is particularly important at a time when most households had very limited financial resources after the conflict. This is also an important consideration of interventions aimed at post-conflict recovery. By promoting tree planting, these types of interventions could help households become self-sufficient in rebuilding their household structures post-conflict.

Unlike other conflicts, households did not report that their land was stolen. This conflict was largely over political control of local government; it was on a larger scale than individual land tenure. However, land tenure remains a sensitive issue in Burat, as virtually no one held land titles at the time of field work. Despite the lack of titling, land was not physically taken or seized in the long run and most returned to their homes. Unlike common narratives, a political ecology perspective examining power relationships and historical context suggests that the conflict was not over scarce natural resources or scarce land, but instead local government representation for historically marginalized people, the Turkana. Political context was important for understanding the conflict, as well as the historical claims to the land in Burat.

Lastly, according to Tanner et al. (2015), livelihood resilience involves the capacity of people to sustain their wellbeing despite social or political disturbances such as violent conflict. According to Jacobsen (2003), livelihoods during times of conflict may be focused on how people use livelihood activities and resources to increase their financial security and reduce the vulnerability created or exacerbated by the conflict. This research provides empirical evidence for how agroforestry is one livelihood activity that can accomplish this. Households who practiced agroforestry often had a greater capacity to sustain their wellbeing during the conflict, with a focus on agroforestry to increase food security and provide a supplemental source of income. Thus, based on Tanner et al.'s (2015) definition of livelihood resilience, agroforestry was one activity that helped increase livelihood resilience. This paper contributes to the body of literature on livelihood resilience by providing an empirical example of how one type of livelihood activity can build livelihood resilience to a specific type of social-political disturbance. Furthermore, it adds to resilience literature more generally by focusing on one critical aspect of social-ecological systems: human livelihoods. If people are able to build livelihoods resilient to disturbances such as that described in this paper, this may increase overall social-ecological resilience. Agroforestry, in particular, contributes both livelihood and environmental benefits, and thus has the ability to potentially help maintain both livelihood and environmental conditions during violent conflicts.

Conclusion

The aim of this paper was to help fill the gap in the body of knowledge about how households cope and build livelihood resilience during violent conflict. This paper focused specifically on one livelihood strategy, agroforestry, and one specific violent conflict event in Burat, Kenya in 2012 before the 2013 elections. The results presented here are context-specific, but, by comparing non-conflict vs conflict livelihood activities, illustrate that agroforestry did help some households build livelihood resilience during and after conflict by providing a source of income and food, places to hide from attackers, and construction materials for rebuilding homes. To support these results more research needs to be conducted in different geographic areas. The type of the conflict most likely plays a significant role in how much agroforestry is able to help. For conflicts where households have no access to their farms, agroforestry may only provide benefits after the conflict ends. The violent conflict presented here was fairly small-scale and concentrated in Burat, Kenya. The potential of agroforestry to build livelihood resilience during a larger-scale war or international conflict may be very different.

Despite these nuances, this paper provides the first effort at research empirically exploring how agroforestry can build livelihood resilience during violent conflict. Thus, it provides some new insight for organizations or interventions aimed at building livelihood resilience pre- and post- conflict. Projects aimed at helping people support themselves more, instead of relying on aid or humanitarian relief, will not only benefit these people, but also benefit organizations who spend significant resources helping displaced hosueholds cope during and after conflict. Projects promoting agroforestry will have many benefits, and helping households build their livelihood resilience, and become more self-sufficient during and after conflict, and generally, will benefit nearly all stakeholders. Agroforestry may help some farmers feed themselves during conflict, and get back on their feet afterwards. A Meru male farmer told us that trees were very important (*muhimu sana*) to him after the conflict was over. He said that to survive he needs three things: trees (*miti*), water (*maji*), and fire (*moto*).

CHAPTER 8. CAN AGROFORESTRY IMPROVE FOOD SECURITY ON FARMS IMPACTED BY WILDLIFE CROP RAIDING?

Abstract

Human-wildlife conflicts are a threat to livelihoods as crop raiding can reduce household food security. This paper explores the role of agroforestry in improving food security for farmers experiencing wildlife crop raiding. The paper draws on 339 surveys and 20 qualitative case study households, conducted during 2014-15 in Isiolo County, Kenya. Results found that ecological context is important when exploring issues of crop raiding. Overall, 56% of survey households reported that agroforestry helped provide income when other crops were damaged by wildlife. Households who could harvest fruit, had a greater number of trees and tree species diversity, were more likely to report that agroforestry helped. This research found two major coping strategies to improve food security when facing wildlife crop raiding: 1. Agroforestry benefits including both food and income, and 2. Utilizing social networks in times of need.

Introduction

"You know, if wildlife comes to raid our farm, it [trees] survives. They [wildlife] are not able to destroy or eat all the fruit from an entire tree. But if it comes across smaller crops, it will finish them. It [wildlife] will just leave the trees and the trees will continue to produce fruit."

- Male farmer in Kinna, Kenya

Protected areas cover nearly 13% of the earth's surface and are critical to biodiversity conservation efforts (Barua et al. 2013). However, wildlife habitat is not confined to protected areas and many wildlife species live or migrate outside of protected areas, often leading to human-wildlife conflicts (Nyamwamu et al. 2015). Crop raiding is one of the major sources of human-wildlife conflict; seriously impacting livelihoods and household food security through crop destruction and income loss (Ogra 2008; Songhurst and Coulson 2014). For example, Hartter et al. (2016) found that outside of protected areas in Uganda, risk to life and livelihood (including food security and crop yields) were reported to be the most severe of all risks. Crop raiding can lead to what Barua et al. (2013) calls the 'hidden impacts' of crop raiding: diminished health and nutritional status. While issues of food security have been dominating academic and policy debates (Vira et al. 2015), there has been less focus on improving food security in the face of wildlife crop raiding. The role of agroforestry in supporting food security and nutrition also remains largely under-researched (Sunderland et al. 2013). Thus, this paper aims to address these gaps by looking at agroforestry as a potential measure to combat food insecurity caused by wildlife crop raiding.

Human-wildlife conflict and crop raiding

While wildlife conservation initiatives are well-intentioned, there are often repercussions for the livelihoods of communities that border protected areas, with crop raiding a rising source of conflict in recent decades. (West et al. 2006; Western et al. 2015; Hartter et al. 2016). For example, Hill (2000) reported that in Uganda, the cost of crop raiding and guarding of farms cost households between US$ 96 to 519 per year. Ogra (2008) found in India that 98% of survey respondents reported that crop raiding negatively impacted their overall food supply. Crop raiding can lead to a reduction in nutrition (Ogra 2008), loss in opportunities for school or other income generating activities in order to guard crops (Mackenzie and Ahabyona 2012; Hartter et al. 2016), and psychological stress from anticipating raids (Barua et al. 2013).

Few universal trends in wildlife crop raiding have been found due to complex variations in wildlife ecology and movements, and human land uses (Songhurst and Coulson 2014). Some important variables include animal density, area of cultivated land, and location of farms on the landscape in relation to water sources, protected areas, and wildlife habitat (Songhurst and Coulson 2014). Elephants often utilize the same migratory pathways, and proximity to these pathways is a significant variable influencing crop raiding (Von Gerhardt et al. 2014). In some places, crop raiding can be seasonal as wild food sources for wildlife are more scarce during the dry season (Hockings and Humle 2009), wildlife disperse from protected areas in the wet season (Otuoma 2004), and wildlife movements can follow rainfall and the availability of water sources (Bohrer et al. 2014). There has been much research focused on interventions to lessen wildlife crop raiding including building fences, planting certain unpalatable crops, and guarding crops (for example, King et al. 2011), and I will not repeat that work here. However, few focus specifically on helping farmers maintain food security and build their own livelihood resilience to wildlife crop raiding.

Food security

The Food and Agriculture Organization (1996) define food security as "when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active lifestyle." Important here is not just eating enough calories, but also micronutrients to maintain health and nutrition.

Approximately 2 billion people globally are deficient of micronutrients including vitamins and minerals (FAO 2012). However, determining a household or individual's food security is complex. For example, a household's vulnerability to food insecurity can depend on factors such as intensity of land and water use, access to economic resources, and population density (Quirin and Dixon 2012). Research has suggested that higher household financial literacy (Millimet et al. 2015) and social capital at both the household level (Sseguya 2009) and the community level (Martin et al. 2004) have been shown to increase food security and decrease the likelihood of experiencing hunger.

Agroforestry and livelihood resilience

Agroforestry is a multifaceted land management system that, through the integration of trees in an agricultural landscape, is believed to diversify and sustain production for increased social, economic, and environmental benefits for land users (Schroth et al. 2004). Agroforestry involves different combinations of trees, crops, and animals on the landscape over different spatial arrangements or temporal sequences (Sinclair 1999). There is considerable evidence that agroforestry systems play an important role in supplementing agricultural production for better food security and nutrition, while delivering ecosystem services that enhance crop production (Mbow et al. 2014b; Vira et al. 2015). Fruit is an important source of micronutrients, including vitamin A, vitamin C, and folate (Sunderland et al. 2013), while nuts are an important source of protein. However, Eastern Africa has the lowest per capita fruit consumption of any region of the developing world, and expansion of agroforestry could have significant effects on both quantity and quality of nutrition, particularly for children (Garrity 2004). Agroforestry not only supplies food, but can be a source of money to buy food.

The theoretical framework used in this research is livelihood resilience. Tanner et al. (2015; 23) define livelihood resilience as "the capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances." Crop raiding is one type of environmental disturbance. Important to livelihood resilience are the coping strategies used by a household in times of wildlife crop raiding; agroforestry is explored here as one potential coping strategy. However, crop raiding and its relationship with food security and resilience can only be understood, and potentially alleviated, when analyzed within the social, political, and environmental context (Quirin and Dixon 2012).

Methods

This study utilized a mixed methods approach with 20 qualitative case study households and 339 quantitative household surveys. All households included in this study practiced agriculture. Households both with and without agroforestry practices were included to provide a comparison. While in the Oxford English Dictionary (2016), a tree is defined as a woody perennial plant, in this study this definition was expanded to include other tree-like plants such as bananas and papayas.

Study areas

Kenya is world renowned for its rich wildlife and has 54 national parks and reserves, with 10% of the land area in national parks (Western et al. 2015). However, most wildlife in Kenya remain outside of protected areas and wildlife populations have declined 41% from the late 1970s (Western et al. 2009; Western et al. 2015). In Kenya, human-wildlife conflict is particularly prevalent on farms bordering wildlife habitats (Graham et al. 2009). Thus, this research was conducted in two communities either adjacent to a protected area (Kinna) or in a wildlife migration corridor (Burat) in Isiolo County, Kenya (Figure 8.1). Isiolo County is an arid region dominated by pastoralists, with agriculture practiced in a few communities located along waterways using irrigation.

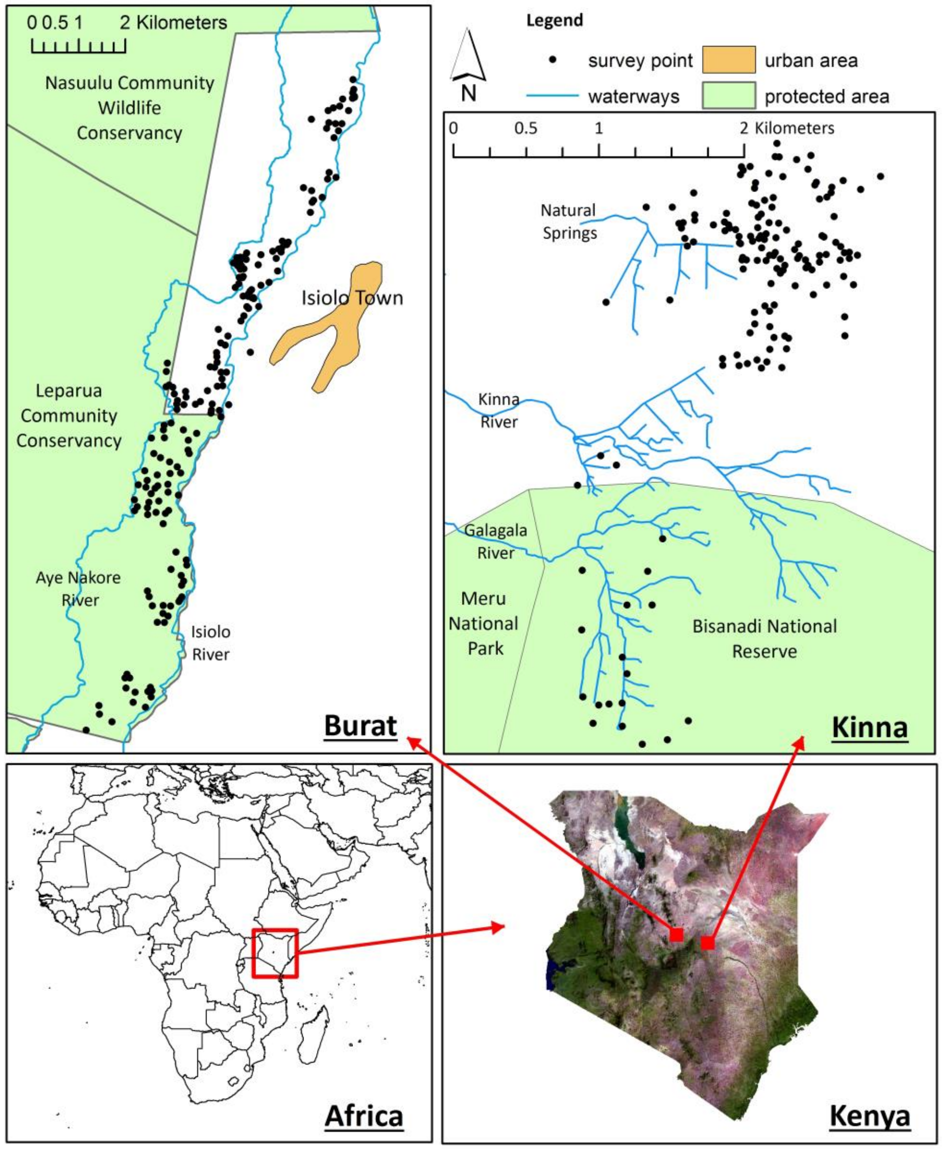


Figure 8.1 Study area map

Burat

Burat makes up an area located immediately west of Isiolo Town. Research was conducted with farmers who live in Burat between the Isiolo and Aye Nakore Rivers, critical resources for irrigation. A mix of ethnic groups live in Burat, including Turkana, Meru, Somali, Borana, and Samburu. Within Burat is the Nasuulu Community Wildlife Conservancy and Leparua Community Conservancy. To the south lies Il Ngwesi Community Trust, and Lewa Downs Wildlife Conservancy. North are the internationally renowned Buffalo Springs and Samburu National Reserves.

Burat is part of the larger Laikipia-Samburu ecosystem, home to Kenya's second largest elephant population, around 6,500 individuals (Ihwagi et al. 2015). Human-wildlife conflict is prominent as numbers of illegally killed elephants increased in the area between 2002 and 2012 (Ihwagi et al. 2015). Douglas-Hamilton et al. (2005) tracked elephant movement in the Samburu Ecosystem and found that elephants migrate through Burat between Lewa Downs Wildlife Conservancy to the south and Buffalo Springs and Samburu National Reserves to the north.

Kinna

Research was conducted around the small urban center of Kinna Town. Kinna is predominantly populated by Borana pastoralists; however, some households do practice agriculture using a canal-based irrigation scheme. Kinna borders Meru National Park to the west and Bisanadi National Reserve to the south (Sitienei et al. 2014). These protected areas are part of the larger Meru Conservation Area, the second largest protected area in Kenya, and also includes Kora National Park, Mwingi National Reserve, and Rahole National Reserve (Otuoma 2004).

Over the past few decades the Meru Conservation Area witnessed significant agricultural growth around its borders (Otuoma 2004). In 1985, a 15km electrified fence between Kinna and Meru National Park was built to reduce elephant crop raiding (Otuoma 2004; Sitienei et al. 2014). A newer, 25 km electric fence was built in 2002. Despite the fence, Douglas-Hamilton et al. (2005) mapped the movement of elephants in these areas and found that elephants still sometimes make their way around the fence and into Kinna. The fence was also erected to keep pastoral livestock from encroaching into the protected area (Otuoma 2004). A study by Sitienei et al. (2014) of 144 farms outside Meru National Park, including Kinna, found that crop raiding was highest in August during the driest part of the year. Additionally, relationships between park authorities and the community is particularly poor and has led to violence from both parties (personal observation).

Sustainable livelihoods approach

This research utilized the sustainable livelihoods approach to explore questions of livelihood resilience and food security (Table 8.1). The sustainable livelihoods approach states that livelihoods should be considered in terms of people's access to capital assets (financial, physical, natural, human, and social), the ways in which people combine these capital assets to create livelihoods, and how they are able to enlarge their asset base through interactions with other actors and institutions (Chambers and Conway 1992; Carney 1998; Bebbington 1999). This study used quantitative indicators to measure each of the five capital assets (Table 8.1) The assumption here is that higher livelihood capital scores would indicate increased household food

Table 8. 1 Household survey livelihood resilience indicators

Asset	**Quantitative Indicator** (Independent Variables)
Financial Capital	• Salaried job (yes or no) • Access to a bank account (yes or no) • Remittances (yes or no) • Household belongings (# of belongings) • Livestock (# of livestock) • Size of farmland (# of acres) • Ownership of farm equipment (own, rent, borrow pieces of equipment)
Human Capital	• Labor availability (number of household members between 18 – 55) • Education (level of education of respondent) • General health of family (scale of poor to good) • Health problems impact on ability to practice livelihoods (Scale of no to very much)
Social Capital	• Family living nearby (yes, how close) • Political influence or power (scale of none to a lot) • Participation in groups (# of groups) • Participation in agriculture or tree planting group (yes or no) • Strength of relationship with neighbors (# of activities done with neighbors)
Physical Capital	• Normal and rainy season road conditions (scale of good to bad) • Presence of facilities (schools, hospitals, etc.) near home (yes or no) • Access to irrigation schemes (yes or no) • Ownership of farming equipment (own, rent, borrow pieces of equipment)
Natural Capital	• Size of farmland (# of acres) • Own farmland (yes or no) • Diversity of farm crops (# of different crops planted) • Livestock (# of livestock) • Soil erosion (rank of severity of soil erosion on farm)

security (Adato and Meizen-Dick 2002). Greater access to resources, be it financial, physical, human, social, or natural, would increase food security through access to money, food, social networks, natural resources, physical infrastructure and markets, and so forth.

Data collection

Data collection took place between July 2014 and July 2015. A total of 339 quantitative household surveys were conducted from March to May 2015; 152 in Kinna and 187 in Burat. The surveys provide a statistically representative sample size of agricultural households in both Kinna and Burat. The survey was comprised of questions about livelihood capital assets, demographic characteristics, wildlife disturbance, and agroforestry practices. Surveys were conducted by enumerators after they underwent a two day training. Surveys were conducted in either Swahili or Borana based on the language ability of the respondents. At each household either the male or female household head took part in the survey based on who was available and willing to participate. Enumerators surveyed every other household along a transect (road or path), and if no one was available at a household enumerators surveyed the very next available household. GPS points were taken at each survey household.

The qualitative household case studies included 20 households total; 13 in Burat and 7 in Kinna. The case study households were selected to provide a variety of in-depth opinions, but are not necessarily representative of the communities. Each household was interviewed three times, and when possible both male and female households head were interviewed. The main purpose of these unstructured interviews was to capture what Bernard (2011) calls the 'lived experience' of humans. Interviews took place in Swahili, were recorded, and were later transcribed verbatim using Phillips SpeechExec Transcribe 7.1 software.

Data analysis

The quantitative survey data was analyzed in Microsoft Excel and Stata IC13 software programs. Summary and descriptive statistics were conducted. In addition, one-way ANOVAs, logistic regressions, Pearson's correlation, and χ^2 tests were utilized to compare responses between different groups of survey respondents. While a variety of analytical methods exist to compare and contrast livelihood capitals, the methods used here are based on past work by Erenstein et al. (2007) and Campbell et al. (2001). For each indicator, the answers were given a score from 0 (worst, less desirable), to 1 (best, most desirable). Then for each survey household an unweighted, composite index was calculated as the average of the indicator values for each livelihood capital. Thus, each household received a score for all five livelihood capital assets.

The qualitative case study interviews were coded using QSR NVivo 10. The coding process was conducted with the interview text in Swahili in order to maintain the original themes and ideas. Codes were developed based on a review of academic literature, the interview discussion topics, and themes that emerged during the research process.

Results

Crop raiding on farms

Crop raiding was perceived to be prevalent in the study areas; 83% of survey respondents in Kinna and Burat reported having experienced wildlife crop raiding. The major wildlife species participating in crop raiding were statistically correlated with study area (Table 8.2). In Burat, the major wildlife menace was from elephants, while in Kinna it was monkeys, porcupines, dik-diks, gazelles, and buffaloes. It is important to note here that monkeys refered to

Table 8.2 Major crop-raiding wildlife species according to household survey respondents. Respondents listed all wildlife species that impact their farms in both communities. A Pearson's correlation was conducted to test for correlations between wildlife species and study area. These results found that most wildlife species are significantly more prevalent in one study area than the other. No correlation was done for squirrel and rabbit due to small sample sizes.

Wildlife Species	**Total** (n = 274)	**Burat** (n = 154)	**Kinna** (n = 120)	χ^2	p-value
Monkeys	163	63	100	50.3698	0.0000
Elephant	161	115	46	36.7592	0.0000
Porcupine	116	47	69	19.7393	0.0000
Dik Dik	106	39	67	26.4657	0.0000
Gazelles	72	15	57	49.6394	0.0000
Buffalo	67	0	67	113.8137	0.0000
Zebra	16	16	0	12.9917	0.0000
Squirrel	8	8	0	-	-
Rabbit	4	4	0	-	-

all primates as respondents used the Swahili work “Nyani” which generically refers to primates. However, different primate species do have different feeding habits which could impact wildlife crop raiding by primates.

Table 8.3 Time of year when wildlife disturbance occurs most often and type of crop most impacted by wildlife, by percentage of survey respondents. Survey respondents chose one answer to both questions.

Site	Time of year when wildlife disturbance occurs most often[1]			Type of crop impacted most by wildlife[2]		
	Dry periods	Wet periods	Same throughout the year	Trees	Ground crops	Both the same amount
Burat	38.3	38.36	23.29	2.60	53.25	44.16
Kinna	59.20	6.40	34.40	18.42	36.84	44.74

[1] Pearson’s correlation test found that time of year when wildlife disturbance occurs most was significantly correlated with study area at $\chi^2 = 38.1460$ and $p = 0.000$.
[2] Pearson’s correlation test found that type of crop impacted most by wildlife was significantly correlated with study area at $\chi^2 = 11.4432$ and $p = 0.003$

Survey respondents were asked which time of year crop raiding has typically been most prevalent: dry periods, wet periods, or the same throughout the year (Table 8.3). In Burat, wildlife disturbance was reported to be the same during both the dry and wet periods; however, in Kinna almost 60% of respondents reported crop raiding was worse during dry periods. As stated by an elderly female farmer in Kinna, “yes, wildlife bother us, especially those of us who farm using water from canals. Now they [wildlife] see that there is a green area, and if they see our green farms they come and eat.” Survey respondents were also asked if crop raiding on their farms was worse for tree crops, ground crops, or if it impacted both the same (Table 8.3). Ground crops were classified as crops not grown in trees including maize, beans, and vegetables. Overall, survey respondents from both study areas reported that ground crops were impacted more than tree crops by wildlife raiding. Many household case study participants agreed with this (for example, see quote in the introduction); however, some participants did qualify that elephants are able to completely destroy trees.

About 63% of our survey respondents in Burat and 61% in Kinna practiced agroforestry. The five most common trees planted in Burat were, in order, papaya, banana, mango, guava, and avocado. In Kinna, the five most common trees planted were, in order, mango, guava, papaya, neem (*Azadirachta indica*), and banana. In Burat, 42% of households with agroforestry sold fruit and 50% consumed it within the household; while in Kinna 48% sold fruit and 80% consumed it within the household.

The household survey results found that there was no significant correlation between crop raiding and practicing agroforestry. Additionally, a logistic regression found that the number of trees on a farm, diversity of tree species, or density of trees were not a statistically significant predictor of crop raiding. There was no significant correlation between agroforestry and crop raiding from any specific wildlife species based on one-way ANOVA tests. These data suggest that practicing agroforestry did not either increase or decrease the probability that a farmer has experienced wildlife crop raiding.

Table 8.4 Comparing agroforestry characteristics with if agroforestry provides income when other crops are destroyed by wildlife.

Agroforestry characteristics	Trees help provide income when other crops are destroyed by wildlife?	Burat	Kinna	Both
Number of trees (#)	Yes	51**	42	23*
	No	16**	34	38*
Diversity of tree species (# of different species)	Yes	6.0**	5.9**	6.0**
	No	3.8**	4.4**	4.0**
Tree Density (trees per acre)	Yes	15.9**	10.3	11.9
	No	7.8**	15.3	9.7

* p-value < 0.10
**p-value < 0.05

Agroforestry and crop-raiding

Overall, 56% of household survey respondents with agroforestry reported that when crops are

Table 8.5 Correlations between the major benefits of agroforestry and if agroforestry helps provide income in the face of crop raiding. These numbers are percentages of survey respondents with agroforestry who answered either yes or no trees help for each benefit. For example, for households who eat fruit from their trees, 66.4% said trees help provide income.

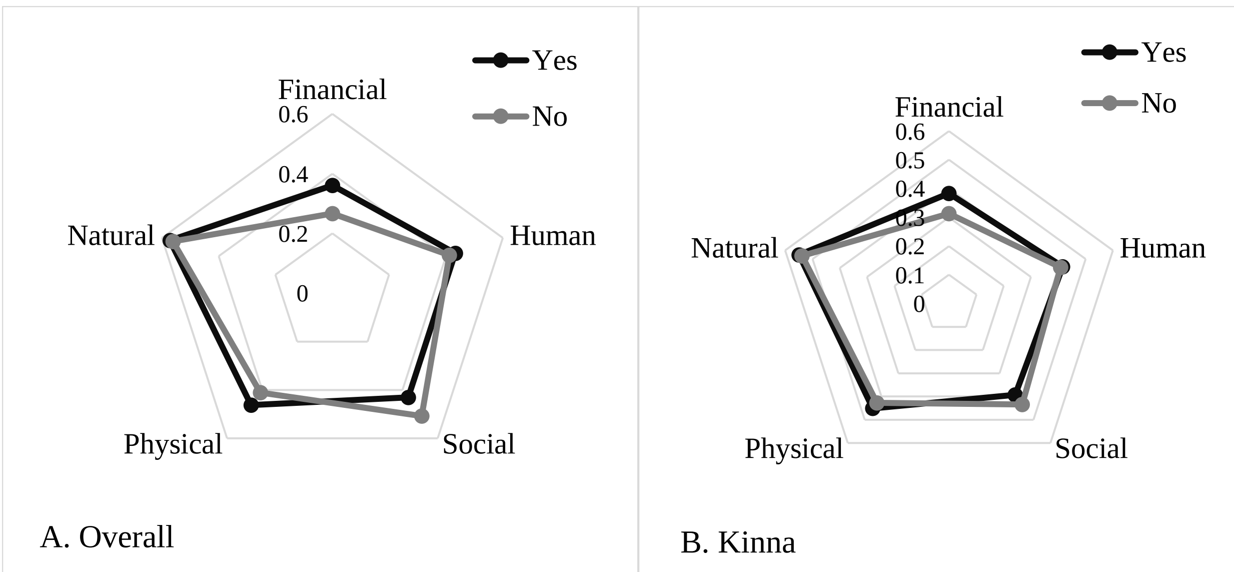
Benefits of Agroforestry		Trees help provide income in the face of crop raiding	
		Yes	No
Fruit for household consumption[1]	Yes	66.4	33.6
	No	28.2	71.79
Fruit for sales[2]	Yes	68.6	31.4
	No	29.8	70.2

[1] Pearson's correlation test found that fruit for household consumption and if trees help provide income was significantly correlated with study area at χ^2 = 17.1914 and p = 0.000.
[2] Pearson's correlation test found that fruit for sales and if trees help provide income was significantly correlated with study area at χ^2 = 19.8792 and p = 0.000

damaged on their farm by wildlife, trees help make up for their lost income. However, this was significantly correlated with study area (χ^2 = 29.51, p = 0.0000); in Burat, 35% of respondents answered yes, while in Kinna 78% of respondents said yes. Households with a higher diversity of tree species, and greater number of trees were more likely to report that trees provide income when other crops are damaged (Table 8.4).

Data indicates that there may be some correlation between agroforestry and increased food security in the face of crop raiding (Table 8.5). The major benefits of agroforestry were fruit for sales and household consumption, and these are directly (food for household consumption) and indirectly (money to buy food) related to food security. For example, a male farmer in Kinna reported that "Trees, even guava will remain [after crop raiding], and it will help me. Even bananas, if it is not elephants, will remain and help me, even mangos."

To further examine this link between agroforestry and food security in the context of crop raiding, the sustainable livelihoods framework and the five capital assets were utilized (Figure 8.2). This figure uses the composite index scores from the sustainable livelihoods framework five capital assets (Table 8.1) to compare the capital assets of households both with and without agroforestry. Survey households whose trees helped provide income had significantly higher financial capital scores on average. In contrast, households whose trees did not provide income in the face of crop raiding had statistically significant higher social capital scores on average. This figure highlights two coping mechanisms utilized in Burat and Kinna in the face of crop raiding: income from agroforestry trees and relying on social networks.



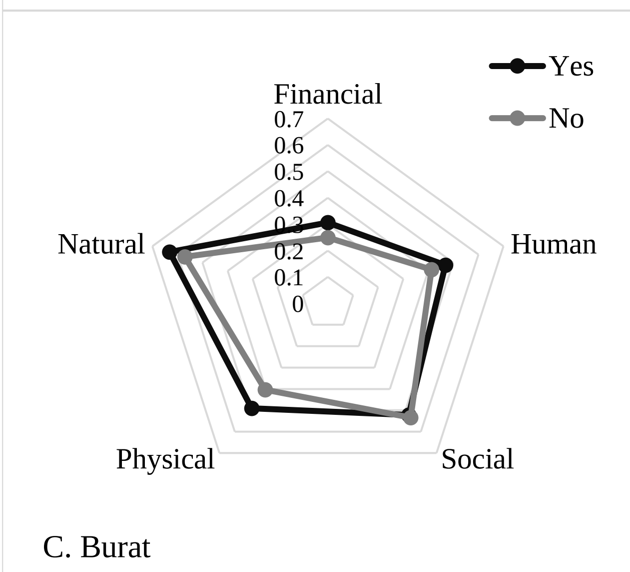


Figure 8.2. Livelihood capital asset scores for households where, when crops are destroyed by wildlife crop raiding, agroforestry can help provide income. Using one-way ANOVA tests, we reject the hypothesis of equal means for financial capital (p = 0.0037), social capital (p = 0.0184), and physical capital (=0.0250). All of the households included here practice agroforestry. For Burat, one-way ANOVA tests found that we reject the hypothesis of equal means for physical capital (p = 0.0168). For Kinna, one-way ANOVA tests found that none of the means are statistically different.

Discussion

Agroforestry plays some role in improving food security for households facing wildlife crop raiding by providing both nutritious food to eat and income to buy food. In Ethiopia, Lemessa et al. (2013), found that fruit trees were more commonly observed in homegardens close to the forest edge than those farther away. This suggests that farmers there may be planting fruit trees, as opposed to maize or sorghum, in areas nearest to forests because they recognize the benefits of agroforestry when faced with crop raiding. Results presented here support this work in Ethiopia, and provide more nuance and understanding to how agroforestry builds livelihood resilience and food security.

However, the relationships between crop raiding, food security, and agroforestry are complex and site specific. The results in Kinna and Burat varied significantly, which is largely explained by the ecological context of each area, supporting the notion that there are few universal trends in wildlife crop raiding (Songhurst and Coulson 2014). In Kinna, wildlife disturbance occurred mainly during the dry season, which is consistent with research by Sitienei et al (2014). Farmers in Kinna farm with irrigation canals, creating green patches on the otherwise dry landscape. Thus, farms in Kinna are sources of food for wildlife from Meru National Park during the dry season, when wild food sources may be scarcer (Hockings and Humle 2009). On the other hand, the data from Burat did not show a distinct seasonal trend in crop raiding.

Different wildlife species were more common in the two communities leading to different impacts of crop raiding. In Burat, elephants were the major crop raiding wildlife species, which is not surprising given the location of Burat in an elephant migration corridor (Douglas-Hamilton et al. 2005; Von Gerhardt et al. 2014). Kinna is different as farms border Meru National Park. In Kinna, smaller wildlife species and ungulates, including monkeys, porcupines, dik-diks, gazelles, and buffalo, were more of a nuisance. The fence in Kinna was built specifically to reduce human-elephant conflict (Sitienei et al. 2014), which it seems to have done. However, it appears to have been less successful at keeping out other, smaller wildlife species.

Agroforestry improved food security by providing food and fruit for income, and households who received these benefits were more likely to say that agroforestry helped improve food security in the face of crop raiding. By providing food directly, agroforestry can help improve nutrition and health, while income from the sales of agroforestry products can provides the means for households to purchase food. The more trees a household has, the more benefits they may be receiving. A greater diversity of trees is also important because agroforestry tree species have different ecologies, may produce fruit at different times of year, or may be more or less favored by wildlife. While crop raiding frequency was not recorded in this research, data does suggest that Kinna experiences more frequent, smaller crop raiding events from smaller wildlife species, while Burat experiences more severe, less frequent crop raiding events from elephants. In Burat, elephants were reported as the most common nuisance and the only animal that can severely destroy agroforestry trees. More farmers in Kinna reported that agroforestry helped improve food security than in Burat. Thus, agroforestry may help more in areas where more frequent, but less severe crop raiding event occurs, and less in areas where severe elephant crop raiding is a problem.

Results suggest two different strategies for building livelihood resilience against crop raiding and improving food security: agroforestry and social capital. Households that received income from agroforestry in the face of wildlife crop raiding, on average, had higher financial capital scores, while those who did not instead had higher social capital scores. Through the sales of fruit and other tree products, households were able to increase their financial capital. While greater financial capital may not always lead to increased food security, a positive link between financial capital and food security has been shown (Millimet et al. 2015).

Social capital is a measure of trust, reciprocity, and membership in social networks or groups (Martin et al. 2004). This can include reciprocity among neighbors or family, access to information from formal or informal institutions, and observance of behavioral norms (Sseguya 2009). Social capital was significantly higher in households who could not rely on their trees for income. This suggests that households without income from trees may instead rely on social capital to obtain food after a wildlife crop raiding event. Sseguya (2009) found that in Uganda, trust and belief in helpfulness with neighbors, and the observance of social norms was positively associated with food security. In the United States, Martin et al (2004) found that social capital was positively associated with household food security. The research presented here provides another example of how social capital may help build food security.

Conclusion

Crop raiding by wildlife can significantly decrease both income and food supplies for smallholder farmers, resulting in decreased food security and poor nutrition. This paper explored how agroforestry may be one potential intervention to improve food security and nutrition when wildlife crop raiding occurs. Food security is important for people to be able to live healthy, fulfilling lives, and agroforestry trees produce nutritious nuts and fruit. The results illustrated that agroforestry may have the potential to help build livelihood resilience and improve food security through four major findings. First, there was no statistically significant relationship between practicing agroforestry and experiencing wildlife crop raiding. Second, the local ecological context matters, as it can change the seasonality of crop raiding and the wildlife species present. Third, in the study areas, trees did help provide income when other crops were damaged by wildlife for some households, with greater benefits for households with more numbers and a diversity of trees. Lastly, households who reported that trees helped provide income if their other crops were destroyed had, overall, greater financial capital scores than households who could not. On the other hand, households who could not utilize their trees for income had, overall, greater social capital scores. This suggests that relying on family, neighbors, and social networks is another strategy for maintaining household food supplies when crops are damaged by wildlife.

More research should be done in order to support the research done here. This paper did illustrate the contextual nature of this issue, so an in-depth understanding of the relationships between agroforestry and food security in the face of wildlife crop raiding requires expanding to other contexts. However, these results do show the potential of agroforestry as an intervention to improve food security and should be considered by development organizations, wildlife conservation groups, and other policy makers. Finding ways to help households living near wildlife areas cope with losses from wildlife crop raiding is an important issue to these stakeholders, and more research may help scale up the results presented here. Agroforestry may provide one specific type of intervention that can help households globally cope with these significant issues.

CHAPTER 9. CONCLUSIONS

Addressing the Research Questions

This research was guided by four sub-questions, which together address the major, overarching research question: does agroforestry enhance livelihood resilience to environmental and socio-economic change and if so how? The sub-questions address different aspects of the overarching research questions. In this section, I will relate the results of this dissertation research from Chapters 5 through 8 back to the research questions presented in Chapter 1. This provides a summary of the major conclusions of this dissertation organized by research sub-question.

Sub-question 1: How do households use agroforestry to cope with, and build resilience against, the impacts of floods and droughts, if they do?

Sub-question 1 was the focus of Chapter 6, with valuable results also in Chapter 5. Chapter 5 emphasized general livelihood resilience to a variety of shocks, which included the impacts of climate change such as floods and droughts. The finding that households with agroforestry had 10% higher scores for the average of all five livelihood capitals, and 36.5% higher scores for financial capital is relevant to floods and droughts. Households with generally more resilient livelihoods (higher livelihood capital scores) would likely also be more resilient to floods and droughts (Thorlakson and Neufeldt 2012). Agroforestry was also found to help increase both on-farm crop diversity and the overall diversity of livelihood activities, important strategies to help farmers reduce their vulnerability to the impacts of global environmental change (McCord et al. 2015).

The results in Chapter 6 provide a wealth of knowledge about how agroforestry can and does build livelihood resilience to floods and droughts. Agroforestry was found to provide both livelihood (income, food, fodder) and environmental benefits (shade, erosion prevention, windbreakers) during floods and droughts. Agroforestry was reported to be very important during drought (55.1% of survey respondents), flood (60.2%), and the El Nino event that occurred in 1997 (53.4%). Particularly, respondents found agroforestry to be important to their livelihoods if they could sell fruit during floods or drought as a supplemental source of income. Furthermore, a majority of respondents stated that they had planted trees with the specific aim that it would help during times of drought.

<u>Sub-question 2</u>*: How do households use agroforestry to cope with, and build resilience against, economic instability, if they do?*

The focus of sub-question 2 is economic instability which is an underlying topic in Chapters 5 through 8. The major livelihood shocks studied in this dissertation (floods, droughts, violent conflict, wildlife crop raiding) can all lead to localized economic instability by reducing agricultural yields, impacting access to local markets, and interrupting people's daily lives and livelihood activities. Therefore, the results presented in Chapters 5 through 8 both directly and indirectly address how agroforestry builds livelihood resilience to economic instability. Results from this research highlight the importance of agroforestry as a source of income during times of economic instability in Isiolo, Kenya through fruit sales. Certain tree species, such as banana and papaya, were planted because they can produce fruit year round. Therefore, many households were able to receive an income year round by selling fruit from their trees. Having this supplemental income may directly increase many household's livelihood resilience to various causes of economic instability (such as those in Chapters 5 through 8) by providing a source of income when other sources of income may be less productive or not feasible.

Indirectly, agroforestry may increase overall livelihood resilience to various causes of economic instability by assisting in the creation and accumulation of the five livelihood capital assets (financial, social, human, physical, natural). A household is assumed to need a balance of these five capitals in order to maintain adaptive capacity and well-being (Jacobs et al. 2015). Accumulation of one type of livelihood capital through practicing agroforestry may help build other livelihood capital assets. For example, income earned through fruit sales could increase human capital by providing school fees which increase the education level of household members. A household with a balance of accumulated livelihood capital assets may be better able to cope with sources of economic instability. The results of this dissertation provide empirical support for the idea that agroforestry can and does increase livelihood resilience to a variety of causes of economic instability for many smallholder farmers in Isiolo, Kenya.

<u>*Sub-question 3*</u>*: What are household's perceptions of the ecological importance of agroforestry?*

Sub-question 3 brings the focus back to the environment by examining the perceptions of households in regards to how their agroforestry trees are benefiting the environment. Results relevant to sub-question 3 are predominantly presented in Chapters 5 and 6. Both these chapters discuss the importance of shade for people and their farms. In the relatively arid climate of Isiolo County, Kenya, many respondents recognized the importance of shade in regulating micro-climates, reducing evapotranspiration, and maintaining soil moisture. During the household survey, respondents were asked to generally name the major benefits of their agroforestry trees. Importantly, five of the top 16 benefits named were environmental. These included shade, windbreaks, preventing erosion, attracting rain, and providing compost/fertilizer. During the household case study interviews, participants also mentioned the benefits of shade and windbreaks as being particularly important. This illustrates that respondents recognize the wide variety of environmental benefits from agroforestry.

Chapter 6 highlighted the ecological importance of trees specifically during both flood and drought events. An interesting finding in Chapter 6 was that in Burat, many households with agroforestry perceived there to be fewer droughts now compared to 10 years ago. In contrast, households without agroforestry predominantly responded that there are more droughts now than 10 years ago. While the explanation for this is most likely complex, it illustrates how both the ecological and financial benefits of agroforestry may be lessening the impact of drought on households with agroforestry. Survey respondents were also asked to list the major benefits of agroforestry during both floods and droughts. During droughts, over 40 respondents answered that trees provide shade, a cool environment, serve as a windbreaker, attract rain, prevent erosion, and provide shade on the farm. Household case study results supported the survey results and many households discussed the environmental benefits of trees during drought including preventing erosion, serving as a windbreaker, attracting rain, and providing compost. In contrast, during floods, over 20 household survey respondents replied that agroforestry trees prevent erosion, serve as a windbreaker, and reduce flood/rainwater flow speed. Household case study participants supported the surveys by discussing how trees prevent soil erosion and reduce flood/rainwater flow or speed.

In summary, many households in Isiolo County, Kenya perceived agroforestry to be ecologically important. The ecological benefits mentioned generally promote sustainable farming, thus not only benefiting the environment but also the livelihoods of these farmers. Building livelihood resilience must not solely focus on income, but promote environmental conservation in order to sustain livelihood resilience in the long term.

<u>Sub-question 4</u>*: What specific types of agroforestry, and specific tree species, are used for what reasons?*

Sub-question 4 is addressed throughout Chapters 5 through 8. A major component of the survey and household case studies was to determine which tree species serve which purposes in terms of building livelihood resilience. Understanding this is particularly important for making recommendations for policy and practitioner communities. This dissertation does not provide the scientifically researched and identified benefits of certain trees, but instead let smallholder farmers identify for themselves which trees provide them with what benefits. According to survey respondents, the top six tree species planted were (in order) papaya, mango, guava, banana, neem, and avocado. These six species were each planted by at least 70 respondents. As prominent throughout this dissertation, the agroforestry benefits of income and food were by far the most important to smallholder farmers regardless of the specific situation (flood, drought, violent conflict, wildlife crop raiding). Case study households were useful in elaborating why each of these species were popular and what general benefits they provided to building livelihood resilience. For example, the top three tree species that provided income were mango, avocado, and papaya, and the top three tree species that provided food were papaya and mango, with avocado and guava in a tie for third. Other species were identified as being important for other reasons; for example, *Grevillea robusta* was named as the top species for construction materials.

Chapter 6 highlighted what tree species are particularly beneficial during either flood or drought events. During drought, case study households discussed how papaya and banana are important because they produce fruit year round (as long as some irrigation is possible). Others said that mango was particularly beneficial during drought because it is drought resistant and provides shade, income, food, and fodder. During floods, mango was also mentioned frequently by case study households because mangos were also considered flood resistant, they reduce water speed and serve as a windbreaker, and provide income and food.

Chapter 7 focused less on specific tree species and instead highlighted the general benefits of agroforestry trees during and after violent conflict. During conflict, some survey respondents reported that they could harvest fruit, firewood, construction materials, and hide behind trees. After conflict, survey respondents reported that agroforestry trees helped them rebuild their homes, and provided food and income from fruit sales. While specific trees were not discussed, understanding the characteristics of trees that helped build livelihood resilience is important. It provides a first step to then deciding which trees might be promoted.

Chapter 8 focused on agroforestry during wildlife crop raiding and highlighted the benefits of agroforestry as a supplemental source of income when other crops (such as maize, beans, and vegetables) are eaten or destroyed by wildlife. The results of Chapter 8 found that the types of trees on a farm, along with the types of wildlife species that raid the crops can matter. For large, woody trees such as mangos and guavas, wildlife must be able to climb the trees in order to eat the fruit. However, for trees such as banana, larger wildlife including buffalo and elephant can be very destructive. As seen when comparing Burat to Kinna, local ecological context is important when understanding what tree species can help build livelihood resilience to wildlife crop raiding, and this dissertation provides some of the first empirical evidence about this relationship.

<u>Research Question 1</u>*: Does agroforestry enhance livelihood resilience to environmental and socio-economic change and if so how?*

The results that address each of the four sub-questions complement each other to provide comprehensive, empirical evidence that agroforestry can and does enhance livelihood resilience to environmental and socio-economic change. This dissertation provides specific evidence for how agroforestry builds resilience by enhancing the five livelihood capital assets and providing benefits to both livelihoods and the environment. Generally, this research found that the more trees and the greater diversity of tree species a household had, the greater the benefits of agroforestry and the more important role agroforestry played in building livelihood resilience. However, the answer to this major overarching research question will depend on the specific context of the research, types of major disturbances and shocks, and agroforestry and livelihood practices of the households.

Additionally, evidence from Chapters 5 thorugh 8 support the idea that agroforestry can cause improved livelihood resilience, and not necessarily that better-off households are more likely to plant trees. This specific question was discussed with household case study participants; who repeatedly voiced their perspective that agroforestry has indeed improved their household financial situation and overall wellbeing. Further, in the household surveys, respondents were asked how much agroforestry had improved both their household financial situation and overall wellbeing (on a scale from *none* to *a lot*). In both communities, many households replied that agroforestry had improved these aspects of their lives *a lot*. Additionally, households who answered *a lot*, had on average a greater number of trees and diversity of tree species. This supports the idea that agroforestry is helping build livelihood resilience because having more trees and a greater diversity of tree species increased the likelihood that a survey responded that trees had helped improve their finances and well-being *a lot*.

Generalizability of the results

The generalizability of these results is an important topic because it potentially sheds empirical light about the often assumed connection between agroforestry and livelihood resilience. This research concludes that agroforestry can build livelihood resilience and provides a working hypothesis about the specific mechanisms and methods through which agroforestry contributes to livelihood resilience. The aim of analytic generalization is to generalize to other concrete situations (Yin 2014), and the multiple-case study design of this dissertation helps to validate the findings from each of the research sites through comparing and contrasting the results. Therefore, I hypothesis that the findings from this dissertation may be generalizable to contexts with some similar characteristics including: being comprised of smallholder farmers, situated in arid or semi-arid environments, and in a location where irrigation is available to some extent to all or most farmers.

First, all participants in this dissertation research were smallholder farmers and I am not confident that their experiences with agroforestry and various livelihood disturbances would be shared by large-scale, industrialized farmers. These two types of farming activities vary significantly as far as farming methods, access to markets and financial resources, and vulnerability to disturbances. Therefore, while the results may be generalizable to other smallholder farming areas, they may not be as applicable to other types of agricultural contexts.

Second, both the case studies in this dissertation are located in semi-arid environments and this environmental constraint has been critical to the development of the research participants overall livelihood strategies. Research participants actively planned their livelihood activities with an understanding that drought, lack of rainfall, lack of soil moisture, and other issues pertaining to living in an arid environment can have severe consequences for their livelihoods, food security, and overall well-being of their family. Farmers living in different environmental conditions may instead be planning their livelihoods with other critical disturbances in mind (e.g. typhoons, monsoon rains, etc.) and thus rely on different livelihood activities to cope with these different types of livelihood disturbances. Lastly, for households in semi-arid and arid environments, having some access to irrigation can be critical for sustaining agriculture and agroforestry. Particularly, for some, access to irrigation can be important in being able to adopt and practice agroforestry. Thus, the results of this dissertation may not be generalizable to arid and semi-arid environments where irrigation is not an option.

This type of analytical generalizability is different than statistical generalization, which was the aim of the household survey. The purpose of the household survey was to collect quantitative, representative data in order to make generalizations, build upon the household case study interview data, and triangulate the research findings. However, these generalizations are statistical generalizations that refer to the two research sites and not to a larger context necessarily.

The Two Research Sites: Burat and Kinna

The previous section summarized the research results by sub-question. The aim of this section is to elaborate on these research results to compare and contrast some of the major results by research site. This dissertation research took place in two research sites in Isiolo County: Burat and Kinna. These two communities were described in detail in Chapter 3 and the rationale for selecting these two sites specifically was provided in Chapter 4. Importantly, I chose to include two case studies, as opposed to one, for this research because, depending on the research questions, evidence and results from multiple case studies is often considered more compelling and robust than a single case study (Yin 2014). Thus, asking the same research questions and using the same research methods in both Kinna and Burat allowed for more nuance and depth to the results. Whenever possible in Chapters 5, 6, and 8, the results from Kinna and Burat were compared to see if and how they varied. Chapter 7 focused only on results from Burat, so a comparison is not possible. In this section, I will briefly compare and contrast the results from Kinna and Burat.

In Chapter 5, focused on general livelihood resilience, there were few major differences between Kinna and Burat that emerged, while smaller differences did exist. The top livelihood activities, outside of agriculture, in Burat was casual labor, while in Kinna it was livestock keeping. This illustrates that livelihood opportunities outside of agriculture, can be somewhat different in Kinna and Burat because of the ecological, social, and political contexts of each community. The survey results about the major tree species planted and main agroforestry benefits were presented separately for Kinna and Burat, as well as aggregated. While the results were fairly similar, in Burat tree species such as cassava, *Grevillea robusta,* and pigeon peas (*Cajunus cajun*) were more common, while in Kinna custard apple, lemon, and guava were more prominent. Major benefits of agroforestry were also generally similar between communities. In

Kinna, the benefits of windbreaks, erosion prevention, medicine, fodder, attracting rain, and drought income were mentioned more frequently than in Burat. In Burat, more respondents replied that their trees were still too small to provide benefits, suggesting that tree planting is a newer practice in Burat than in Kinna. This is consistent with the literature review, qualitative household case studies, and key informant interviews. Furthermore, the summary of household characteristics presented data comparing Burat and Kinna, which were also generally similar. Households with and without agroforestry were significantly different in both Kinna and Burat in regards to having a bank account, access to irrigation, and the number of different crops planted. However, some household characteristics were significant only in Burat between households with and without agroforestry, including household size, labor force between 18 and 55, respondent's length of time living in the area, and the number of months that crops fed the household last year. While only in Kinna, farm size was different between households with and without agroforestry. These comparisons of household characteristics illustrate how there are some differences and nuances between the communities, while several results for household characteristics were similar in both communities. Lastly, results about the percentage of survey respondents who stated that trees had improved their income and/or quality of life was compared between communities. Overall, respondents in Kinna expressed a greater degree of improvement in income and quality of life due to agroforestry. This may be due to the fact that households in Kinna have generally been practicing agroforestry for longer, meaning that trees have had more time to grow and provide benefits than for many households in Burat.

In Chapter 6, comparing how agroforestry can build livelihood resilience to floods and droughts between the two communities did bring out some interesting comparisons. Figure 6.4 compared perceptions of the changes in the frequency of drought over the last 10 years. In

Burat, many households with agroforestry and/or irrigation stated that there were fewer droughts than 10 years ago, while in Kinna, even households with agroforestry and/or irrigation generally replied that there were more droughts. While exploring potential explanations for this difference, it came out that when defining drought, households in Burat generally talked about drought in terms of its impacts, while in Kinna households generally discussed drought in terms of lack of rain. This is an important difference. If households define drought in terms of its impacts (i.e. hunger, lack of pasture, crop failure) there are many factors that can affect how the impacts of drought are 'felt' by community members. For example, as I hypothesized in this dissertation, the more recently acquired benefits of agroforestry and irrigation in Burat have led some households to not 'feel' the impacts of drought as much now as 10 years ago. Thus, these households would answer that there are fewer droughts than before, somewhat regardless of rainfall patterns. Furthermore, there were some differences in the perceived benefits of agroforestry during floods and drought; which may be related to the differences in livelihood activities and agricultural context. For example, in Kinna, fodder was mentioned much more than in Burat as a benefit of agroforestry during both floods and droughts. This makes sense because households in Kinna are more reliant on livestock than in Burat. However, the top three benefits of agroforestry during floods and droughts (fruit for sale, fruit for household consumption, and shade/shelter for people) were commonly mentioned in both communities. Additionally, the importance of agroforestry during drought, floods, or the 1997 El Nino event were similar between Burat and Kinna.

In Chapter 8, the different ecological contexts of Kinna and Burat brought interesting nuance to the discussion of how agroforestry can improve food security and build livelihood resilience in the face of wildlife crop raiding. Particularly, Kinna borders a large protected area, while Burat is in a migration corridor between protected areas. This leads to different types of wildlife disturbances and prominent wildlife species. In Kinna, the major wildlife species that households reported were monkeys, porcupine, dik-dik, and buffalo, while in Burat the major species was elephants. This is due to the large electric fence between Kinna and Meru National Park preventing larger animals, such as elephants, from entering Kinna. Households in Kinna and Burat also had different responses for what time of year wildlife were more of a disturbance on their farms. In Burat, the results were fairly even between wet and dry periods, while in Kinna the overwhelming answer was that wildlife were more of a nuisance during dry periods. Household case study participants discussed how during dry periods, they farm with irrigation so the only green patches on the landscape are their farms, which attracts wildlife. Households were also asked what type of crops were impacted more, trees or ground crops. More households in Kinna, compared to Burat, replied that tree crops were impacted most, and this may be due to the smaller, tree climbing, wildlife species that were more common in Kinna. However, there were also similarities in the results from Kinna and Burat. Households in both communities who replied that trees helped them during wildlife crop raiding had significantly greater diversity of tree species. Overall, Chapter 8 is a good example of why understanding the different contexts of Kinna and Burat was important for analyzing the data and interpreting the results. Using these two communities provided nuance in the details for how agroforestry can build livelihood resilience during wildlife crop raiding.

As summarized here, using a multi-case study design in this dissertation was effective for understanding how agroforestry can build livelihood resilience. It helped to highlight nuance in the empirical evidence for how agroforestry can build livelihood resilience, and emphasized the importance of understanding the context. However, results from each community generally corroborated each other, contributing to the robustness of the general results and conclusions. In the future, I hope to expand this research to more research sites in order to gain an even better understanding of the variety of ways that agroforestry can build livelihood resilience to social-economic and environmental disturbances.

Furthering Knowledge

In addition to providing empirical evidence for how agroforestry can build livelihood resilience, this dissertation furthers knowledge about the major theoretical frameworks guiding this research including livelihood resilience and political ecology. Outlines of these theories were provided in Chapter 2. First, this dissertation drew from the sustainable livelihoods approach to measure resilience, and second, it aimed to integrate political ecology into resilience thinking throughout the research process.

Sustainable livelihoods approach to measuring resilience

Using the sustainable livelihoods approach to measuring livelihood resilience is a relatively new, novel methodology. There are a variety of advantages and benefits to using the sustainable livelihoods approach to measure livelihood resilience. First, conducting qualitative interviews, key informant interviews, or focus groups prior to conducting a survey aimed at measuring livelihood resilience can assist in identifying important and relevant indicators or surrogates of resilience. As Jones and Tanner (2015) point out, often measuring resilience 'objectively' is a top-down process, and drawing indicators from the local people themselves helped to counter this critique (Quandt and Kimathi 2016). Second, including a 'subjective' measure of resilience in the survey itself allowed for comparison to help ensure accuracy and to verify that the indicators of resilience were well chosen (this will be explained more below).

Additionally, using the sustainable livelihoods approach to measure livelihood resilience allows for an easy comparison between households based on their composite capital asset scores. The survey included questions about the indicators or surrogates of resilience along with other questions that assisted in differentiating households (ethnicity, age, agricultural and agroforestry practices). Therefore, it was a simple process to compare capital asset scores between households with different characteristics. For example, capital asset scores were compared between households with and without agroforestry, with and without irrigation, with different numbers of agroforestry trees, and with a different number of overall livelihood activities. One of the major goals of measuring resilience in the first place is to understand what components of the livelihood system help build resilience (Walker et al. 2002). By using this method different household characteristics can emerge as particularly important. For example, in this research important components for building resilience included practicing agroforestry, access to irrigation, and having a diversity of livelihood activities. Different surrogates or types of capital can also emerge as being particularly important. In this dissertation, both financial and natural capital were significantly different between households with and without agroforestry. This illustrates that agroforestry is building resilience particularly in the areas of financial and natural capital.

Brown (2014) has criticized resilience for placing more emphasis on the natural aspects of social-ecological systems. However, this method helps focus surrogates of resilience on both natural and social aspects of livelihood systems. This helps ensure a diversity of surrogates are used to measure livelihood resilience. Diversity is a key component of resilience, and livelihoods can be diversified through the accumulation of a variety of capital assets. The methods used in this dissertation focus on the diversity and multitude of assets that contribute to livelihood resilience (Ellis 2000; Krantz 2001; Hodbod and Eakin 2015).

Lastly, Tanner et al. (2015) promote the livelihood resilience approach because it highlights human agency and capacity to prepare and cope with different shocks. Measuring livelihood resilience through the five livelihood capital assets can highlight how people actively build and accumulate capital in order to better prepare for shocks. It also ensures the inclusion of non-monetary measures of livelihood resilience including social capital (social relationships and networks), and physical capital (access to education and transportation, for example), which is important in understanding the overall picture of livelihood resilience (Rakodi 1999; Lebel et al. 2006).

While using the sustainable livelihoods approach to measure livelihood resilience has many advantages and benefits, there are also drawbacks and critiques of this method. First, it only provides a 'snapshot' of livelihood resilience, and not necessarily a dynamic measure of how livelihood resilience is changing. If the goal was to look at how livelihood resilience has changed over time, households would have to be asked the same questions focused on surrogates of resilience at two different points in time. Additionally, the method used here does not prioritize surrogates of resilience. Some surrogates may be more important than others in building livelihood resilience and this method did not take that into account. However, using the same methods, different surrogates could be weighted during analysis. So weighting different surrogates is possible using the methods presented here, however it was not done in the case study.

Another drawback of this approach is that it may be difficult to include large-scale factors into resilience measurement that can have a significant impact on livelihoods including national politics, macroeconomics, or international trade. This is a critique of the sustainable livelihoods more generally (Serrat 2010), but also applies to the methods described here. Lastly, one critique of measuring resilience is that it is often highly contextualized, and thus difficult to include in policy (Cooper and Wheeler 2015). This critique holds true for the sustainable livelihoods approach to measuring resilience because the specific surrogates of resilience will vary between contexts. However, the general approach could be used regardless of context.

So, in this dissertation, how successful was the sustainable livelihoods approach in measuring livelihood resilience? In order to get some sense of this I compared the overall composite asset index scores with self-reported levels of well-being or 'subjective' resilience. During the survey, respondents were asked to rate their current overall living conditions and well-being compared to their neighbors. While this is not exactly the same as livelihood resilience, it was the most comprehensive question in the household survey that is arguably similar, or at least related, to livelihood resilience. This question was asked on a scale of 1 (much worse) to 5 (much better). Next, the livelihood capital asset overall composite scores were compared to the self-reported scores. These two scores were found to be statistically significantly correlated ($chi^2 = 57.57$, $p = 0.000$). While neither of these scores or measures of resilience are perfect, the fact that the methods used here are similar to self-reported measures suggests that using the sustainable livelihoods approach to measuring livelihood resilience is a valid methodological approach.

Political ecology and resilience thinking

Chapter 2 outlined the benefits of integrating political ecology into resilience-based resource management and this piece was published in the journal *Resources* (Quandt 2016b). While some have discussed this previously (Peterson 2000; Cote and Nightingale 2012; Brown 2014; Fabinyi et al. 2014; Turner 2014; Stone-Jovicich 2015; Turner 2016), this article contributed to this body of work by proposing three major arguments for integrating political ecology into managing for resilience. First, political ecology can help to emphasize the importance of politics in resilience, while resilience thinking's focus on ecology can help political ecology engage with ecology. Second, the multiple critical lenses of political ecology may help define the system for resilience management. Lastly, political ecology's explanatory power can help identify surrogates of resilience for measuring resilience.

While Chapter 2 outlines these ideas from a theoretical perspective, I did aim to integrate these ideas and three major arguments into the dissertation field work and data analysis. Using these two approaches simultaneously further helped ensure that both social/political and ecological/natural variables were included in the research. Archival research and an extensive literature review on the research sites (Chapter 4) helped to situate this research within its social-political context. This was important for understanding the development, or rather underdevelopment, of Isiolo County under British Colonial until the present. It also helped to highlight the long-standing tensions between different ethnic groups in Isiolo. This political context was particularly important for Chapters 7 and 8, but also explain how the existing agricultural and irrigation systems came to exist. This political ecology analysis was complemented by ecological data collection. Understanding how rainfall has changed, as well as river levels, provides some insight into the changing natural environment.

The multiple critical lenses of political ecology helped to define and put some boundaries on the livelihood system. Chapter 4 explains how each research site, Kinna and Burat, are individual case studies within the larger research question, as well as further explaining how these case studies are embedded into larger contexts – Isiolo County, Kenya, and the Global context. Therefore, the livelihood systems were defined as being within the research sites, but interconnected with these three larger contexts. An example of these interconnections between the local livelihood system and these larger contexts is the various markets that households rely on for selling their agricultural and agroforestry products. For example, in Burat, many households must transport their products to Isiolo Town, the closest major market; while in Kinna some households transport their products even farther to Maua in Meru County. The difficulty of transporting goods came up numerous times over the course of research, and was particularly an important topic during floods, when poor roads often make transportation virtually impossible. Therefore, situating the livelihood system within the contexts of Isiolo and Kenya help to illustrate how the inaccessibility of markets during floods can hinder livelihood resilience. In Burat, agricultural groups are helping farmers reach even more distant markets. Finlays, an international business, has partnered with the Bidii Farmers Group in Burat to provide a market for french beans. Members of the Bidii Farmers Group grow french beans and utilize shared storage facilities, where Finlays picks up the product and then ships it to Europe. Access to this type of large-scale market can help increase livelihood resilience by providing an otherwise unavailable market for one agricultural product.

Lastly, a political ecology perspective helped to identify appropriate surrogates of resilience. Resilience has been critiqued for leaving out or ignoring power relationships (Nelson and Stathers 2009; Lebel et al. 2016), and integrating political ecology helps to address this issue. For example, several of the livelihood resilience indicators focused on issues of power and access to resources. Access to a bank account was included in financial capital, while access to irrigation and public services (schools, hospitals, etc.) were included as indicators of physical capital. Power relationships within Burat and Kinna may impact a household's access to these services, therefore decreasing their overall livelihood resilience. Additionally, a respondent's perceived local political influence and power was included in social capital. This could be critically important for a household to garner favor with the local government and direct resources towards their own household and family. These important indicators of livelihood resilience could have been left out without the use of a political ecology perspective in measuring resilience.

In conclusion, this dissertation not only provides a theoretical discussion of the benefits of integrating political ecology into resilience-based management, but utilized this approach in research design and analysis. Specific examples of this are seen throughout this dissertation and during the results-orientated Chapters 5 through 8. Overall, this approach greatly benefitted this research and furthers knowledge in the fields of political ecology and resilience.

Assumptions and Limitations

As briefly mentioned in previous chapters, there were assumptions made during the research process, as well as limitations of the research design. This section will briefly discuss the major assumptions and limitation of this dissertation.

Assumptions

This dissertation research was conducted under the two explicit assumptions that: 1. research participants were providing truthful, accurate information, and 2. livelihood resilience and sustainable livelihoods (sustainable livelihoods approach and capital assets) are related or connected. As is the case is virtually all social science research, I assume that research participants were honest and accurate in their responses. However, it is possible that household case study participants and survey respondents may have either intentionally or unintentionally lied or exaggerated when answering questions. Residents of Isiolo County have become used to various organizations conducting surveys and distributing aid or doing development projects. The motivation to receive aid may have swayed some respondents to answer how they thought they should instead of being completely honest and accurate. In order to combat this issue, survey enumerators were required to rank the honesty and willingness of survey respondents. Surveys were thrown out if the respondents received negative scores. Additionally, with the household case study participants, a rapport was built in order to establish trust and promote honest, accurate discussions. Based on my personal knowledge and experience in Isiolo, along with discussions with research assistants, the research responses and results seem to be accurate. However, this is an assumption.

Second, in using the sustainable livelihoods approach to measure livelihood resilience, the data collection and analysis processes assumed a connection or relationship between the sustainable livelihoods approach's five livelihood capital assets and livelihood resilience. I felt comfortable making this assumption based on a review of the literature and the few case studies that have also used this approach (Campbell et al. 2001; Elasha et al. 2005; Erenstein et al. 2010; Thulstrup 2015). First, according to Thulstrup (2015), resilience is a key component of sustainable livelihoods and vice versa. Additionally, as Campbell et al. (2001) state, "the capital assets approach to livelihoods may be an appropriate organizing principal for the selection of indicators of system performance." Using the five capital assets serves as a way to ensure that a diversity of indicators are considered, including material, social, and natural factors that may help to measure and ultimately build resilience. Diversity is often considered a critical component for increasing a livelihood's ability to cope with change (Ellis 2000; Hodbod and Eakin 2015). These capital assets constitute a stock of capital that can be stored, accumulated, exchanged, or allocated to activities to generate an income or means of livelihoods and other benefits (Rakodi 1999; Babulo et al. 2008), thus increasing livelihood resilience.

Limitations

There are three major limitations of this research project. First, the research was based on the memories, perceptions, and opinions of farmers. While this gave farmers their own voice, some element of accuracy may have been sacrificed and some details may have been excluded or left out. This is a major limitation of this type of research methodology compared to physically measuring specific variables, when possible. For example, we did not walk the farm and count how many trees were planted and what types of trees, and instead relied on the respondent to provide us estimates. We also did not do any sort of financial analysis of what agroforestry products sell for in the local markets and how much households are earning from their agroforestry products. Agroforestry was found to be significantly important in building financial capital, and conducting an accurate financial analysis would have given us exact figures for how much income agroforestry can provide for a household. While physically measuring variables is possible in future research, they are a limitation of this dissertation.

The second limitation is that this research provides only a snapshot of people's lives and livelihoods. Research took place over the course of one year, between July 2014 and July 2015. While a year is an appropriate amount of time for dissertation field work, the results would be more robust if research was conducted over the course of many years (or even decades). While archival research, literature review, and ecological data collection provide some context into how the area is changing, it does not necessarily comprehensively explain how livelihood practices or socio-economic and environmental disturbances are changing over time. In order to accomplish this, a longer-term, longitudinal study would need to be conducted. While revisiting these communities at a later date is a possibility for future research, the results here provide information from only one year in time. Therefore, this dissertation was unable to draw any conclusions about how agroforestry may impact livelihood resilience in the past or future. Instead, the results compared households with agroforestry to households with few or no trees, and does not compare households to themselves in different years.

Lastly, an important limitation of this research is the use of the sustainable livelihoods approach to measure resilience. Measuring resilience is a difficult task and while the approach used here provided some measure of livelihood resilience, it was not perfect. The success and limitations of using the sustainable livelihoods approach to measure resilience was discussed in detail in the previous section.

Policy Relevance and Future Research Directions

Development and policy relevance

The results of this research are meant to be applicable and useful both for development organizations and policy makers. These results can be used for both development projects and broader policies that aim at building livelihood resilience. The idea of resilience is being used by a multitude of international development and humanitarian organizations. During field work I saw examples of projects focused on building resilience from the Kenya Red Cross Society, Cordaid, Wetlands International, and USAID (United States Agency for International Development). This research provides specific examples of how agroforestry can build livelihood resilience which could be incorporated into resilience-building development projects. These specific examples and recommendations are discussed in detail in Chapters 5 through 8. Furthermore, this research outlines an innovative method for measuring resilience (Chapters 2 and 4). This could be used by development organization to measure resilience and identify key variables that help build resilience. Through the World Agroforestry Centre, in Nairobi, these results will be disseminated to appropriate agricultural development organization as well. By partnering with the World Agroforestry Centre from the beginning stages of this research through manuscript publication, the goal of providing usable science has always be at the forefront of this research project.

Resilience has also gained prominence in policy making at a wide variety of scales. This dissertation has the ability to provide guidance to larger-scale policy making as well. For example, I am participating in a series of workshops (2015 in Bangladesh, 2016 in Germany, 2017 in New York) that aims to provide policy recommendations to the United Nations Framework Convention on Climate Change (UNFCCC) on how to build livelihood resilience to loss and damage from climate change. This workshop brings together 30 or so practitioners and academics to help inform policy. My dissertation has contributed to the policy recommendations of the workshop thus far by emphasizing the importance of agroforestry for 1. enhancing livelihood resilience and 2. utilizing ecosystem services for reducing loss and damage from climate change. The policy brief that we produced in September 2016 states these two ideas as key insights from the workshop (Resilience Academy 2016). Therefore, this research has already had the ability to impact policy and I will continue to emphasize the usefulness of these results to policies regarding climate change, agricultural development, and agroforestry.

Furthermore, this research can have direct impact in Isiolo County and the two communities of Burat and Kinna. In the future, I hope to have the opportunity to disseminate the major results back to research participants. This could be in the form of a workshop, feedback meeting, or short plain language results report. By reporting the results back to research participants, I hope to demonstrate to them the importance and relevance their agroforestry practices to others and motivate households with no/little agroforestry to plant more trees in order to help support themselves during future livelihood disturbances.

Research: future directions

The results of this dissertation provide important evidence and insights into the roles agroforestry can play in building livelihood resilience to a variety of shocks. This dissertation addresses the call from both the academic and development communities for more empirical evidence about the links between agroforestry and livelihood resilience (Lin 2011; Maathai 2012; Nair and Garrity 2012; Thorlakson and Neufelt 2012). This dissertation begins to provide the needed empirical evidence; however, much more research needs to be done to fully understand the complex relationships between agroforestry and livelihood resilience. In this section I will discuss three major future directions for this research: conducting a longitudinal study, expanding the context, and moving beyond farmer perceptions and memories. These three future directions for research build off the limitations of this dissertation as explained earlier.

A longitudinal study of how agroforestry builds livelihood resilience would be useful for two major reasons. First, it would allow for greater understanding about how agroforestry, livelihoods, and the environment are changing over time. Looking at a change in agroforestry over time would also be particularly useful. Agroforestry is a relatively newer practice in Burat and Kinna as some pastoralist ethnic groups have only begun practicing agriculture over the past 40 years or so. Therefore, looking at how agroforestry practices change in these communities over time will help add to the understanding about which tree species are providing the most benefits to farmers. Second, a longitudinal study would allow for the links between agroforestry and livelihood resilience to be examined during real-time disturbances or events. For example, research could be conducted during and immediately after a flood, drought, violent conflict, or wildlife crop raiding incident to get a first-hand look at how agroforestry is being utilized during those events in Isiolo, Kenya. This type of research, called 'event ecology', is gaining momentum in the field of political ecology and was promoted by Vayda and Walters (1999) as a research method that could help study the causes and impacts of environmental change (for a more recent overview of event ecology see Walters and Vayda 2009).

A second future direction of this research is to expand the context of this study to other locations. Conducting a similar study in a few different places with different environmental, social, and economic contexts would help deepen the understanding of how agroforestry can and does build livelihood resilience. Many of the results in this dissertation were context specific including how drought impacts households in the research communities, the irrigation systems present and their role in agriculture, as well as how agroforestry can provide food after wildlife crop raiding. A changing context may impact either the major types of disturbance or their characteristics. Furthermore, households living in different places may have different abilities to cope and respond to shocks and disturbances. Local politics, land tenure policy, educational opportunities, and weather conditions can have important influence over livelihood opportunities and how a household may be impacted and able to cope with shocks. In the future, I hope to expand research on how agroforestry can and does build livelihood resilience to the Tanzanian context. Tanzania and Kenya would provide a good comparison because they are similar in that many households rely on agriculture or agro-pastoralism for their livelihoods, while the political, social, and environmental contexts can be significantly different. Comparing results from Tanzania to the Kenyan results in this dissertation may corroborate the results here, or provide important nuance.

Finally, a major limitation of this research is that it was based on the memories, perceptions, and opinions of farmers. The limitations of this approach to research were discussed above. In order to address these limitations, an important future direction of this research is to move past farmers perceptions and actually measure various variables. For example, it would be useful to survey the research participant's land and document the types of agroforestry practices and tree species. It would also be helpful to measure what agroforestry products are sold and when in order to fully understand the impact of fruit sales on household income. Furthermore, the same could be done for household consumption of agroforestry products. These types of measurements were left out of this dissertation because they are time consuming and limit the number of research participants. However, they would be helpful in the future for quantifying the benefits of agroforestry during specific shocks.

The three future directions for this research would complement this dissertation and deepen our understanding of the links between agroforestry and livelihood resilience. This dissertation begins to provide empirical evidence, but future research, as explained in this section, would help provide more generalizable results, important nuances, and specific details about the relationship between agroforestry and livelihood resilience.

Conclusions

This dissertation has provided comprehensive empirical evidence for how agroforestry can build livelihood resilience to a variety of environmental and socio-economic shocks and disturbances. This chapter specifically has outlined how the results relate back to each of the research questions and the two research sites, how the dissertation furthers knowledge at a theoretical level, the assumption and limitations of this research, as well as policy relevance and further research directions. As stated by the late Wangari Maathai (2004 Nobel Peace Prize Winner and Founder of the Green Belt Movement) we face grave challenges of climate change, environmental degradation, and poverty, and it is "more important than ever before to redouble our efforts to protect the environment… and provide smallholder farmers with sustainable ways of increasing their production and meeting their livelihood needs" (Maathai 2012, pg. 4-5). This dissertation has addressed this call to action from Wangari Maathai by providing specific examples and evidence on how agroforestry is one tool that can be used to improve the livelihoods of farmers and address issues of climate change and environmental degradation.

REFERENCES

Abdille, A., & Abdi, R. (2016). *Kenya: Development, County Governments and Risk of the 2017 Election Violence*. Retrieved from http://blog.crisisgroup.org/africa/kenya/2016/04/07/kenya-development-county-governments-and-the-risk-of-2017-election-violence/

Acacia Consultants Ltd. (2011). *Baseline Survey for Climate-Proof Disaster Risk Reduction Programme (CPDRRP) in Kenya, Final Report*. Nairobi, Kenya: Partners for Resilience.

Adamson, J. (1967). *The People of Kenya*. New York: Helen and Kurt Wolff Book.

Adato, M, & Meizen-Dick, R. (2002). Assessing the Impact of Agricultural Research on Poverty Using the Sustainable Livelihoods Framework, FCND Discussion Paper 128, and EPTD Discussion Paper 89. International Food Policy Research Institute.

Adger,W. N., Benjaminsen, T. A., Brown, K., & Svarstad, H. 2001. Advancing a political ecology of global environmental discourses. *Development and Change*, 32, 681-714.

Adger, N. (2003). Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography*, 79(4), 387-404. doi: 10.1111/j.1944-8287.2003.tb00220.x

Agrawal, A. & Gibson, C. C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World Development*, 27(4), 629-649. doi:10.1016/S0305-750X(98)00161-2.

Agrawal, A. (2005). *Environmentality: technologies of government and the making of subjects*. North Carolina, USA: Duke University Press.

Agrawal, A., & Perrin, N. (2008). *Climate adaptation, local institutions, and rural livelihoods, IFRI Working Paper #W081-6.* International Forestry Resources and Institutions Program. Retrieved from: http://www.umich.edu/~ifri/Publications/W08I6%20Arun%20Agrawal%20and%20Nicolas%20Perrin.pdf

Aguilar, M. I. (1999). Pastoral identities: memories, memorials, and imaginations in the postcoloniality of East Africa. *Anthropos*, 94, 149-161.

Akabwai, D. M. O. (1992). *Extension and livestock development: experience from among the Turkana pastoralists of Kenya*. Retrieved from Overseas Development Institute website: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/5387.pdf.

Allison, E. H. & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy*, 25, 377-388.

AlterNet. (2011). *Is a new kind of civil war brewing inside Kenya?* Retrieved from:

http://www.alternet.org/story/153219/is_a_new_kind_of_civil_war_brewing_inside_kenya.

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society*, 9(1), 18. Retrieved from: http://www.ecologyandsociety.org/vol9/iss1/art18

Auma, E. (2015). *Saferworld briefing: Isiolo County conflict analysis*. Retrieved from: www.saferworld.org.uk/downloads/pubdocs/isiolo-conflict-analysis.pdf

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J, Deckers, J, & Mathis, E. (2008). Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. Agricultural Systems, 98, 147-155. doi: 10.1016/j.agsy.2008.06.001

Bahadur, A., Lovell, E., Wilkinson, E., & Tanner, T. (2015). *Resilience in the SDGs: developing an indicator for Target 1.5 that is fit for purpose*. Retrieved from the Overseas Development Institute Website: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9780.pdf

Bakker, M., & Bridge, G. (2006). Material worlds? Resource geographies and the ‘matter of nature’. *Progress in Human Geography*, 30, 2-5. doi: 10.1191/0309132506ph.5880a

Barrow E., & Mlenge W. (2003). *Trees as key to pastoralist risk management in semi-arid landscapes in Shinyanga, Tanzania and Turkana, Kenya.* Bonn, Germany: International Conference on Rural Livelihoods, Forests and Biodiversity. Retrieved from: http://www.cifor.org/publications/corporate/cd-roms/bonn-proc/pdfs/papers/T3_FINAL_Barrow.pdf

Barua, M., Bhagwat, S. A., & Jadhav, S. (2013). The hidden dimensions of human-wildlife conflict: health impacts, opportunity and transaction costs. *Biological Conservation*, 157, 309-316. doi: 10.1016/j.biocon.2012.07.014

Bebbington, A. (1999). Capitals and Capabilities: A Framework for analyzing peasant viability, rural livelihoods and poverty. *World Development*, 27(12), 2021-2044. doi: S0305-705X(99)00104-7

Beichler, S. A., Hasibovic, S., Davidsen, B. J., & Deppisch, S. (2014). The role played by social-ecological resilience as a method of integration in interdisciplinary research. *Ecology and Society*, 19(3), 4. doi: 10.5751/ES-06583-190304

Belsky, J. M. (1993). Household food security, farm trees, and agroforestry: a comparative study in Indonesia and the Philippines. *Human Organization*, 52(2), 130-141.

Bennett, E. M., Cumming, G. W., & Peterson, G. D. (2005). A systems model approach to determining resilience surrogates for case studies. *Ecosystems*, 8, 945-957. doi: 10.1007/s10021-005-0141-3

Berkes, F., Colding, J., & Folke, C, eds. (2003). *Navigating social-ecological systems: building resilience for complexity and change*. United Kingdom: Cambridge University Press.

Berkes, F., & Seixas, C. C. (2005). Building resilience in lagoon social-ecological systems: a local-level perspective. *Ecosystems*, 8(8), 967-974. doi: 10.1007/s10021-005-0140-4

Bernard, H. R. (2011). *Research Methods in Anthropology: Qualitative and Quantitative Approaches, 5th edition*. United Kingdom: AltaMira Press.

Bewket, W. (2005). Biofuel consumption, household level tree planting and it's implications for environmental management in the Northern Highlands of Ethiopia. *East Africa Social Science Research Review*, 21(1), 20-38.

Bilali, S. (2013). *The nature of conflicts between the Borana and Meru communities in Isiolo County of Kenya*. Master's thesis, Rural Sociology and Community Development of the University of Nairobi.

Blaikie, P., & Brookfield, H. (1987). *Land degradation and society*. MA, USA: Methuen.

Blank, H.G., Mutero, C.M., & Murray-Rust, H., eds. (2002). *The changing face of irrigation in Kenya: opportunities for anticipating change in Eastern and Southern Africa*. Colombo, Sri Lanka: International Water Management Institute. Retrieved from: http://www.iwmi.cgiar.org/Publications/Books/PDF/Changing_face_of_Irrigation.pdf?galog=no

Blench, R. (2000). *Extensive pastoral livestock systems: issues and options for the future*. Rome Italy: Food and Agriculture Organization of the United Nations

Bohrer, G., Beck, P. S. A., Ngene, S. M., Skidmore, A. K., & Douglas-Hamilton, I. (2014). Elephant movement closely tracks precipitation-driven vegetation dynamics in a Kenyan forest-savanna landscape. *Movement Ecology*, 2(2), 12. Retrieved from: http://www.movementecologyjournal.com/content/2/1/2

Borland, A. M., Wullschleger, S. D., Weston, D. J., Hartwell, J., Tuskan, G. A., Yang, X., & Cushman, J. C. (2015). Climate-resilient agroforestry: physiological responses to climate change and engineering of crassulacean acid metabolism (CAM) as a mitigation strategy. *Plant, Cell and Environment*, 38, 1833-1849. doi: 10.1111/pce.12479

Boye, R. S., & Kaarhus R. (2011). Competing claims and contested boundaries: legitimizing land rights in Isiolo District, Northern Kenya. *Africa Spectrum*, 46(2), 99-124. Retrieved from: http://journals.sub.uni-hamburg.de/giga/afsp/article/view/463

Branch, D. (2011). *Kenya: between hope and despair, 1963-2011*. New Haven, Connecticut: Yale University Press.

Brandt, S. A., Spring, A., Hiebsch, C., McCabe J. T., Tabogie, E., Diro, M., Wolde-Michael, G., Yntiso, G., Shigeta, M., & Tesfaye, S. (1997). *“The tree against hunger” Enset-based agricultural systems in Ethiopia*. USA: American Association for the Advancement of Science. Retrieved from: http://users.clas.ufl.edu/aspring/publications/enset.pdf

Brown, J. C., & Purcell, M. (2005). There's nothing inherent about scale: political ecology, the local trap, and the politics of development in the Brazilian Amazon. *Geoforum*, 36, 607-624. doi: 10.1016/j.geoforum.2004.09.001

Brown, K. (2014). Global environmental change 1: a social turn for resilience? *Progress in Human Geography*, 38(1), 107-117. doi: 10.1177/0309132513498837

Brown, M. E., & Funk, C. C. (2008). *Food security under climate change, Nasa Publications Paper 131*. Lincoln, Nebraska: NASA Publications. Retrieved from: http://digitalcommons.unl.edu/nasapub/131

Brück, T. (2004). *Coping strategies post-war rural Mozambique, HiCN Working Paper No. 02.* University of Sussex, UK: Households in Conflict Network. Retrieved from: www.hicn.org

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management,* 114, 26-35. doi: 10.1016/j.jenvman.2012.10.036

Bryant, R. L. (1998). Power, knowledge and political ecology in the third world: a review. *Progress in Physical Geography*, 22(1), 79-94. doi: 10.1191./030913398674890974

Buchanan-Smith, M., & Jaspars, S. (2006). *Conflict, camps and coercion: the continuing livelihoods crisis in Darfur, final report*. Sudan: World Food Program. Retrieved from: http://www.alnap.org/resource/19312

Cabell, J. F., & Oelofse, M. (2012). An indicator framework for assessing agroecosystem resilience. *Ecology and Society*, 17(1), 18. doi: 10.5751/ES-04666-170118

Campbell, B., Sayer, J. A., Frost, P., Vermeulen, S., Ruiz Perez, M., Cunningham, A., & Prabhu, R. (2001). Assessing the performance of natural resource systems. *Conservation Ecology*, 5(2), 22. Retrieved from: http://www.consecol.org/vol5/iss2/art22

Capital FM. (2012). *Moyale clashes are political, says Kibunjia*. Retrived from: http://www.capitalfm.co.ke/news/2012/01/moyale-clashes-are-political-says-kibunjia/

Carney, D. (1998). Implementing the sustainable rural livelihoods approach. In Carney, D., *Sustainable rural livelihoods: what contribution can we make*? London, UK: DFID.

Carpenter, S., Walker, B., Anderies, M., & Abel, N. (2001). From metaphor to measurement: resilience of what to what? *Ecosystems,* 4, 765-781. doi: 10.1007/s10021-001-0045-9

Carpenter, S. R., Westley, F., & Turner, M. G. (2005.) Surrogates for resilience of social-ecological systems. *Ecosystems,* 8, 941-944. doi: 10.1007/s10021-005-0170-y

Carrier, N., & Kochore, H. H. (2014). Navigating ethnicity and electoral politics in northern Kenya: the case of the 2013 election. *Journal of Eastern African Studies,* 8(1), 135-152. doi: 10.1080/17531055.2013.871181

Castagno, A. A. (1964). The Somali-Kenyan controversy: implications for the future. *The Journal of Modern African Studies,* 2(2),165-188.

Castree, N. (2005). *Nature*. New York: Routledge.

Chambers, R. & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st Century, IDS Discussion Paper 296*. Brighton, UK: Institute of Development Studies.

Chambers, R. 1994. The origins and practice of participatory rural appraisal. *World Development*, 22(7), 953-969.

Ching, L. L., Edwards, S., & El-Hage Scialabba, N, eds. (2011). *Climate Change and Food Systems Resilience in Sub-Saharan Africa*. Food and Agriculture Organization of the United Nations. Retrieved from www.fao.org/docrep/014/i2230e/i2230e.pdf

Chitere, P. O., & Ngundo, V. M. (2015). Devolution as a means for self-governance: its potential for poverty reduction in Kenya. *International Journal of Social Work and Human Services Practice*, 3(1), 38-49. Retrieved from: www.hrpub.org/download/**2015**0301/IJRH5-19203417.pdf

Cooper, S. J., & Wheeler, T. (2015). Adaptive governance: livelihood innovation for climate resilience in Uganda. *Geoforum*, 65, 96-107. doi: 10.1016/j.geoforum.2015.07.015

Cote, M., & Nightingale, A. J. (2012). Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. *Progress in Human Geography*, 36(4), 475-489. doi: 10.1177/0309132511425708

Cumming, G. S., Barnes, G., Perz, S., Schmink, M., Sieving, K. E., Southworth, J., et al. (2005). An exploratory framework for the empirical measurement of resilience. *Ecosystems*, 8, 975 - 987. doi: 10.1007/s10021-005-0129-z

Dahl, G. (1979). *Suffering grass: subsistence and society of Waso Borana*. Stockholm, Sweden: Stockholm Studies in Social Anthropology, University of Stockholm, Department of Social Anthropology.

Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L., & Davoudi, S. (2012). Resilience: a bridging concept or a dead end? "Reframing" resilience: challenges for planning theory and practice, Interacting traps: resilience assessment of a pasture management system in Northern

Afghanistan, Urban resilience: what does it mean in planning practice? The politics of resilience for planning: a cautionary note. *Planning Theory and Practice*, 13, 299-333. Retrieved from: http://www.academia.edu/6531352/Resilience_a_bridging_concept_or_a_dead_end

Dawson, I. K., Guariguata, M. R., Loo, J., Weber, J. C. Lengkeek, A., Bush, D., Cornelius, J., & Guarino, L., et al. (2013). What is the relevance of smallholders' agroforestry systems for conserving tropical tree species and genetic diversity in circa situm, in situ and ex situ settings? A review. *Biodiversity and Conservation*, 22, 301- 324. doi: 10.1007/s10531-012-0429-5

De Leeuw, J., Njenga, M., Wagner, B., Liyama, M., (Eds.) (2013). *Treesilience, an assessment of the resilience provided by trees in the dry lands of Eastern Africa*. Nairobi, Kenya: ICRAF

DeWalt, K. M., & DeWalt, B. R. (2011). *Participant observation: a guide for fieldworkers*. USA: AltaMira Press.

Dokata, M. D. (2014). *Factors influencing camel milk production in central division of Isiolo District: a case of three camel milk women self-help groups in Isiolo County, Kenya*. MA thesis, Project planning and management, University of Nairobi. Retrieved from: http://erepository.uonbi.ac.ke/handle/11295/74148

Douglas-Hamilton, I., Krink, T., & Vollrath, F. (2005). Movements and corridors of African elephants in relation to protected areas. *Naturwissenschaften*, 92, 158 – 163. doi: 10.1007/s00114-004-0606-9

Elasha, B. O., Elhassan, N. G., Hanafi, A, & Zakieldin, S. (2005). *Sustainable livelihood approach for assessing community resilience to climate change: case studies from Sudan, Working Paper No. 17*. Assessments of Impacts and Adaptations of Climate Change (AIACC). Retrieved from: http://www.start.org/Projects/AIACC_Project/working_papers/Working%20Papers/AIACC_WP_No017.pdf

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford, UK: Oxford University Press.

Enns, C., & Bersaglio, C. (2015). *Exploring the implications of oil and gas development for livelihood resilience in Turkana, Kenya*. For the PRISE small grant programme of the Overseas Development Institute. Retrieved from: http://www.academia.edu/13047117/Exploring_the_implications_of_oil_and_gas_development_for_livelihood_resilience_in_Turkana_Kenya

Erenstein, O., Hellin, J., & Chandna, P. (2007). *Livelihoods, poverty and targeting in the Indo-Gangetic Plains: A spatial mapping approach. Research Report*. New Delhi, India: CIMMYT/RWC. Retrieved from:

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.597.5921&rep=rep1&type=pdf

Erenstein, O., Hellin, .J, & Chandna, P. (2010). Poverty mapping based on livelihood assets: A meso-level application in the Indo-Gangetic Plains, India. *Applied Geography*, 30, 112-125. doi: 10.1016/j.apgeog_2009.05.001

Fabinyi, M., Evans, L., & Foale, S. J. (2014). Social-ecological systems, social diversity, and power: insights from anthropology and political ecology. *Ecology and Society*, 19(4), 28. doi: 10.5751/ES-07029-190428

Fadiman, J. A. (1973). Early history of the Meru of Mt. Kenya. *The Journal of African History*, 14(1), 9-27. Retrieved from: http://www.jstor.org/stable/180774

Fath, B. D., Dean, C. A., & Katzmair, H. (2015). Navigating the adaptive cycle: an approach to managing the resilience of social systems. *Ecology and Society*, 20(2), 24. doi: 10.5751/ES-07467-200224

Fazan, S. H. (2015). *Colonial Kenya Observed: British Rule, Mau Mau and the Wind of Change.* New York, New York: I.B. Tauris and Co. Ltd.

Folke, C. (2006). Resilience: the emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16, 253-267. doi: 10.1016/j.gloenvcha.2006.04.002

Food and Agriculture Organization (FAO). (2012). *The state of food insecurity in the world: economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition*. Rome, Italy: FAO. Retrieved from: http://www.fao.org/docrep/016/i3027e/i3027e.pdf

Forsyth, T. (2009). *Critical political ecology: the politics of environmental science*. New York: Routledge.

Foucault, M. (1972). *Archeology of knowledge*. London, UK: Tavistock.

Foucault, M. (1980). *Power/knowledge: selected interviews and other writings 1972-1977*. London, UK: Vintage.

Franzel, S., & Scherr, S. J., eds. (2002). *Trees on the Farm: Assessing the Potential of Agroforestry practices in Africa*. UK: CABI Publishing.

Fratkin, E. (1996). Traditional medicine and concepts of healing among Samburu pastoralists of Kenya. *Journal of Ethnobiology*, 16(1), 63-97. Retrieved from: https://www.smith.edu/anthro/documents/FratkinTradmedicineinSamburu1996_000.pdf

Funk, C., Eilerts, G., Davenport, F., & Michaelsen, J. (2010). *A climate trend analysis of Kenya-August 2010, US Geological Survey, Fact Sheet, 3074*. Retrieved from:

https://pubs.usgs.gov/fs/2010/3074/pdf/fs2010-3074.pdf

Gadd, M. E. (2005). Conservation outside of parks: attitudes of local people in Laikipia, Kenya. *Environmental Conservation*, 32(1), 50-63. doi: 10.1017/S0376892905001918

Garrity, D. P. (2004). Agroforestry and the achievement of the millennium development goals. *Agroforestry Systems*, 61-62(1-3), 5-17. Retrieved from: http://www.worldagroforestry.org/downloads/Publications/PDFS/ja04026.pdf

Garrity, D., Okono, M., Grayson, & Parrott, S. eds. (2006). *World Agroforestry into the Future*. Nairobi, Kenya: World Agroforestry Centre.

Garrity, D., Akinnifesi, F. K., Ajayi, O. C., Weldesemayat, S. G., Mowo, J. G., Kalinganire, A., Larwonou, M., & Bayala, J. (2010). Evergreen Agriculture: a robust approach to sustainable food security in Africa. *Food Security*, 2, 197-214. doi: 10.1007/s12571-010-0070-7

Goldman, M. (2011). The politics of connectivity across human-occupied landscapes: corridors near Nairobi National Park, Kenya. In Goldman, M.J.; Nadasdy, P.; Turner, M.. (Eds.), *Knowing nature: conversations at the intersection of political ecology and science studies* (pp. 186 – 202). Chicago, USA: The University of Chicago Press.

Graham, M. D., Gichohi, N., Kamau, F., Aike, G., Craig, B., Douglas-Hamilton, I., & Adams, W.M. (2009). *The use of electric fences to reduce human-elephant conflict: a case study of the Ol –Pejeta Conservation, Laikipia District, Kenya, Working Paper 1*. Nanyuki, Kenya: Laikipia Elephant Project. Retrieved from: http://savetheelephants.org/wp-content/uploads/2014/03/2009ElectrifiedFences.pdf

Gunderson, L., & Holling CS. (2002). *Panarchy: understanding transformation in human and natural systems*. Washington DC: Island Press.

Hahn, T. (2011). Self-organized governance networks for ecosystem management: who is accountable? *Ecology and Society*, 16(2), 18. Retrieved from: http://www.ecologyandsociety.org/vol16/iss2/art18/

Hall, M. (2013). *How planting trees can prevent violence in Africa's drylands*. Retrieved from: EurActiv.com.

Haraway, D. (1988). Situated knowledges: the science question in feminism and the privilege of partial perspective. *Feminist Studies*, 14(3), 575-599. Retrieved from: http://faculty.washington.edu/pembina/all_articles/Haraway1988.pdf

Hartter, J., Dowhaniuk, N., MacKenzie, C. A., Ryan, S. J., Diem, J. E., Palace. M. W., & Chapman, C. A. (2016). Perceptions of risk in communities near parks in an African biodiversity hotspot. *Ambio*, 45(6): 692-705. doi: 10.1007/s13280-016-0775-8

Harvey, D. (1993). The nature of the environment: the dialects of social and environmental change. *Socialist Register*, 29, 1-51. Retrieved from: http://socialistregister.com/index.php/srv/article/view/5621/2519#.WG1vxPkrLIU

Helland, J. (1998). Institutional erosion in the drylands: the case of the Borana pastoralist. *Eastern Africa Social Science Research Review*, 14(2), 49-71. Retrieved from: http://www.africabib.org/rec.php?RID=197031285

Herlocker, D. J., Shabaan, S. B., & Wilkes, S. (1993). *Range Management Handbook of Kenya. Volume II, 5. Isiolo District.* Nairobi, Kenya: Ministry of Agriculture, Livestock Development and Marketing.

Herlocker, D. (1999). Rangeland resources in eastern Africa, their ecology and development. Nairobi, Kenya: GTZ.

Hill, C. M. (2000). Conflict of interest between people and baboons: crop raiding in Uganda. *International Journal of Primatology*, 21, 299-315. doi: 0164-0291/00/0400-0299$10.00/0

Hjort, A. (1979). *Savana town: rural ties and urban opportunities in Northern Kenya*. Stockholm, Sweden: University of Stockholm, Department of Social Anthropology.

Hockings, K., & Humle, T. (2009). *Best practice guidelines for the prevention and mitigation of conflict between humans and great apes*. Gland, Switzerland: IUCN/SSC Primate Specialist Group (PSG). Retrieved from: https://portals.iucn.org/library/efiles/documents/ssc-op-037.pdf

Hodbod, J. & Eakin, H. (2015). Adapting a social-ecological resilience framework for food systems. *Journal of Environmental Studies and Science*, 5, 474-484. doi: 10.1007/s13412-015-0280-6

Hogg, R. (1980). Pastoralism and impoverishment: the case of the Isiolo Boran of Northern Kenya. *Disasters*, 4(3), 17-30.

Hogg, R. (1983). Re-stocking the Isiolo Boran: an approach to destitution among pastoralists. *Nomadic Peoples*, 14, 35-39. Retrieved from: http://cnp.nonuniv.ox.ac.uk/pdf/NP_ journal_back_issues/Restocking_the_Isiolo_Boran_R_Hogg.pdf

Hogg, R. (1985). *Re-stocking pastoralists in Kenya: A strategy for relief and rehabilitation, ODI, Pastoral Development Network, Paper 19 (c*). Retrieved from the Overseas Development Institute website at https://www.**odi**.org/resources/docs/5265.pdf

Hogg, R. (1986). The new pastoralism: Poverty and dependency in northern Kenya. *Africa*, 56, 319-333.

Hogg, R. (1987). Development in Kenya: drought, desertification and food scarcity. *African*

Affairs, 86(342), 47-58. Retrieved from: http://afraf.oxfordjournals.org/content/86/342/47.extract

Hogg, R. (1989). The politics of changing property rights among Isiolo Boran pastoralists in Northern Kenya. In Baxter, P. T. W. & Hogg, R (Eds.), *Property, Poverty and People: Changing Rights in Property and Problems of Pastoral Development* (pp. 20-31). Manchester, UK: University of Manchester.

Holiday, E. M. (1942). Some preliminary notes on Meru Age Grades. *Man*, (42), 58-65.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecological Systems*, 4, 1-23. doi: 10.1146/annurev.es.04.110173.000245

Holling, C. S. (2001). Understanding the complexity of economic, ecological and social systems. *Ecosystems*, 4, 390-405. doi: 10.1007/s10021-001-0101-5

Holling, C. S., Gunderson, L. H., & Peterson, G. D. (2002). Chapter three: sustainability and panarchies. In Gunderson, L. H., & Holling, C. S. (Eds.), *Panarchy: understanding transformation in human and natural systems*. Washington D.C.: Island Press.

Holtzman, J. D. (2003). In a cup of tea: commodities and history among Samburu pastoralists in Northern Kenya. *American Ethnologist*, 30(1), 136-155. Retrieved from: https://wmich.pure.elsevier.com/en/publications/in-a-cup-of-tea-commodities-and-history-among-samburu-pastoralist-3

Holtzman, J. (2004). The local in the local models of time and space in Samburu District, Northern Kenya. *Current Anthropology*, 45(1), 61-84. doi: 10.1086/379635

Huka, H. (2012, February 12). Fights erupt as investors scramble for land in Isiolo. *Daily Nation*. Retrieved from: http://www.hiraan.org/news4/2012/feb/22748/fights_erupt_as_investors_scramble_for_land_in_isiolo.

Hussein, K., & Nelson, J. (1998). *Sustainable livelihoods and livelihood diversification, IDS Working Paper 69*. UK: Institute of Development Studies, University of Sussex.

ICRAF. (2006). *Agroforestry for improved livelihoods and natural resources conservation: an agroforestry policy brief*. Nairobi, Kenya: African Network for Agriculture, Agroforestry, and Natural Resource Education.

ICRAF. (2009). Agroforestry Practiced on Nearly Half World's Farms. *World Watch,* 22(6), 9.

Ihwagi, F. W., Wang, T., Wittemyer, G., Skidmore, A. K., Toxopeus, A. G., Ngene, S., et al. (2015). Using poaching levels and elephant distribution to assess the conservation efficacy of private, communal and government land in Northern Kenya. *PLoS ONE,* 10(9), 17. doi:10.1371/journal.pone.0139079

IRIN News. (2012). *KENYA: Several thousand displaced after fresh clashes in Isiolo.* Retrieved from: http://www.irinnews.org/report/95219/kenya-several-thousand-displaced-after-fresh-clashes-in-isiolo.

Jacobs, B., Nelson, R., Kuruppu, N., & Leith, P. (2015). *An adaptive capacity guide book: Assessing, building and evaluating the capacity of communities to adapt in a changing climate*. Hobart, Tasmania: Southern Slopes Climate Change Adaptation Research Partnership (SCARP), University of Technology Sydney and University of Tasmania.

Jacobsen, K. (2003). Livelihoods in conflict: the pursuit of livelihoods by refugees and the impact on the human security of host communities (pp. 71-100). In Van Hear, N. & Sorensen, N. N. (Eds), *The Migration-Development Nexus*. Geneva, Switzerland: International Organization for Migration.

Jasanoff, S. (2004). *States of knowledge*. USA: Routledge.

Jaspars, S., & Maxwell, D. (2009). *Food security and livelihood programming in conflict: a review, HPN Network Paper 65.* London, UK: Overseas Development Institute.

Jillo, A., Aboud, A. A., & Coppock, D. L. (2006). *From herd diversification to livelihood diversification as a response to poverty: the case of the Waso Boran of northern Kenya. Research Brief 06-05-PARIMA*. University of California, Davis: Global Livestock Collaborative Research Support Program. Retrieved from: http://digitalcommons.usu.edu/envs_facpub/347/

Johansson, K. (2015). *Barriers and bridges for introducing agroforestry and community-based forestry among food insecure households in eastern Africa*. Doctoral Thesis, Skinnskatteberg, Swedish University of Agricultural Sciences.

Jones, L., & Tanner, T. (2015). *Measuring subjective resilience: using people's perceptions to quantify household resilience, Overseas Development Institute Working Paper 423*. doi: 10.13140/RG.2.1.2438.1289

Justino, P. (2006). *On the links between violent conflict and chronic poverty: how much do we really know? Chronic Poverty Research Centre Working Paper 61*. Brighton, UK: Institute of Development Studies.

Justino, P. (2012). *Nutrition, governance and violence: a framework for the analysis of resilience and vulnerability to food insecurity in contexts of violent conflict, Households in Conflict Network Working Paper 132*. Rome, Italy: FAO.

Kajembe, G. C., Julius, F., Nduwamungu, J., Mtakwa, P. W., & Nyange, D. A. (2005). Impacts of indigenous based interventions on land conservation: A case study of a soil conservation and agroforestry project, Arumeru District, Tanzania. *Land Degradation and Development*, 16, 311-325. doi: 10.1002/ldr.656

Kameri-Mbote, P., & Kindiki, K. (2008). Trouble in Eden: how and why unresolved land issues landed "Peaceful Kenya" in trouble in 2008. *Forum for Development Studies*, 35(2), 167-193.

Kandji, S. T., Verchot, L. V., Mackensen, J., Boye, A., van Noordwijk, M., Tomich, T. P., Ong, C., Albrecht, A., & Palm, C. (2006). Chapter 13: Opportunities for linking climate change adaptation and mitigation through agroforestry systems. In Garrity, D., Okono, A., Grayson, M. & Parrott, S. (Eds.), *World Agroforestry into the Future*. Nairobi, Kenya: World Agroforestry Centre.

Kariuki, P. N. (2010). *Water resource use conflicts and implications for sustainable livelihoods in the Ngare Ndare catchment, north-central Kenya*. MS Thesis, Kenya: School of Environmental Studies of Kenyatta University

Kenya Decides 2012. (2014, April 16). *Isiolo*. Retrieved from: http://kenyadecides.co.ke/county/isiolo/

Kenya National Archives. Microfilm of documents accessed June 2014.

Kenya National Bureau of Statistics (KNBS). (2013). *Exploring Kenya's inequality: pulling apart or pooling together? Isiolo County*. Retrieved from: http://www.knbs.or.ke/index.php?option=com_content&view=article&id=279:exploring-%09kenya-s-inequality-pulling-apart-or-pooling-together&catid=82&Itemid=593

Kenya Red Cross Society. (2011). *Vulnerability and capacity assessment, Kinna Division, Garbatulla District*. Kenya: Kenya Red Cross Society.

Khalif, Z. K., & Oba, G. (2013). 'Gaafa dhaabaa – the period of stop': narrating impacts of shifta insurgency on pastoral economy in northern Kenya, c. 1963 to 2007. *Pastoralism: Research, Policy and Practice*, 3, 14. Retrieved from: http://wwwpastoralismjournal.com/content/3/1/14

Kidane, S. (2002). *Borana folktales: a contextual study*. London, UK: HAAN publishing.

Kimenyi, M. S., & Ndung'u, N. S. (2005). Sporadic ethnic violence: why has Kenya not experienced a full-blown civil war? (pp. 123-156). In Collier, P., & Sambanis, N. (Eds.) *Understanding Civil War, Volume 1: AFRICA*. Washington, D.C.: The World Bank.

Kindt, R., Van Damme, P. Simons, A. J., & Beckman, H. (2006). Planning tree species diversification in Kenya based on differences in tree species composition on famers. I. Analysis of tree uses. *Agroforestry Systems*, 67, 215-228. doi: 10.1007/s10457-005-3824-z

King, L. E., Douglas-Hamilton, I., & Vollrath, F. (2011). Beehive fences as effective deterrents for crop-raiding elephants: field trials in northern Kenya. *African Journal of Ecology*, 49(4),1-9. doi: 10.1111/j.1365-2028.2011.01275.x

Kirui, P. K., & Biwott, C. (2013). Power plays between the centre and the periphery: problems and prospects of devolution under constitution of Kenya 2010. *International Journal of Innovative Research and Studies*, 2(9), 174-180. Retrieved from: karuspace.karu.ac.ke:8080/xmlui/handle/123456789/332

Korf, B. (2004). War, livelihoods and vulnerability in Sri Lanka. *Development and Change*, 35(2), 275-295. doi: 10.111/j.1467-7660.2004.00352.x

Krantz, L. (2001). *The sustainable livelihood approach to poverty reduction: an introduction*. Sweden: Swedish International Development Cooperation Agency. Retrieved from: http://www.sida.se/contentassets/bd474c210163447c9a7963d77c64148a/the-sustainable-livelihood-approach-to-poverty-reduction_2656.pdf

Kuriyan, R. (2002). Linking local perceptions of elephants and conservation: Samburu pastoralists in Northern Kenya. *Society and Natural Resources*, 15(10), 949-957. doi: 10.1080/08941920290107675

Kwesiga F., Akinnifesi, F. K., Mafongoya, P. L., McDermott, M. H., & Agumya, A. (2003). Agroforestry research and development in southern Africa during the 1990s: Review and challenges ahead. *Agroforestry Systems*, 59, 173-186. doi: 10.1023/B:AGFO.0000005222.68054.38

Lambert, H. E. (1950). *The systems of land tenure in the Kikuyu Land Unit: Part I, History of the tribal occupation of the land*. Cape Town: University of Captown.

Lamphear, J. (1976). Aspects of Turkana leadership during the era of primary resistance. *The Journal of African History*, 17(2), 225-243. Retrieved from: http://www.jstor.org/stable/180399

Larick, R. (1986). Age grading and ethnicity in the style of Loikop (Samburu) spears. *World Archaeology*, 18(2), 269-283. doi: 0043-8243/86/1802/269

Leakey, R. R. B., Tchoundjeu, Z., Shreckenberg, K., Shackleton, S. E., & Shackleton, C. M. (2005). Agroforestry tree products (AFTPs): targeting poverty reduction and enhanced livelihoods. *International Journal of Agricultural Sustainability*, 3(1), 1-23. doi: 10.1080/14735903.2005.9684741

Lebel, L., Anderies, J. M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T. P., & James W. (2006). *Governance and the capacity to manage resilience in regional social-ecological systems, Marine Sciences Faculty Scholarship, Paper 52*. Retrieved from: http://digitalcommons.library.umain.edu/sms_facpub/52

Lemessa, D., Hylander, K., & Hambäck, P. (2013). Composition of crops and land-use types in relation to crop raiding patterns at different distances from forests. *Agriculture, Ecosystems and Environment*, 167, 71-78. doi: 10.1016/j.agee.2012.12.014

Leslie, P., & McCabe, J. T. (2013). Response diversity and resilience in social-ecological systems. *Current Anthropology*, 54(2), 114-143. doi: 10.1086/669563

Lewis, M. W. (1998). Iterative triangulation: A theory development process using existing case studies. *Journal of Operation Management*, 16(4), 455-69.

Lin, B. (2007). Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. *Agricultural and Forest. Meteorology*, 114(1/2), 85-94. doi: 10.1016/j.agroformet.2006.12.009

Lin, B. (2011). Resilience in agriculture through crop diversification: adaptive management for environmental change. *BioScience*, 61, 183-193. doi: 10.1525/bio.2011.61.3.4

Maalim, M. (2001). *A media handbook for reporting food security and drought in pastoral areas*. Nairobi, Kenya: Indigenous Information Network.

Maathai, W. (2012). Agroforestry, climate change, and habitat protection (pp. 3-7). In Nair, P. K. R., & Garrity, D. (Eds.), *Agroforestry - the future of global land use: advances in agroforestry volume 9*. Dordrecht: Springer.

MacKenzie, C. A., & Ahabyona, P. (2012). Elephants in the garden: Financial and social costs of crop raiding. *Ecological Economics*, 75, 72-82. doi: 10.1016/j.ecolecon.2011.12.018

Marschke, M. J., & Berkes, F. (2006). Exploring strategies that build livelihood resilience: a case from Cambodia. *Ecology and Society*, 11(1), 42. Retrieved from: http://www.ecologyandsociety.org/vol11/iss1/art42/

Martin, K. S., Rogers, B. L., Cook, J. T., & Joseph, H. M. (2004). Social capital is associated with decreased risk of hunger. *Social Science and Medicine*, 58, 2645-2654. doi: 10.1016/j.socscimed.2003.09.026

Mati, B. M., Muchiri, J. M., Njenga, K., de Vries, F. P., & Merrey, D. J. (2005). *Assessing water availability under pastoral livestock systems in drought-prone Isiolo District, Kenya, Working Paper 106*. Colombo, Sri Lanka: International Water Management Institute.

Mati, B. M. (2008). Capacity development for smallholder irrigation in Kenya. *Irrigation and Drainage*, 57, 332-340. doi: 10.1002/ird.437

Mbow, C., Smith, P., Skole, D., Duguma, L, & Bustamante, M. (2014a). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, 6, 8-14. doi: 10.1016/j.cosust.2013.09.002

Mbow, C., Van Noordwijk, M., Luedeling, E., Neufeldt, H., Minang, P. A., & Kowero, G. (2014b). Agroforestry solutions to address food security and climate change challenges in Africa. *Current Opinion in Environmental Sustainability,* 6, 61-67. doi: 10.1016/j.cosust.2013.10.014

Mburu, N. (2001). Firearms and political power: the military decline of the Turkana of Kenya 1900-2000. *Nordic Journal of African Studies*, 10(2), 148-162. Retrieved from: http://www.njas.helsinki.fi/pdf-files/vol10num2/mburu.pdf

McCabe, J. T. (1985). *Livestock management among the Turkana: a social and ecological analysis of herding in an East African pastoral population*. Ph.D. dissertation, State University of New York, Binghamton.

McCabe, J. T. (2004). *Cattle bring us to our enemies: Turkana ecology, politics, and raiding in a disequilibrium system*. Ann Arbor: The University of Michigan Press.

McCord, P. F., Cox, M., Schmitt-Harsh, M., & Evans, T. (2015). Crop diversification as a smallholder livelihood strategy within semi-arid agricultural systems near Mount Kenya. *Land Use Policy*, 42, 738-750. doi: 10.1016/j.landusepol.2014.10.012

McGinty, M. M., Swisher, M. E., & Alavalapati, J. (2008). Agroforestry adoption and maintenance: self-efficacy, attitudes and socio-economic factors. *Agroforestry Systems*, 75(1), 99-108. doi: 10.1007/s10457-008-9114-9

McIntosh, R. P. (1987). Pluralism in ecology. *Annual Review of Ecology and Systematics*, 18, 321-341. doi: 10.146/annurev.es.18.110187.001541

McKay, A., & Loveridge, S. (2005). *Exploring the paradox of Rwandan agricultural household income and nutritional outcomes in 1990 and 2000, Staff Paper 2005-06*. Michigan, USA: Department of Agricultural Economics, Michigan State University.

Menkhaus, K. (2005). *Kenya-Somalia border conflict analysis*. Washington, DC: USAID. Retrieved from: http://www.somali-jna.org/downloads/Kenya-Somalia%20Menkhaus%20(2).pdf

Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems*, 2(44), 311-328. doi: 10.1023/B:AGFO.0000029007.85754.70

Meze-Hausken, E. (2004). Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia. *Climate Research*, 27, 19-31. Retrieved from: http://www.int-res.com/articles/cr2004/27/c027p019.pdf

Millimet, D. L., McDonough, I. K., & Fomby, T. B. (2015). *Financial literacy and food security in extremely vulnerable households, Institute for the Study of Labor Discussion Paper No. 9103*. Bonn, Germany: Institute for the Study of Labor. Retrieved from: http://ftp.iza.org/dp9103.pdf

Ministry of Tourism and Wildlife. (2007). *Draft Wildlife Policy*. Kenya: Ministry of Tourism and

Wildlife. Retrieved from: http://www.nema.go.ke/images/Docs/Legislation%20and%20 Policies/Wildlife%20Draft%20Policy.pdf

Mitchell, R., & Hanstad, T. (2004). *Small homegarden plots and sustainable livelihoods for the poor, Food and Agriculture Organization of the United Nations Working Paper 11*. Rome, Italy: Food and Agricultural Organization. Retrieved from: ftp://ftp.fao.org/docrep/fao/007/J2545E/J2545E00.pdf

Mosberg, M., & Eriksen, S. H. (2015). Responding to climate variability and change in dryland Kenya: the role of illicit coping strategies in the politics of adaptation. *Global Environmental Change*, 35, 545-557. doi: 10.1016/j.gloenvcha.2015.09.006

Munas, M., & Lokuge, G. (2016). Shocks and coping strategies of coastal communities in war-conflict-affected areas of the north and east of Sri Lanka. *Regional Environmental Change*, 16, 289-299. doi: 10.1007/s10113-014-0632-x

Munro, J. F. (1967). Migrations of the Bantu-speaking peoples of the Eastern Kenya highlands: a reappraisal. *The Journal of African History*, 8(1), 25-28. Retrieved from: http://www.jstor.orgstable/180049

Murniati, D. P., Garrity, D., & Gintings, A.N. (2001). The contribution of agroforestry systems to reducing farmers' dependence on the resources of adjacent national parks: a case study from Sumatra, Indonesia. *Agroforestry Systems*, 52, 171- 184. doi: 10.1023/A:1012047602192

Mwale, S. (2000). Changing relationships: the histry and future of wildlife conservation in Kenya. *Swara*, 22(4), 11-17.

Nadasdy, P. (2005). The anti-politics of TEK: the institutionalization of co-management discourse and practice. *Anthropologica*, 47(2), 215-232. Retrieved from: http://www.jstor.org/stable/25606237?seq=1#page_scan_tab_contents

Nadasdy, P. (2007). Adaptive co-management and the gospel of resilience. In Armitage, D., Berkes, F., Doubleday, D., (Eds.), *Adaptive co-management: collaboration, learning, and multilevel governance.* Vancouver, Canada: University of British Columbia Press.

Naidoo, R. (2004). Species richness and community composition of songbirds in a Tropical forestry-agricultural landscape. *Animal Conservation*, 7, 93-105. doi: 10.1017/S1367943003001185

Nair, P. K. R. (1993). *An Introduction to Agroforestry*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Nair, P. K. R., & Garrity, D. (2012). Agroforestry research and development: the way forward. In Nair, P. K. R., & Garrity, D. (Eds.), *Agroforestry - the future of global land use: advances in agroforestry volume 9*. Dordrecht: Springer.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., & Bernabucci, U. (2010). Effects of climate changes on animal production and sustainability of livestock systems. *Livestock Science*, 13, 57-69. doi: 10.1016/j.livsci.2010.02.011

Ndeta, J. H. (2014). *Conflicts in Upper/North Eastern fueled by ethnicity*. PeaceNet Kenya. Retrieved from: http://peacenetkenya.or.ke/index.php?option=com_content&view =article&id=203:conflicts-in-uppernorth-eastern-fueled-by-ethnicity&catid=3:newsflash

Negin, J., Remans, R., Karuti, S., & Fanzo, J. C. (2009). Integrating a broader notion of food security and gender empowerment into the Africa Green Revolution. *Food Security*, 3, 351-360. doi: 10.1007/s12571-009-0025-z

Nelson, D., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environment and Resources*, 32, 395-419. doi: 10.1146/annurev.energy.32.051807.090348

Nelson, V., & Stathers, T. (2009). Resilience, power, culture, and climate: a case study from semi-arid Tanzania, and new research directions. *Gender and Development*, 17(1), 81-94. doi: 10.1080/135520708026696946

Ngigi, M. W., Muller, U., & Birner, R. (2015). *The role of livestock portfolios and group-based approaches for building resilience in the face of accelerating climate change: an asset-based panel data analysis from rural Kenya, ZEF – Discussion Papers on Development Policy No. 205*. Bonn, Germany: Center for Development Research.

Noble, I. R., Huq, S., Anokhin, Y. A., Carmin, J., Goudou, D., Lansigan, F. P., Osman-Elasha, B. & Villamizar, A. (2014). Adaptation needs and options. In Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., Chatterjee, M., & Ebi, K. L., et al., (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 833-868). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Nyamwamu, R. O., Mwangi, J. G., &Ombati, J. M. (2015). Untapped potential of wildlife agricultural extension mitigation strategies in influencing the extent of human-wildlife conflict: a case of smallholder agro-pastoralist in Laikipia County, Kenya. *International Journal of Agricultural Extension*, 3(1), 73-81.

Ogra, M. V. (2008). Human-wildlife conflict and gender in protected area borderlands: A case study of costs, perceptions, and vulnerabilities for Uttarakhand (Uttaranchal), India. *Geoforum*, 39(3), 1408-1422. doi: 10.1016/j.geoforum.2007.12.004

Okello, M. M. & Kiringe, J. W. (2004). Threats to biodiversity and their implications in protected and adjacent dispersal areas of Kenya. *Journal of Sustainable Tourism*, 12(1), 55-69. doi: 10.1080/09669580408667224

Okoli, A. C., & Atelhe, A. G. (2014). Nomads against natives: a political ecology of herder/farmer conflicts in Nasarawa State, Nigeria. *American International Journal of Contemporary Research*, 4(2), 76-88. Retrieved from: http://www.aijcrnet.com/journals/Vol_4_No_2_February_2014/11.pdf

Olsson, L., Jerneck, A., Thoren, H., Persson, J., & O'Bryne, D. (2015). Why resilience is unappealing to social science: theoretical and empirical investigations of the scientific use of resilience. *Science Advances*, 1(4), 11. doi: 10.1126/sciadv.1400217.

Omari, A. O., Kaburi, S. N., Omato, D. N., Ochoti, G. N., & Memba, F. (2012). Change dilemma: a case of structural adjustment through devolution in Kenya. *International Journal of Arts and Commerce*, 1(7), 40-47. Retrieved from: http://www.ijac.org.uk/images/frontImages/gallery/Vol1no7december2012/5.pdf

Omondi, P., Bitok, E., & Kagiri, J. (2004). Managing human-elephant conflicts: the Kenyan experience. *Pachyderm*, 36, 80-96.

Otuoma, J. (2004). *The effects of wildlife-livestock-human interactions on habitat in the Meru Conservation Area, Kenya, Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 36*. Nairobi, Kenya: International Livestock Research Institute. Retrieved from: http://www.lucideastafrica.org/publications/Otuoma_LUCID_WP39.pdf

Otuoma, J., Kinyamario, J., Ekaya, W., Kshatriya, M. & Nyabenge, M. (2009). Effects of human-livestock -wildlife interactions on habitat in an eastern Kenya rangeland. *African Journal of Ecology*, 47, 567-573.

Owino, A. O., Jillo, A. H., & Kenana, M. L. (2012). Socio-economics and wildlife conservation of a peri-urban national park in central Kenya. *Journal for Nature Conservation*, 20, 384-392. doi: 10.1016/j.jnc.2012.08.004

Oxford English Dictionary Online. (2016). *Tree*. Retrieved from Oxford University Press website: http://www.oxforddictionaries.com/us/definition/american_english/tree

Paavola, J. (2008). Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. *Environmental Science & Policy*, 11, 642-654. doi: 10.1016/j.envsci.2008.06.002

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resource Management*, 21, 49-62. doi: 10.1007/s11269-006-9040-4

Pearce, D. & Mourato, S. (2004). Chapter 4: the economic valuation of agroforestry's environmental services. In Schroth, G., de Fonseca, G. A. B., Harvey, C. A., Gascon, C., Vasconcelos, H. L. & Izac, A.N., (Eds.), *Agroforestry and Biodiversity Conservation in Tropical Landscapes* (pp. 67-87). USA: Island Press.

Perrings, C. (1998). Resilience in the dynamics of economy-environment systems. *Environmental and Resource Economics*, 11(3-4), 503-520. Retrieved from: http://beslter.org/products/distribution/perrings-envresecon98.pdf

Peterson, G. (2000). Political ecology and ecological resilience: an integration of human and ecological dynamics. *Ecological Economics*, 35, 323-336. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.4799&rep=rep1&type=pdf

Phadke, R. (2011). Reclaiming the technological imagination: water, power, and place in India. In Goldman, M. J., Nadasdy, P., Turner, M. D., (Eds.), *Knowing nature: conversations at the intersection of political ecology and science studies.* Chicago: The University of Chicago Press.

Philpott, S. M., Lin, B. B., Jha, S., & Brines, S.J. (2008). A multi-scale assessment of hurricane impacts on agricultural landscapes based on land use and topographic features. *Agriculture, Ecosystems and Environment*, 128, 12-20. doi: 10.1016/j.agee.2008.04.016

Porter, J. R., Xie, L., & Challinor, A. J. et al. (2014). Food security and food production systems. In Field, C. B., Barros, V. R., & Dokken, D. J. et al. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 485-533). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Pratt, D. J., & Gwynne, M.D., (Eds.). (1977). *Rangeland management and ecology in East Africa*. London, England: Hodder and Stoughton.

Qualtrics. (2011). *Sampled Sized Determination for Survey Design*. Retrieved from: https://www.qualtrics.com/blog/tips-for-survey-sampling/

Quandt, A. (2016a). Farmers and forest conservation: how might land sparing work in practice? *Society and Natural Resources*, 29(4), 418 – 431. doi: 10.1080/08941920.2015.1095381

Quandt, A. (2016b). Towards integrating political ecology into resilience-based resource management. *Resources*, 5(4), 31. doi: 10.3390/resources5040031.

Quandt, A., & Kimathi, A. (2016). Adapting livelihoods to climate change in arid Kenya: local perspectives and insights. *African Journal of Rural Development*, 1(1), 51-60.

Quirin, C., & Dixon, A. (2012). Food security, politics and perceptions of wildlife damage in Western Ethiopia. *International Journal of Pest Management*, 58(2), 101-114. doi: 10.1080/09670874.2012.667583

Rakodi, C. (1999). A capital assets framework for analysing household livelihood strategies: implications for policy. *Development Policy Review*, 17, 315-342. doi: 10.1111/1467-

7679.00090

Rao, K. P. C., Ndegwa, W. G. Kizito, K., & Oyoo, A. (2011). Climate variability and change: farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental Agriculture*, 47(2), 267-291. doi: 10.1017/S0014479710000918

Republic of Kenya. (2013). *Isiolo County First County Integrated Development Plan 2013-2017*.

Resilience Academy Participants. (2016). *Loss and Damage, Livelihood Resilience: 5 key insights from the Resilience Academy and 5 recommendations for the 5-year work plan on Loss and Damage, Policy Brief 10*. Bonn, Germany: United Nations University-Institute for Environment and Human Security. doi: 10.13140/RG.2.2.25250.63689

Robbins, P. (2012). *Political ecology: a critical introduction*. USA: J. Wiley and Sons.

Rocheleau, D., Weber, F., & Field-Juma, A. (1988). *Agroforestry in Dryland Africa*. Nairobi, Kenya: International Council for Research in Agroforestry.

Rocheleau, D., & Edmunds, D. (1997). Women, men and trees: gender, power and property in Forest and Agrarian Landscapes. *World Development*, 25(8), 1351-1371. doi: 0305-750X/97$17.00+0.00

Rossi, A., & Lambrou, Y. (2008). *Gender and equity issues in liquid biofuels production: minimizing the risks to maximize the opportunities*. Rome: Food and Agriculture Organization. Retrieved from: ftp://ftp.fao.org/docrep/fao/010/ai503e/ai503e00.pdf

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative interviewing: the art of hearing data, 2nd Edition*. Thousand Oaks, CA: Sage Publications.

Rufino, M. C., Quiros, C., Teufel, N., Douxchamps, S., Silvestri, S., Mango, J., Moussa, A. S., & Herrero, M. (2012). *Household characterization survey - IMPACTlite Training Manual*. Nairobi, Kenya: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Ruto, D., Musoi, K., Tule, I., & Kirui B. (2010). Conflict dynamics in Isiolo, Samburu East, and Marsabit South Districts of Kenya. *Amani Papers*, 1(3), 1-20.

Sanchez, P.A. (2002). Soil fertility and hunger in Africa. *Science*, 295, 2019-2020. doi: 10.1126/science.1065256

Sanginga, P. C., Kamugisha, R. N., & Martin, A.M. (2007). Conflicts management, social capital and adoption of agroforestry technologies: empirical findings from the highlands of southwestern Uganda. *Agroforestry Systems*, 69, 67-76. doi: 10.1007/s10457-006-9018-5

Schlager, E., & Ostrom, E. (1992). Property rights regime and natural resources: aconceptual analysis. *Land Economics*, 68(3), 249-262. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.422.8178&rep=rep1&type=pdf

Schlee, G. (2007). Brothers of the Boran once again: on the fading popularity of certain Somali identities in Northern Kenya. *Journal of Eastern African Studies*, 1(3), 417-435. doi: 10.1080/17531050701625524

Schmink, M., & Wood, C. H. (1987). The political ecology of Amazonia. In Little, P., & Horowitz, M. (Eds.), *Lands at risk in the third world: local level perspectives*. Boulder, Colorado: Westview Press.

Schroeder, R. A. (1997). "Re-claiming" land in The Gambia: gendered property rights and environmental intervention. *Annals of the Association of American Geographers*, 87(3), 487-508. Retrieved from: http://www.popline.org/node/271779

Schroth, G., de Fonseca, G. A. B., Harvey, C. A., Gascon, C., Vasconcelos, H. L., & Izac, A. N., (Eds.). (2004). *Agroforestry and Biodiversity Conservation in Tropical Landscapes*. USA: Island Press.

Scoones, I. (1998). *Sustainable Rural Livelihoods: A Framework for Analysis, IDS Working Paper 72*. Retrieved from: https://www.staff.ncl.ac.uk/david.harvey/AEF806/Sconnes1998.pdf

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies*, 36(1), 171-196. doi: 10.1080/03066150902820503

Sendzimir, J., Reij, C. P., & Magnuszewski, P. 2011. Rebuilding resilienc eint eh Sahel: regreening in the Maradi and Zinder regions of Niger. *Ecology and Society*, 16(3), 1. doi: 10.5751/ES-04198-160301

Serrat, O. (2010). *The sustainable livelihoods approach*. Washington, DC: Asian Development Bank.

Sharamo, R. (2014). *The politics of pastoralist violence: a case study of Isiolo County, Northern Kenya, Working Paper 095*. Future Agricultures Consortium. Retrieved from: https://assets.publishing.service.gov.uk/media/57a089c4ed915d3cfd000408/FAC_Working_Paper_095.pdf

Shaw, R. (2006). Community-based climate change adaptation in Vietnam: inter-linkages of environment, disaster, and human security. In Sonak, J. (Ed.), *Multiple dimensions of global environmental change* (pp. 521-547). TERI publications. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.475.8279&rep=rep1&type=pdf

Simelton, E., Viet Dam, B., & Catacutan, C. (2015). Trees and agroforestry for coping with extreme weather events: experiences form northern and central Viet Nam. *Agroforestry Systems*, 89, 1065-1082. doi: 10.1007/s10457-015-9835-5

Sinclair, F. L. (1999). A general classification of agroforestry practice. *Agroforestry Systems,* 46, 161-180. doi: 10.1023/A:1006278928088

Sitienei, A. J., Jiwen, G., & Ngene, S. M. (2014). Assessing the cost of living with elephants (*Loxodonta africana*) in areas adjacent to Meru National Park, Kenya. *European Journal of Wildlife Research,* 60, 323-330. doi: 10.1007/s10344-013-0789-5

Slegers, M. F. W. (2008). "If only it would rain": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. *Journal of Arid Environments*, 72, 2106-2123. doi: 10.1016/j.jaridenv.2008.06.011

Sobania, N. (2003). *Culture and Customs of Kenya*. United States, Greenwood Publishing Group, Inc.

Songhurst, A, & Coulson, T. (2014). Exploring the effects of spatial autocorrelation when identifying key drivers of wildlife crop-raiding. *Ecology and Evolution,* 4(5), 582-593. doi: 10.1002/ece3.837

Spencer, P. (1965). *The Samburu*. London, UK: Routledge and Kegan Paul.

Spencer, P. (1973). *Nomads in Alliance: symbiosis and growth among the (Rendille and Samburu of Kenya*. London, UK: Oxford University Press.

Speranza, C. I. (2012). Buffer capacity: capturing a dimension of resilience to climate change in African smallholder agriculture. *Regional Environmental Change,* 13, 521-535.

Sseguya, H. (2009). *Impact of social capital on food security in southeast Uganda*. Ph.D. Dissertation, Iowa State University. Retrieved from: http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1764&context=etd

Steeves, J. (2015). Devolution in Kenya: Derailed or on track? *Commonwealth and Comparative Politics,* 53(4), 457-474. doi: 10.1080/14662043.2015.1089006

Stone-Jovicich, S. (2015). Probing the interfaces between the social sciences and social-ecological resilience: insights form integrative and hybrid perspectives in the social sciences. *Ecology and Society*, 20(2), 25. doi: 10.5751/ES-07347-200225

Sunderland, T., Powell, B., Ickowitz, A., Foli, S., Pinedo-Vasquez, M., Nasi, R., & Padoch, C. (2013). *Food security and nutrition: the role of forests*. Bogor, Indonesia: CIFOR. Retrieved from: http://www.cifor.org/publications/pdf_files/WPapers/DPSunderland1301.pdf

Syagga, P. M. (2006). Land ownership and use in Kenya: policy prescriptions from an inequality perspective. In *Society for International Development, Readings in Inequality in Kenya, Nairobi* (pp. 291-330). Retrieved from:

https://learning.uonbi.ac.ke/courses/GPR203_001/document/Property_Law_GPR216-September,_2014/Articles/Syagga_Chapter8.pdf

Tacoli, C. (1999). *Understanding the opportunities and constraints for low-income groups in the peri-urban interface: the contribution of livelihood frameworks*. London, UK: Development Planning Unit: Strategic Environmental Planning and Management for the Peri-Urban Interface Research Project. Retrieved from: http://www.ucl.ac.uk/dpu-projects/drivers_urb_change/urb_economy/pdf_Urban_Rural/DPU_PUI_Takodi_opportunities.pdf

Tanner, T., Lewis, D., Wrathall, D., Bronen, R., Cradock-Henry, N., Huq, S., Lawless, C. et al. (2015). Livelihood resilience in the face of climate change. *Nature Climate Change*, 1, 23-26. doi: 10.1038/NCLIMATE2431

Tanzania Agroforestry Research and Dissemination Team. (2000). *Agroforestry Research and Development in Tanzania: An Overview*. Shinyanga/Tabora, Tanzania: Tanzania Agroforestry Research and Dissemination Team.

Thorlakson, T., & Neufeldt, H. (2012) Reducing subsistence farmers' vulnerability to climate change: evaluating the potential contributions of agroforestry in western Kenya. *Agriculture and Food Security*, 1, 15. doi: 10.1186/2048-7010-1-15

Thulstrup, A. W. (2015). Livelihood resilience and adaptive capacity: tracing changes in household access to capital and central Vietnam. *World Development*, 74, 352-362. doi: 10.1016/j.worlddev.2015.05.019

Tilman, B. (2004). *The welfare effects of farm household activity choices in post-war Mozambique, DIW- Diskussionspapiere, No. 4133*. Berlin, Germany: German Institute for Economic Research.

Tjosvold, D. (2006). Defining conflict and making choices about its management: lighting the dark side of organization life. *International Journal of Conflict Management*, 17(2), 87-95. doi: 10.1108/10444060610736585

Tokuhisa, J. (2013). *Tree Definition, Newton Ask a Scientist.* Retrieved from: http://wayback.archive.org/web/20131206131101/http://www.newton.dep.anl.gov/askasci/bot00/bot00761.htm

Turner, M. D. (2014). Political ecology I: an alliance with resilience? *Progress in Human Geography*, 38(4), 616-623. doi: 10.1177/030913251350770

Turner, M. D. (2016). Political ecology II: engagements with ecology. *Progress in Human Geography*, 40(3), 1-9. doi: 10.1177/0309132515577025

Turton, E. R. (1972). Somali resistance to colonial rule and the development of Somali political activity in Kenya 1893-1960. *The Journal of African History*, 13(1), 119-143. Retrieved from: http://www.jstor.org/stable/180970

Turton, E. R. (1974). The Isaq Somali diaspora and poll-tax agitation in Kenya, 1936-41. *African Affairs*, 73(292), 325-246. Retrieved from: http://www.jstor.org/stable/720811

UNDP. (1994). *Human Development Report 1994*. New York, USA: United Nationals Development Programme. Retrieved from: http://hdr.undp.org/en/content/human-development-report-1994

UNICEF. (2007). *The state of the world's children 2008, child survival*. New York, USA: The United Nations Children's Fund. Retrieved from: https://www.unicef.org/sowc08/docs/sowc08.pdf

Vayda, A. P., & Walters, B. B. (1999). Against political ecology. *Human Ecology*, 27(1), 167-179. Retrieved from: http://www.jstor.org/stable/4603312

Verchot, L. V., Van Noordwijk, M., Kandji, S., Tomich, T., Ong, C, Albrecht, A., Mackensen, J., Bantilan, C., Anupama, K.V. & Palm, C. (2007). Climate change: linking adaptation and mitigation through agroforestry. *Mitigation and Adaptation Strategies for Global Change*, 12, 901-918. doi: 10.1007/s11027-007-9105-6

Verpoorten, M. (2009). Cattle sales in war and peacetime: a study of household coping in Rwanda, 1991-2001. *Journal of Development Economics*, 88(1), 67-86. Retrieved from: http://EconPapers.repec.org/RePEc:eee:deveco:v:88:y:2009:i:1:p:67-86

Vira, B., Agarwal, B., Jamnadass, R., Kleinschmidt, D., McMullin, S., Mansourian, S., Neufeldt, H., Parrotta, J. A., Sunderland, T., & Wildburger, C. (2015). Chapter 1. Forests, Trees and Landscapes for Food Security and Nutrition. In Vira, B., Wildburger, C., & Mansourian, S., (Eds.), *Forests and Food: Addressing Hunger and Nutrition Across Sustainable Landscapes*, (pp. 9-28). Cambridge, UK: Open Book Publishers. doi: 10.11647/OBP.0085.

Von Gerhardt, K., Van Niekerk, A., Kidd, M., Samways, M., & Hanks, J. (2014). The role of elephant *Loxodonta africana* pathways as a spatial variable in crop-raiding location. O*ryx*, 48(3), 436-444. doi: 10.1017/S003060531200138X

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., et al. (2002). Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology*, 6(1), 14. Retrieved from: http://www.consecol.org/vol6/iss1/art14/

Walker, B., & Salt, D. (2006). *Resilience thinking: sustaining ecosystems and people in a changing world.* USA: Island Press.

Walsh-Dilley, M., Wolford, W., & McCarthy, J. (2016). Rights for resilience: food sovereignty, power, and resilience in development practice. *Ecology and Society*, 21(1), 11. doi:

10.5751/ES-07981-21011

Walters, B. & Vayda, A. (2009). Event ecology, causal historical analysis and human environment research. *Annals of the Association of American Geographers*, 99(3), 534-553. doi: 10.1080/00045600902931827

Wasonga, V. D., Bekele, A., Lötters, S., & Balakrishnan, M. (2006). Amphibian abundance and diversity in Meru National Park, Kenya. *African Journal of Ecology*, 45, 55-61. doi: 10.1111/j.1365-2028.2006.00677.x

Watson, D. J., & Van Binsbergen, J. (2008). *Livestock market access and opportunities in Turkana, Kenya, ILRI Research Report 3*. Nairobi, Kenya: ILRI (International Livestock Research Institute.

West, P., Igoe, J., & Brockington, D. (2006). Parks and peoples: the social impact of protected areas. *Annual Review of Anthropology*, 35, 251-277. doi: 10.1146/annurev.anthro.35.081705.123308

Western, D., Russell, S., & Cuthill, I. (2009). The status of protected areas compared to non-protected areas of Kenya. *PLoS One*, 4(7), 1-6. doi: 10.1371/journal.pone.0006140

Western, D., Waithaka, J., & Kamanga, J. (2015). Finding space for wildlife beyond national parks and reducing conflict through community-based conservation: the Kenya experiences. *Parks*, 21(1), 52-62. doi: 10.2305/IUCN.CH.2014.PARKS-21-1DW.en

Whittaker, H. A. (2012). The socioeconomic dynamics of the *shifta* conflict in Kenya, c. 1963-8. *The Journal of African History*, 53, 391-408. doi: 10.1017/S0021853712000448

World Bank. (2011). *World Development Report 2011*. Washington, D.C.: World Bank.

Yin, R. (2014). *Case Study Research: Design and Methods, 5th Edition*. Thousand Oaks, CA: Sage Publications.

Young, H., Osman, A. M., Aklilu, Y., Dale, R., Badri, B. & Fuddle, A. J. A. (2005) *Darfur – Livelihoods under Siege.* Medford, MA, USA: Feinstein International Famine Center, Tufts University. Retrieved from: http://pdf.usaid.gov/pdf_docs/Pnadc475.pdf

Zimmerer, K, & Bassett, T. (2003). *Political ecology: an integrative approach to geography and environment-development studies*. New York: Guilford Press.

Zomer, R. J., Bossio, D. A., Trabucco, A., Yuanjie, L., Gupta, D. C., & Singh, V. P. (2007). *Trees and water: smallholder agroforestry on irrigated lands in Northern India, Research Report 122*. Colombo, Sri Lanka: International Water Management Institute.

APPENDIX A

This appendix includes the data collection tools. First, is the household case study interviews including the initial interview, which was the same for Burat and Kinna. Second, are an example of wet and dry season discussion guide sheets. I have not included all of the discussion guides here because they varied between Burat and Kinna and between households depending on how the answers during the first interview. Third, is the survey guide for Burat. The survey guide for Burat was the same as Kinna but with additional question about violent conflict.

In summary, this appendix includes:

1. Household case study initial interview
2. Example of wet season discussion guide – Kinna Household 10
3. Example of dry season discussion guide – Burat Household 5
4. Burat Survey

Household Case Study Initial Interview

Initial In-Depth Household Interview

My name is ______________. We are conducting research in Isiolo County in collaboration with the University of Colorado, in the United States, the Kenya Red Cross Society – Isiolo Branch, and the World Agroforestry Centre. I do not represent the government or any political party. The purpose of this research is to learn about agroforestry and how agroforestry is used as part of the household livelihood in times of weather and economic stress. We wish to interview you three times throughout the course of the next year. All information you may provide will be confidential and will be used solely for this study. Your participation is voluntary and you can choose to not participate. With your permission, I will ask you a set of questions related to this research, and this should take about an hour. I will be taking some brief notes as you answer the questions.

Jina langu ni _____________. Tunafanya utafiti hapa Isiolo County pamoja na Chuo Kikuu cha Colorado, Merikani, Msalaba Mwekundu Isiolo, na Shirika la World Agroforestry Centre, Nairobi. Sisi siyo watu kutoka kwa serikali au chama cha kisiasa. Maana ya utafiti huu ni kujifunza kuhusu aina ya miti inayopandwa na matumizi yake wakati wa mafuriko, ukame, na katika matitizo ya kiuchumi. Tungependa kukuhoji mara tatu katika mwaka huu. Majibu yako yatakuwa kwa siri na ni kwa ajili ya utafiti huu pekee. Kuhojiwa kwako ni wa kujitolea na una haki ya kukataa kujibu maswali. Ukikubali nitakuuliza maswali, na mahojiano yatachukua muda wa saa moja hivi. Nitakuwa nikiandika tunapoendelea.

Does the household consent to participate in this research and being interviewed? Yes ( ), No ( )
Unakubali kuhojiwa kwa utafiti huu? Ndiyo ( ), au La ( )

1. General Respondent Information

Name (Jina)	
Age (Umri)	
Gender (Jinsia)	
Gender of HH Head (Jinsia ya Mkuu wa Nyumba):	
Education (Elimu)	
Ethnicity (Kabila)	

Religion (Dini)	
Marital Status (Umeolewa/ Umeoa?)	
Polygamous Marriage (y/n) (Ndoa ya Mitala)	
How long have you lived in this area? (Umeishi katika maeneo haya kwa muda gani?)	
GPS Coordinates (lat, long)	

2. Household Financial Capital

To be read to respondent: A household includes those spend the majority of the year living under the same roof, eating from the same pot, and sharing in livelihood activities. (Kwa utafiti huu, familia ina maana ya watu wanaoishi katika boma moja, wanaokula kutoka sufuria moja, na wanaogawana kazi ya nyumba)

<table>
<tr><td>How would you classify your household in terms of wealth? (Unadhani familia yako wako wapi kimali?)</td><td>Very poor (Maskini sana)</td><td colspan="2">Poor (Maskini)</td><td>Average
(Katikati)</td><td>Well off
(Tajiri)</td><td colspan="2">Very well off (Tajiri sana)</td></tr>
<tr><td>How would you classify your household wealth compared to your neighbors? (Kulengana na majirani, unadhani familia yako wako wapi kimali?)</td><td>Much Poorer
(Maskini zaidi)</td><td colspan="2">Poorer (Maskini)</td><td>Same
(Sawa)</td><td>Wealthier (Tajiri)</td><td colspan="2">Much Wealthier
(Tajiri zaidi)</td></tr>
<tr><td>Do you own or rent your house? (Mnakomboa au mnamiliki nyumba yenu).</td><td colspan="3">RENT (Kukomboa)
If they RENT, skip next 2 questions.</td><td colspan="4">OWN (Kumiliki)</td></tr>
<tr><td>What are your houses made out of and how many of each type? (Je, majengo yenu imejengwa kutumia nini? Kuna nyumba ngapi ya kila aina?</td><td>Grass (Nyasi)</td><td>Dirt (Udongo)</td><td>Bricks (Matofauli)</td><td>Timber (Mbao)</td><td>Stone block (Mawe)</td><td>Metal Sheet (Mabati)</td><td>Others (Kitu kingine)</td></tr>
<tr><td>What are the roofs made of? How many of each type? (Paa ya nyumba imetengezwa na nini? Kuna nyumba ngapi ya kila aina?)</td><td colspan="3">GRASS (Majani)</td><td colspan="2">IRON SHEET (Bati)</td><td colspan="2">OTHER (Kitu kingine):</td></tr>
</table>

What do you cook with? (Mnapika kutumia nini?)	FIREWOOD (Kuni)	CHARCOAL (Makaa)	GAS/ Propane, Kerosene (Gesi)	OTHER (Kitu kingine):
Do you have a motorcycle, car, or bicycle? (Mna pikipiki, gari, au baiskeli?)	MOTORCYCLE (Pikipiki)		CAR (Gari)	BICYCLE (Baiskeli)
Do you own a TV, radio or both? (Mna TV, redio, au yote mbili?)	TV (Televisheni)		RADIO (Redio)	
Does your household receive remittances? From whom? (Mnapata usaidizi wa fedha kutoka kwa familia yako wanoishi mbali?)	YES (Ndiyo)		NO (Hapana)	WHO (Kutoka kwa nani?):
Does your household have a bank account? (Mnakuwa na akaunti ya benki?)	YES (Ndiyo)		NO (Hapana)	WHO (Nani?)

3. Human Capital (Section 1) - Household Composition and Labor Activities

Person (Mtu)	Who (Nani?)	Age (Umri)	Gender (Jinsia)	Season (Msimu)	Farm (Kilimo)	Herding (Kuchunga)	Non-agro-pastoral work (Kazi nje ya kilimo na mifugo)	Agroforestry Work (Kazi ya miti)
HH1				Rainy mvua				
				Dry ukame				
HH2				Rainy				
				Dry				
HH2				Rainy				
				Dry				
HH3				Rainy				
				Dry				
HH4				Rainy				
				Dry				
HH5				Rainy				
				Dry				
HH6				Rainy				
				Dry				
HH7				Rainy				
				Dry				
HH8				Rainy				
				Dry				

4. Natural Capital: Household Land, Crops, Livestock, Trees

Plot (Ardhi)	Use/ Livelihood Activities Practiced (Mnatumia vipi hiyo ardhi?)	Physical Area (estimate acres) (Ukubwa wake kwa ekari?)	Distance to HH (estimate) (Ubali kutoka makazi?)	Land Tenure (Owned, rented, inherited) (Umilikaji wa aina gani na nani anamiliki hiyo ardhi? Kununua, kukomboa, kurithi)
1				
2				
3				
4				
5				

Who decides what crops will be planted on the farm? (Nani anaamua mtapanda mazao gani shambani?)	
Do you have certainty that your plots will belong to your household indefinitely? Why or why not? (Una uhakika ardhi yenu itakuwa yenu daima? Kwa nini ndiyo au hapana?)	

Do you have concerns that your plots will be taken by the government or other people? Why or why not? (Una wasiwasi kwamba ardhi yenu itachukuliwa na serikali au watu wengine? Kwa nini ndiyo au hapana?)	

Agroforestry Inventory:

Tree Species (Aina ya mti):	
Agroforestry Practice (how is the tree planted on your land? Is it planted with crops, if so which crops?) (Mmepanda miti vipi? Mnapanda na mazao? Mazao gani?)	
Year Planted (Imepandwa mwaka gani?)	
Planted by Who? (Nani alipanda?)	
Why Planted? Benefits of the tree? (Kwa nini imepandwa? Mnapata faida gani kutoka miti hii?)	

Tree Species (Aina ya mti):	
Agroforestry Practice (how is the tree planted on your land? Is it planted with crops, if so which crops?) (Mmepanda miti vipi? Mnapanda na mazao? Mazao gani?)	
Year Planted (Imepandwa mwaka gani?)	
Planted by Who? (Nani alipanda?)	

Why Planted? Benefits of the tree? (Kwa nini imepandwa? Mnapata faida gani kutoka miti hii?)	

Tree Species (Aina ya mti):	
Agroforestry Practice (how is the tree planted on your land? Is it planted with crops, if so which crops?) (Mmepanda miti vipi? Mnapanda na mazao? Mazao gani?)	
Year Planted (Imepandwa mwaka gani?)	
Planted by Who? (Nani alipanda?)	
Why Planted? Benefits of the tree? (Kwa nini imepandwa? Mnapata faida gani kutoka miti hii?)	

Tree Species (Aina ya mti):	
Agroforestry Practice (how is the tree planted on your land? Is it planted with crops, if so which crops?) (Mmepanda miti vipi? Mnapanda na mazao? Mazao gani?)	
Year Planted (Imepandwa mwaka gani?)	
Planted by Who? (Nani alipanda?)	
Why Planted? Benefits of the tree? (Kwa nini imepandwa? Mnapata faida gani kutoka miti hii?)	

Tree Species (Aina ya mti):	
Agroforestry Practice (how is the tree planted on your land? Is it planted with crops, if so which crops?) (Mmepanda miti vipi? Mnapanda na mazao? Mazao gani?)	
Year Planted (Imepandwa mwaka gani?)	
Planted by Who? (Nani alipanda?)	
Why Planted? Benefits of the tree? (Kwa nini imepandwa? Mnapata faida gani kutoka miti hii?)	

Uses of household livestock and crops during different times of the year

Livestock (Mifugo)	Normal Conditions (Hali ya kawaida)			Important during Drought? (Hali ya ukame)			Important during Flood? (Hali ya mafuriko)		
	Food (Chakula)	Sales (Kuuza)	Other? (kingine)	Food	Sales	Other?	Food	Sales	Other?
Cows (Ng’ombe)									
Goats (Mbuzi)									
Sheep (Kondoo)									
Plants, Crops and Trees (Mazao na miti)									

Ranking of Crops, Livestock, and Trees

What crop, livestock species, or tree species fits each category? (Kati ya mazao, mifugo, na miti, ipi inakufaidi katika nyakati ifuatayo?

Ranking	Most Important in Drought (Muhimu kwa wakati wa ukame)	Most Important in Flood (Muhimu kwa wakati wa mafuriko)	Most Important during Economic Hardships (Muhimu kwa wakati mbaya ya uchumi)	Most Important for Household Consumption (Muhimu kwa matumizi nyumbani)
1 (ya kwanza)				
2 (ya pili)				
3 (ya tatu)				
4 (ya nne)				
5 (ya tano)				

Food Security Questions:

After the last harvest, for how many months did the household crops feed the household? (Baada ya mavuno iliopita, mazao yalitosheleza famila yako kwa muda gani?)			
Does your household grow all the food that you need? (Mnalima mazao yote ambaye mnahitaji kwa chakula?)	YES	NO	
Does your household rely on neighbors or family for food? If yes, who? (Mnategemea familia au majirani kwa chakula? Kama ndiyo, nani?)	YES	NO	NANI?

Does your household receive food aid or food relief? (Mnapata chakula cha msaada?)	YES	NO	
Do your trees provide food for your household? If yes, what? (Miti yenu inawapa chakula? Gani?)	YES	NO	GANI?

5. Physical Capital

Where is the nearest market for you to sell livestock? How far is it from your boma? (Soko la kuuza mifugo liko wapi? Ni umbali gani kutoka zizi la mifugo?)	
Where is the nearest market for you to sell crops? How far is it from your farms? (Soko la kuuza mazao liko wapi? Ni umbali gani kutoka shambani?)	
Do you have problems accessing livestock markets? Why? (Kuna shida kufika kwa soko la mifugo? Nieleze shida gani.	
Do you have problems accessing farm produce markets? Why? (Kuna shida kufika kwa soko la mazao? Nieleze shida gani.)	
What is your source of water for household use? (Mnapata maji ya kutumia nyumbani wapi?)	
Source of water for crops and trees? Distance from farm? (Mnapata maji wapi kwa kukuza mazao na miti? Ni umbali gani kutoka shamba?)	

Source of water for livestock? Distance from grazing areas? (Mnapata maji wapi kwa mifugo? Ni umbali gani kutoka kwa mahali pa malisho?)	
Where do you go to receive health care? How far is it from your house? (Mnaenda wapi kupata huduma za afya? Ni umbali gani kutoka nyumbani?)	
Where do you take your children for school? How far is it from home? (Mnapeleka wapi watoto wenu kwa shule? Ni umbali gani kutoka nyumbani?)	

6. Social Capital

Institutions and Social Capital	
Does your household belong to any agriculture groups? (Mmejiunga na kikundi cha kilimo? Nani na kikundi gani?)	
Does your household belong to any livestock groups? (Mmejiunga na kikundi cha mifugo? Nani na kikundi gani?)	
Does your household belong to any tree planting groups? (Mmejiunga na kikundi cha upandaji miti? Nani na kikundi gani?	

Does your household participate in any self-help groups? (Mmejiunga na kikundi cha kujisaidia wenyewe? Nani na kikundi gani?)	
Has your household participated in development projects? (Mmewahi kufanya kazi na miradi ya maendaleo?)	
If you go to church, do you belong to any church groups? What group? (Ukienda kanisani, umejiunga kwa kikundi cha kanisa? Kikundi gani?)	
Do you take part in local politics? (Mnajiusisha kwa siasa?)	
Do you have other family living near you? Who? (Kuna familia wengine wanaoishi karibu nanyi? Nani?)	
Do you seek advice from neighbors about farming? (Mnawauliza majirani kwa ushauri kuhusu kilimo?)	
Do you seek advice from neighbors about livestock? (Mnawauliza majirani kwa ushauri kuhusu mifugo?)	
Do you seek advice from neighbors about trees? (Mnawauliza majirani kwa ushauri kuhusu miti?)	

7. Human Capital (Section 2) and Health

Do you ever have problems breathing the air or it hurts for you to breathe the air? If yes, why do you think that is? (Unakuwa na matitizo ya kuvuta hewa? Kama ni ndiyo, kwa nini?)	YES, why (Ndiyo, kwa nini):			NO
IF YES TO ABOVE QUESTION: Is there a time of year that makes the air harder to breath or it hurts more than other times? (Kuna wakati wa mwaka ambaye inakuwa ngumu zaidi kuvuta hewa?)				
Generally, how many times in a year do you get a fever? (Unapata homa – joto mwilini mara ngapi kwa mwaka?)				
What is the most common sickness that you have suffered from in the last year? (Ni maradhi yapi umepata kwa mwaka uliopita?)				
Over the last year, what has been the most severe sickness? (Kwa mwaka uliopita ni maradhi ipi iliokudhuru zaidi?)				
Generally, how often do you get malaria? (Unagoneka malaria baada ya muda kiasi gani?)				
How do you know you have malaria? (Unajuaje una malaria?)	Recognize symptoms because I have had malaria before (Nina tambua dalili za malaria kwa sababu nimewahi	I got a blood test (Nikaenda kupimwa damu)	Took medicine and my sickness went away (Nilimeza dawa na ugonjwa iliisha)	Other (kingine):

DO NOT READ CHOICES	kupata malaria)			
In general, describe the health of your family. (Kwa ujumla, nielezea kuhusu afya ya familia yako.)				
Do health problems prohibit livelihood activities? How? (Matatizo ya afya yanawazuia kufanya kazi? Yanawazuiaje?)				

Besides cooking, how do you use fire? (Kando ya kupika, mnatumiaje moto?)	Make charcoal (kuchoma makaa)
	Make bricks (kuchoma matofali)
	Burn fields (kuchoma mashamba)
	Burn cow dung (kuchoma kinyesi ya ng’ombe)
	Burn trash (Kuchoma takataka)
	Burn crop residues (Kuchoma masalio ya mazao?)

	Clear land (Kuchoma ardhi kwa kuanzisha shamba)
	Brewing (Kupika pombe)
	Other (kitu kingine):
If they burn fields ask (Wakichoma mashamba waulize):	
Why do you burn your fields? (Kwa nini mnachoma mashamba?)	
What are you burning in your fields? (name all the crops) (Mnachoma nini shambani? Mazao gani?)	
When do you burn your fields? (Mnachoma mashamba lini? Mwezi gani?)	
How often do you burn your fields? (Mnachoma mashamba mara ngapi kwa mwaka?)	

Compared to 10 years ago, can you tell me generally if there have been any changes in weather? Please describe those changes. (Ukilinganisha miaka kumi iloyopita, kuna mabadiliko ya hali ya hewa? Nieleze ni mabadiliko gani?)		
Please tell me how the population has changed in this area since you started your farm here? (Nieleze kuhusu mabadiliko na idadi ya watu hapa tangu ulipoanza ukulima hapa.)		
Are there certain groups of people moving in and out? (Kuna kikundi cha watu wanaohamia hapa au nje?)	IN	OUT

Has cattle-rustling been a problem in this area? How? (Uwizi wa mifujo ni shida katika maeneo hili? Vipi?)		
Do you have any problems with wildlife on your farm or with your livestock? Please tell me about those problems and which types of animals. (Mnakuwa na matatizo na wanyama wa pori kwa shamba au kwa mifugo yako? Ni wanyama wa pori gani na ni matatizo gani?)	FARM	LIVESTOCK

8. Historical Events and Impacts

Was your household impacted by the 2007/ 2008 post-election violence? If yes, how? (Familia yako mliathirika na vurugu wa uchaguzi wa mwaka 2008? Mliathirika vipi?)	
Was your household impacted by the 2012/ 2013 election? (Familia yako iliathirika na uchaguwi wa mwaka 2012/ 2013? Mliathirika vipi?)	
Has your area been impacted by tribal or clan clashes? (Mnakuwa na matitizo ya vurugu wa kikabila au ukoo katika maeneo hili? Matitizo gani?)	
How has the local economy changed in the past 10 years? (Uchumi wa eneo hili limebadilikaje kwa muda wa miaki kumi iliopita? Vipi?)	

Have there been any times of very low prices for important household crops or livestock in the last 5 years? If yes, when and how did that impact your household? (Je, kuna wakati bei duni ya mifugo au mazao katika familia yako kwa miaka tano iliopita? Kama ndiyo, lini na ilikuwa na matokeo gani?	
In times of economic hardship, does your household utilize your trees? If so, how? (Wakati wa shida za uchumi, mnatumia vipi miti yenu?)	

What big economic and political events have occurred in the past 10 years? (Mlikuwa na matukio makubwa ipi ya kiuchumi na kisiasa katika miaka kumi iliopita?)

Event (Tukio)	Year (Mwaka)	Duration (Muda yake)	Severity (Ukali)	Impacts (Matokeo gani?)

Mapping – Ramani ya ardhi yenu, mazao, miti, manyumba, na maliasili

Is there anything else you would like to discuss or add? (Kuna mambo mengine ungependa kuongezea?)

Je, una maswali yoyote kwetu?

Asante kwa muda wako, sasa tumefika mwisho ya hojiano. Tunakushukuru sana kwa uda wako na majibu yako. Mungu akubariki.

Observations/comments:

Did the respondent appear to be telling the truth?

Are there any personal observations you made that seem to contradict what the respondent said? What?

Overall comments about respondent?

Example of Wet Season Discussion Guide – Kinna Household 10

Rainy Season Household Interview

My name is _______________. We are conducting research in Isiolo County in collaboration with the University of Colorado, in the United States, the Kenya Red Cross Society – Isiolo Branch, and the World Agroforestry Centre. We interviewed you previously and would like to conduct a follow up interview. This interview focuses on floods and the use of trees during the rainy season. As before, your answers are confidential and your participation is voluntary. You have the right to refuse to be interviewed or to answer specific questions. This interview is short and we will record the interview as well as take notes.

Jina langu ni ______________. Tunafanya utafiti hapa Isiolo County pamoja na Chuo Kikuu cha Colorado, Merikani, Msalaba Mwekundu Isiolo, na Shirika la World Agroforestry Centre, Nairobi. Tumeshakuhoji na sasa tunataka kukuhoji tena kwa kufafanua. Hojiano hii ni kuhusu mafuriko na matumizi ya miti wakati wa mafuriko. Majibu yako yatakuwa kwa siri na ni kwa ajili ya utafiti huu pekee. Kuhojiwa kwako ni wa kujitolea na una haki ya kukataa kujibu maswali. Mahojiano yatachukua muda chache na tutaandika majibu pamoja na kurekodi sauti yako.

Does the household consent to participate in this research and being interviewed? Yes ( ), No ( )
Unakubali kuhojiwa kwa utafiti huu? Ndiyo ( ), au La ( )

In your opinion for this area, do you think that the frequency of floods is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya marudio ya mafuriko kulingana na miaka kumi iliopita?)	
Yes, there are more floods than there were before (Ndiyo, kuna mafuriko zaidi sasa kuliko miaka kumi iliopita)	1
Yes, there are fewer floods than there were before (Ndiyo, kuna mafuriko chache sasa kuliko miaka kumi iliopita)	2
No, there has been no change in the frequency of flood (Hapana, hakuna mabadiliko)	3
I am not sure, there is no way to tell if there has been a change (Sina uhakika, na sina jinsi ya kujua)	4
I do not know (Mimi sijui)	99

In your opinion for this area, do you think that the severity of flood is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya ukali wa mafuriko kulingana na miaka kumi iliopita?)	
Yes, floods are more severe than 10 years ago (Ndiyo, ukali wa mafuriko imeongezeka zaidi kuliko miaka kumi iliopita)	1
Yes, floods are less severe than before (Ndiyo, ukali wa mafuriko umepungua kuliko miaka kumi iliopita.)	2
No, there has been no change in the severity of floods (Hapana, hakuna mabadiliko)	3
I am not sure, there is no way to tell if there has been a change (Sina uhakika, na sina jinsi ya kujua)	4
I do not know (Mimi sijui)	99

In your opinion for this area, do you think that the predictability of the rains is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya utabiri wa mvua kulingana na miaka kumi iliopita?)	
Yes, rains are more predictable than 10 years ago, they always come when they are predicted to. (Ndiyo, kulingana na miaka kumi iliopita mvua inaweza kutabiriwa zaidi wakati wa kunyesha.)	1
Yes, rains are less predictable than 10 years ago, it is hard to predict when they will come. (Ndiyo, kulingana na miaka kumi iliopita mvua haiwezi kutabiriwa wakati wa kunyesha.)	2
No, there has been no change in the predictability of the rains (Hapana, hakuna mabadiliko ya utabiri wa mvua.)	3
I am not sure, there is no way to tell if there has been a change (Sina uhakika, na sina jinsi ya kujua mabadiliko)	4
I do not know (Mimi sijui)	99

Flood Events in the Past 10 Years (Matukio ya mafuriko katika miaka kumi iliopita)

Year (Mwaka)	Duration (Muda gani)	Impacts (Matokeo gani?)

1. Have floods impacted your household? (Mafuriko imewaathiri nyumbani?)
    - If no, skip to question 4
    - If yes, ask all questions.

2. For each flood event above (Kwa kila tukio ya mafuriko):

    Tell me about how you and your family coped with the impacts of floods. (Niambie mlifanya nini kujimudu kimaisha kupambana na matokeo ya mafuriko?)
    - *How did you earn cash?(Mlipataje pesa kwa mahitaji?)*
    - *How did you feed your family?(Mlipataje chakula?)*
    - *Are there any diseases affecting your family during flood? (Kuna ugonjwa inawaathiri familia yako wakati wa mafuriko?)*

3. Do your trees help you and your family maintain your livelihoods during flood? (Miti inawasaidia kujimudu kimaisha wakati wa mafuriko?)
    - *How? Be specific by tree species. (Vipi? Ni aina gani ya miti?)*
    - *Did you plant trees with floods in mind? Why or why not?(Ulifikiria kuhusu mafuriko wakati ulipanda miti yako? Kwa nini ndiyo au hapana?)*

Sub-question:

3a. What tree species that you have are most important to your livelihood during flood? (rank highest to lowest) (Ni aina gani ya miti muhimu kwako wakati wa mafuriko?)		3b. What are the criteria you use for picking tree species that may help your livelihood during flood? (Ulichaguaje aina ya miti ambaye ni muhimu kwako wakati wa mafuriko?)
1.		1.
2.		2.
3.		3.
4.		4.
5.		5.

3c. Which tree species that you named above fit which criteria? (Draw a line between tree species and criteria) (Linganisha miti na umuhimu wake.)

4. What economic problems are caused by floods? (Mafuriko yanasababisha matatizo gani ya kiuchumi?)

- *Do trees help you cope? How?(Miti inawasaidia kupambana na matatizo haya? Vipi?)*
- *Which trees? (Miti gani?)*

5. Are there ecological benefits of having trees during floods or the rainy season? (Kuna faida ya mazingira kutokana na miti yenu wakati wa mafuriko ama msimu ya mvua?)

- *What? (Nini?)*
- *Which tree species provide what benefits?(Miti gani iko na faida gani?)*

6. Which has a bigger impact on your household livelihoods, floods or droughts? (*Kitu gani inawaathiri zaidi kwa kujimudu kimaisha, ukame ama mafuriko?*)

- *Why? (Kwa nini?)*
- *How do you balance the risks of floods and droughts to your livelihood?(Unawezaje kujimudu kati ya athari ya ukame na mafuriko?)*

- *Are there trees that help you cope with both floods and droughts? (Kuna aina ya miti inasaidia wakati yote mbili ya mafuriko na ya ukame? Vipi?)*

7. Please tell me what you can about the history of tree planting in the area. (*Niambie unavyojua historia ya upandaji wa miti kwa hii area.)*
    - *When and why did people start planting trees? (Watu walianza kupanda miti lini na kwa sababu gani?)*
    - *How has tree planting changed over time? (Upandaji wa miti imebadilika?)*
    - *Is there more tree planting today or more in the past? Why?(Upandaji wa miti imeongezeka zaidi wakati huu ama kitambo?)*

8. What diseases impact your livestock? (Ugonjwa gani inaathiri mifugo yako?)

Disease (Ugonjwa)	Livestock Species (Aina ya mfugo)

Example of Dry Season Discussion Guide – Burat Household 5

Dry Season Household Interview

My name is _______________. We are conducting research in Isiolo County in collaboration with the University of Colorado, in the United States, the Kenya Red Cross Society – Isiolo Branch, and the World Agroforestry Centre. We interviewed you previously and would like to conduct a follow up interview. This interview focuses on drought and the use of trees during drought. As before, your answers are confidential and your participation is voluntary. You have the right to refuse to be interviewed or to answer specific questions. This interview is short and we will record the interview as well as take notes.

Jina langu ni ______________. Tunafanya utafiti hapa Isiolo County pamoja na Chuo Kikuu cha Colorado, Merikani, Msalaba Mwekundu Isiolo, na Shirika la World Agroforestry Centre, Nairobi. Tumeshakuhoji na sasa tunataka kukuhoji tena kwa kufafanua. Hojiano hii ni kuhusu matumizi ya miti wakati wa ukame. Majibu yako yatakuwa kwa siri na ni kwa ajili ya utafiti huu pekee. Kuhojiwa kwako ni wa kujitolea na una haki ya kukataa kujibu maswali. Mahojiano yatachukua muda chache na tutaandika majibu pamoja na kurekodi sauti yako.

Does the household consent to participate in this research and being interviewed? Yes ( ), No ( )
Unakubali kuhojiwa kwa utafiti huu? Ndiyo ( ), au La ( )

Opinions about drought and past drought events:

In your opinion for this area, do you think that the frequency of drought is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya marudio ya ukame kulingana na miaka kumi iliopita?)	
Yes, there are more droughts than there were before (Ndiyo, kuna ukame zaidi sasa kuliko miaka kumi iliopita)	1
Yes, there are fewer droughts than there were before (Ndiyo kuna ukame chache sasa kuliko miaka kumi iliopita)	2
No, there has been no change in the frequency of drought (Hapana, hakuna mabadiliko)	3
I am not sure, there is no way to tell if there has been a change (Sina uhakika, na sina jinsia ya kujua)	4

I do not know (Sijui)	99

In your opinion for this area, do you think that the severity of drought is changing? (Kwa mawazo yako, kuna mabadiliko ya ukali wa ukame kuligana na miaka kumi iliopita?)	
Yes, droughts are more severe than 10 years ago (Ndiyo, ukali wa ukame imeongezeka zaidi kuliko miaka kumi iliopita)	1
Yes, droughts are less severe than before (Ndiyo, ukali wa ukame imepumgua kuliko miaka kumi iliopita)	2
No, there has been no change in the severity of drought (Hapana, hakuna mabadiliko)	3
I am not sure, there is no way to tell if there has been a change (Sina uhakika, na sina jinsi ya kujua.)	4
I do not know (Mimi sijui)	99

Drought Events in the Past 10 Years (Matukio ya ukame katika miaka kumi iliopita)

Year (Mwaka)	Duration (Muda gani)	Impacts (Matokeo gani?)

1. For each drought event above (Kwa kila tukio ya ukame):

Tell me about how you and your family cope with the impacts of drought (Niambie mlifanya nini kujimudu kimaisha kupambana na matokeo ya ukame?) (Go through the impacts named above one by one).

- *How did you earn cash? (Mlipataje pesa kwa mahitaji?)*
- *How did you feed your family? (Mlipataje chakula?)*

2. How did your family cope with the violence in Burat between 2007 and 2013? (Mliwezaje kujimudu kimaisha wakati wa vurugu katikati ya miaka 2007 na 2013?)

- *How did you feed yourself and earn an income? (Mlifanya nini kupata pesa na chakula?)*
- *Did the household trees play a role? How? Which trees?(Miti iliwasaidiaje? Miti gani na vipi?)*
- *Do trees help in a significant way or a little? How? Why?(Miti yako iliwasaidia kidogo au sana?)*
- *Did trees help you when you returned to your farm?(Miti iliwasaidia wakati mlirudi shambani?)*
- *Do trees help your family cope with cattle rustling?(Miti inawasaidia kujimudu kimaisha kama kuna uwizi wa mifugo?)*

3. Do your trees help you and your family maintain your livelihoods during drought? (Miti inawasaidia kujimudu kimaisha wakati wa ukame?)

- *How? Be specific by tree species. (Vipi? Ni aina ya mti gani?)*
- *Did you plant trees with drought in mind? Why or why not?(Ulifikiria kuhusu ukame wakati ulipanda miti yako? Kwa nini ndiyo au hapana?)*

Sub-question:

3a. What tree species that you have are most important to your livelihood during drought? (rank highest to lowest) (Ni aina gani ya miti muhimu kwako wakati wa ukame?)		3b. What are the criteria you use for picking tree species that may help your livelihood during drought? (Ulichaguaje aina ya miti ambaye ni muhimu kwako wakati wa ukame?)
1.		1.
2.		2.
3.		3.
4.		4.
5.		5.

3c. Which tree species that you named above fit which criteria? (Draw a line between tree species and criteria) (Linganisha miti na umuhimu wake.)

4. Are there ecological benefits you receive because of having trees during drought? (Kuna faida ya mazingira kutokana na miti yenu wakati wa ukame?)
    - *What? (Nini?)*
    - *Which tree species do what? (Ni aina ya miti gani inakuwa na faida gani?)*

5. During economic hardship how do your trees support your household? (Wakati wa shida ya kiuchumi au pesa miti inakusaidiaje?)
    - *Food?(Kwa chakula? Miti gani?)*
    - *Cash?(Kwa pesa? Miti gani?)*
    - *What do you use and from which trees?(Mnatumia nini kutoka miti na miti gani?)*

6. Have your trees helped your household be better off than before planting trees? (Je, miti yenu imeweza kukusaidia kuinua hali yenu ya kiuchumi, ukilinganisha na kabla ya kupanda miti?)
    - *How?* (*Vipi?)*
    - *What trees and how? (Miti gani na vipi?)*

- *Do trees contribute to your household's wealth/livelihood in a small way or a significant way?(Miti inawasaidia kiuchumi kidogo au sana?)*

7. Please tell me about your participation in the Bidii farming group. (Niambie kuhusu kazi yako katika Kikundi cha Bidii?)

- *Does this advise you to plant trees?(Bidii inawashauri upandaji wa miti?)*
- *How?(Vipi?)*

Livelihood Resilience and Agroforestry Survey - Burat

My name is _______________. We are conducting research in Isiolo County in collaboration with the University of Colorado, in the United States, the Kenya Red Cross Society – Isiolo Branch, and the World Agroforestry Centre, Nairobi. I do not represent the government or any political party. The purpose of this research is to learn about agroforestry and how agroforestry is used as part of the household livelihood in times of weather and economic stress. In order to understand the household and the household livelihoods we will also ask questions about health, livelihoods, conflict, and wildlife. We wish to conduct a short survey with you. All information you may provide will be confidential and will be used solely for this study. Your participation is voluntary and you can choose to not participate. With your permission, I will ask you a set of questions related to this research, and this should take some of your time.

Jina langu ni ______________. Tunafanya utafiti hapa Isiolo County pamoja na Chuo Kikuu cha Colorado, Merikani, Msalaba Mwekundu Isiolo, na Shirika la World Agroforestry Centre, Nairobi. Sisi siyo watu kutoka kwa serikali au chama cha kisiasa. Maana ya utafiti huu ni kujifunza kuhusu aina ya miti inayopandwa na matumizi yake wakati wa mafuriko, ukame, na katika matitizo ya kiuchumi. Pia kuelewa vizuri jinsi mnajimudu kimaisha tutauliza maswali kuhusu afya, vurugu, na wanyama pori. Majibu yako yatakuwa kwa siri na ni kwa ajili ya utafiti huu pekee. Kuhojiwa kwako ni wa kujitolea na una haki ya kukataa kujibu maswali. Ukikubali nitakuuliza maswali, na mahojiano yatachukua muda yako.

Does the household consent to participate in this research and being interviewed? Yes ( ), No ( )
Unakubali kuhojiwa kwa utafiti huu? Ndiyo ( ), au La ( )

INTERVIEWER: After introducing yourself and explaining about the survey as in the script above, then ask the respondent the following question:
Do you practice agriculture? (Unalima?)

- If **NO** politely explain that this research involves only community members who practice agriculture, say good-bye, and move on to the VERY NEXT HOUSEHOLD
- If **YES** continue with the interview and read the following definition of household: A household includes those who spend the majority of the year living under the same roof, eating from the same pot, and sharing in livelihood activities. (Kwa utafiti huu, familia ina maana ya watu wanaoishi katika boma moja, wanaokula kutoka sufuria moja, na wanaogawana kazi ya kujimudu kimaisha)

SECTION 1: Basic Respondent Information

Q1: **How old are you? (Uko na miaka mingapi?)**	

Q2: **Gender of the respondent (Jinsia)**	
1 Male (Mwanaume)	2 Female (Mwanamke)

Q3: **Are you currently the head of this household? (Wewe ndiyo mkuu wa familia?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	98	99

Q4: How long have you lived in this area? (Umeishi kwa sehemu hili kwa muda gani?)	
Years (Miaka)	

Q5: **What is the highest level of education you have completed? (Umesoma mpaka kiwango gani?)**	
No schooling (Sijasoma)	0
Some primary school (Sikumaliza shule ya msingi)	1
Primary school completed (Nilimaliza shule ya msingi)	2
Some secondary school/ high school (Sikumaliza shule ya sekondari)	3
Secondary school/ high school completed (Nilimaliza shule ya sekondari)	4
Some university (Sikumaliza chuo kikuu)	5
University completed (Nilimaliza chuo kikuu)	6
Adult learning (Shule ya gumbaru)	7
Other (Nyingine):	8
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q6: **What is your ethnic group? (Kabila yako ni gani?)**	
Borana	1
Turkana	2
Meru	3
Samburu	4
Somali	5
Other (Nyingine):	6
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q7: **What is your marital status? (Umeoa, umeolewa?)**	
Single, unmarried (Bado sijaoa / sijaolewa)	1
Married (living together) (Nimeoa/nimeolewa)	2
Married (separated) (Nimeoa/nimeolewa lakini hatukai pamoja)	3
Married (multiple wives) (Nimeoa/nimeolewa na kuna wake zaidi ya moja)	4
Divorced (Nilikuwa nimeoa/nimeolewa lakini tuliachana)	5
Widowed (Nimeoa/nimeolewa lakini ameaga)	6
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siewezi kusema)	99

Interviewer: Only ask Q7b if respondent is **female** and her husband has **other wives**

Q7b: Which number wife are you and how many are there total? (Wewe ni mke wa ngapi na kuna wake wenza wangapi kwa ujumla?)	
Number:	Total (Ujumla):

<u>SECTION 2: Livelihood Capitals and Livelihoods</u>

Q8H: **How many people are part of your household younger than 18, between 19 and 55, and older than 55? (Mko wangapi kwa familia yako wa umri chini ya miaka 18, katikati ya 18 na 55, na juu ya 55?)** *(Write the number in the space)*	
Between ages 0 – 18 (Umri kati ya 0 na 18)	
Between ages 19 – 55 (Umri kati ya 19 na 55)	
Over 55 years (Umri zaidi ya 55)	
Refused to answer (Amekataa kujibu)	98
Don't know or can't say (Sijui ama siwezi kusema)	99

Q9F: **In general, how would you describe your family's present living conditions compared to your neighbors? (Kwa ujumla, hali ya maisha ya familia yako iko vipi ukilinganisha na majirani yenu?)**

Much worse (Mbaya sana)	Worse (Mbaya kidogo)	Same (Sawa)	Better (Afadhali kidogo)	Much better (Afadhali sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	5	98	99

Q10F: **Does anyone in your household have a salaried job? (Kuna mtu yeyote katika familia yako ambaye anafanya kazi ya mshahara?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

Q11F: **Does your household receive remittances? (Mnapata msaada wa kifedha kutoka kwa mtu yeyote?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

Q12F: Does anyone in your household have a bank account? (Kuna mtu yeyote kwa famila yako ako na accounti ya benki?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

Q13F: Which of the following items does your household own? (Kwa nyumba yako mnamiliki nini kati ya vitu vifuatavyo?)	
Car (Gari)	1 Yes (Ndiyo)
Motorbike (Pikipiki)	1 Yes (Ndiyo)
Bicycle (Baiskeli)	1 Yes (Ndiyo)
TV (Televisheni)	1 Yes (Ndiyo)
Radio (Redio)	1 Yes (Ndiyo)

Q14H: How many times a year do you get a fever? (Unapata joto kwa mwili mara ngapi kwa mwaka?)	
None (Hakuna)	0
Once (Mara moja)	1
Twice (Mara mbili)	2
Three times (Mara tatu)	3
More than three times (Zaidi ya mara tatu)	4
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

Q15H: What is the most common sickness that you have suffered from in the last year? (Ni ugonjwa gani imeksumbua sana mwaka iliopita?) *(Write only one)*

Q16H: Over the last year, what has been the most severe sickness you have suffered? (Kwa mwaka uliopita ni maradhi ipi iliokudhuru zaidi?) *(Write only one)*

Q17H: Generally, how many times do you get malaria each year? (Kwa ujumla, unagonjeka malaria mara ngapi kwa mwaka?)	
None (Hakuna)	0
Once (Mara moja)	1
Twice (Mara mbili)	2
Three times (Mara tatu)	3
More than three times (Zaidi ya mara tatu)	4
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

Interviewer: If NONE, skip **Q18H** and **Q19H**

Q18H: How do you know you have malaria? (Unajuaje una malaria?)	
I recognize the symptoms because I have had malaria before (Ninatambua dalili za malaria kwa sababu nimewahi kupata tena)	1
I got a blood test (Nikaenda kupimwa damu)	2
I took medicine and my sickness went away (Nlimeza dawa na ugonjwa iliisha)	3
Other (Nyingine):	4
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kujua)	99

Q19H: How did you treat malaria? (Ulitibu vipi malaria?)

Q20H: In general, describe the health of your family? (Kwa ujumla, afya ya familia yako iko vipi?)						
Very poor (Mbaya sana)	Poor (Mbaya)	Not poor and not good (Siyo mbaya na siyo nzuri)	Good (Nzuri)	Very good (Nzuri sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	5	98	99

Q21H: How much money do you spend per year to treat sickness in your household? (Kwa kila mwaka, mnatumia pesa ngapi kupambana na magonjwa?)	
0 – 5,000 shillings	1
5,000 – 10,000 shillings	2
10,000 – 30,000 shillings	3
More than 30,000 shillings	4
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q22H: In this community, how common is HIV/AIDS? Would you say that no one has it, very few people have it, some people have it, or many people have it? (Kwa sehemu hili UKIMWI ni kitu ya kawaida? Ungesema hakuna watu wenye UKIMWI, ni watu wachache, watu kiasi, ama watu wengi?)	
No one (Hakuna)	0
Very few (Watu wachache)	1
Some (Watu kiasi)	2
Many (Watu wengi)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q23H: To what extent do health problems impact your ability to farm, herd, collect firewood, or other activities? (Matatizo ya afya yanawazuia kiasi gani kufanya kazi kama kulima, kuchunga, kuokota kuni na vitu vingine?)					
Not at all (Hapana)	A little (Kidogo)	Average (Katikati)	Very much (Sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

Q24S: Does your household have family living nearby? (Kuna familia yenu wanaoishi karibu?) *(Read, Select all that apply)*	
No (Hakuna)	0
Yes, they are neighbors (Ndiyo, ni majirani)	1
Yes, in the same general area (Ndiyo, kwa sehemu hili)	2
Yes, in nearby towns (Ndiyo, kwa miji ya karibu)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui na siwezi kusema)	99

Q25S: Does anyone in your household belong to any of the following groups? (Kuna mtu yeyote kwa familia yako amejiunga na vikundi vifuatavyo?) *(Read, Select all that apply)*	
Agricultural group (Kikundi cha kilimo)	1
Livestock group (Kikundi cha mifugo)	2
Tree planting group (Kikundi cha upandaji miti)	3
Self-help group	4
Merry-go-round	5
Women's group (Kikundi cha akina mama)	6
Church group (Kikundi cha kanisa)	7
Youth group (Kikundi cha vijana)	8
Political group or organization (Kikundi ama chama cha kisiasa)	9
Community group (Kikundi cha jamii yote)	10
Other (Kikundi kingine):	11
We belong to no groups (Hatujajiunga na vikundi)	0
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q26S: Do you and your neighbors do any of the following? (Mnafanya nini na majirani yenu kwa hivi vitu vifuatavyo?) *(Read, Select all that apply)*	
Share advice about agriculture (Tunashauriana kuhusu kilimo)	1
Share advice about tree planting (Tunashauriana kuhusu upandaji miti)	2
Borrow farming equipment from one another (Tunasaidiana vifaa vya kilimo kama generator, jembe)	3
Children play together (Watoto wetu wanacheza pamoja)	4
Look after each other's children (Tunatunziana watoto wetu)	5
Borrow money in times of need (Tunakopeshana pesa wakati wa matatizo)	6
Share food in times of need (Tunagawa chakula wakati wa matatizo)	7
Herd livestock together (Tunachunga mifugo pamoja)	8
Share seeds (Tunagawa mbegu)	9
None of the above (Hakuna)	0

Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q27S: In general, how much power or influence do you think you have in local politics? (Kwa ujumla na kwa mawazo yako, unafikiria ya kuwa uko na uwezo au sauti katika siasa ya jimbo au sehemu yako?					
None (Hakuna)	A little (Kidogo)	Average (Katikati)	A lot (Sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

Q28P: In general, how would you describe the condition of the roads in your area? (Kwa ujumla, mabarabara kwa sehemu yako iko vipi?)						
Very bad (Mbaya sana)	Fairly bad (Mbaya kidogo)	Average (Katikati)	Fairly good (Nzuri kidogo)	Very good (Nzuri sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	5	98	99

Q29P: During the rainy season which is true about roads in your area? (Msimu wa mvua, mabarabara yenu iko vipi?) *(Read)*	
They remain in good condition (Bado iko nzuri tu)	1
Sometimes the roads get muddy (Kuna wakati inakuwa na matope)	2
The roads become bad (Barabara inakuwa mbaya)	3
They are completely impassable (Barabara haipitiki kabisa)	4
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q30P: **Does your household live on or near your farm? (Familia yako mnaishi kwa shamba ama karibu kwa shamba?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui na siwezi kusema)
1	0	98	99

Q31P: Which of the following are located WITHIN 3 km from you? (Lipi lifuatalo liko kati ya kilometa 3 kutoka kwako?) *(Read, Select all that apply)*	HOME (Nyumba)	FARM (Shamba)
Livestock market (Soko ya mifugo)	1	1
Farm produce market (Soko ya mazao)	2	2
Shops (Maduka)	3	3
Hospital or dispensary (Hospitali ama zahanati)	4	4
Primary school (Shule ya msingi)	5	5
Secondary school (Shule ya sekondari)	6	6
River or stream (Mto ama laga)	7	7
Water for household consumption (Maji kwa kutumia nyumbani)	8	8
Water for farming (Maji kwa kulima)	9	9
Water for livestock (Maji kwa mifugo)	10	10
Government administration office (Ofisi ya serikali utawala)	11	11
Refused to answer (Amekataa kujibu)	98	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99	99

Q32: What activities does your household depend upon for its livelihood? (Mnafanya nini kujimudu kimaisha?) *(Select all that apply)*	
Livestock keeping (Mifugo)	1
Poultry farming (Kufuga kuku)	2
Crop farming (Kilimo)	3
Tree farming (Kilimo cha miti)	4
Small business (Biashara ndogondogo)	5
Casual labor (Kibarua)	6
Salaried employment (Kazi ya mshahara)	7
Charcoal production (Kuchoma makaa)	8
Selling firewood (Kuuza kuni)	9
Aid or Relief (Msaada)	10
Other (Kazi nyingine):	11
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui na siwezi kusema)	99

Q33: What activity does your household <u>PRIMARILY</u> depend upon for income this year? (Ni kazi gani ambalo familia lako linategemea zaidi kwa mapato mwaka huu?) *(Chose only one activity)*	
Livestock keeping (Mifugo)	1
Poultry farming (Kufuga kuku)	2
Crop farming (Kilimo)	3
Tree farming (Kilimo cha miti)	4
Small business (Biashara ndogondogo)	5
Casual labor (Kibarua)	6
Salaried employment (Kazi ya mshahara)	7
Charcoal production (Kuchoma makaa)	8
Selling firewood (Kuuza kuni)	9
Aid or Relief (Msaada)	10
Other (Kazi nyingine):	11
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui na siwezi kusema)	99

Q34: What activity did your household <u>PRIMARILY</u> depend upon for income last year? (Ni kazi gani ambalo familia lako linategemea zaidi kwa mapato mwaka jana?) *(Chose only one activity)*	
Livestock keeping (Mifugo)	1
Poultry farming (Kufuga kuku)	2
Crop farming (Kilimo)	3
Tree farming (Kilimo cha miti)	4
Small business (Biashara ndogondogo)	5
Casual labor (Kibarua)	6
Salaried employment (Kazi ya mshahara)	7
Charcoal production (Kuchoma makaa)	8
Selling firewood (Kuuza kuni)	11
Aid or Relief (Msaada)	9
Other (Kazi nyingine):	10
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui na siwezi kusema)	99

Q35N: How did you aquire your farmland? (Ulipataje ardhi yako ya kilimo?) *(Select all that apply)*	
We bought our farm land (Tulinunua shamba yetu)	1
We rent our farm land (Tunakodesha shamba ya mtu)	2
We use community held land (Tunalima kwa ardhi ya jamii)	3
We inherited our farm land (Tulirithi shamba)	4
We use land owned by relative/friend (Shamba ni ya jamaa yetu ama rafiki)	5
We cleared and claimed our farmland (Tulishika ardhi)	6
Squatting (Tunakalia bila ithini)	7
Other (Nyingine):	8
Refused to answer (Amekataa kujibu)	98
Don't' know or cannot say (Sijui ama siwezi kusema)	99

If the household owns their farm, ask the following questions:		
Q36N: How many farms does your household own (Mnamiliki shamba ngapi?) *(Select one)*	**Q37N/F: How many acres is each farm? (Kila shamba ina ekari ngapi?)** *(Write in the number)*	**Q38N: For each farm, how long have you farmed there? (Kwa kila shamba, umelima shamba kwa muda gani?)** *(Write in the number)*
1		
2		
3		
4		
98 Refused to answer (Amekataa kujibu)	98 Refused to answer (Amekataa kujibu)	98 Refused to answer (Amekataa kujibu)
99 Don't know or cannot say (Sijui ama siwezi kusema)	99 Don't know or cannot say (Sijui ama siwezi kusema)	99 Don't know or cannot say (Sijui ama siwezi kusema)

Q39P/F: Does your household use the following farm equipment? (Familia yako mnatumia vifaa vifuatavyo kwa ukulima?) *(Read, select all that apply)*			
	Own (Kumiliki)	Rent (Kukomboa)	Lend/Borrow (Kuazimwa)
Tractor	1	2	3
Oxe plow (Kulima kwa ng'ombe)	1	2	3
Generator (Genset, water pump)	1	2	3
Pipes/Hoses	1	2	3
Sprinklers	1	2	3
Refused to answer (Amekataa kujibu)	98	98	98
Don't know or cannot say (Sijui na siwezi kusema)	99	99	99

Q40: Does your household receive food aid? (Mnapata chakula cha msaada?)	
Yes, on a regular basis (Ndiyo, kila wakati)	1
Yes, in times of need (Ndiyo, wakati wa dharura)	2
Yes, but rarely (Ndiyo, lakini mara chache tu)	3
No (Hapana)	0
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui na siwezi kusema)	99

Q41: For how long did your crops feed your family the last year? (Kwa mwaka huu, mazao uliovuna imelisha familia yako kwa muda gani?)

Q42: For how long did your crops feed your family the year before last? (Kwa mwaka uliopita, mazao uliovuna imelisha familia yako kwa muda gani?)

Q43N: Typically, on the farm what are the main crops that you plant? (Kama kawaida, mnapanda mazao gani kwa shamba lenu?) *(Select all that apply)*		
1 Corn (Mahindi)	10 French beans (Mishiri)	19 Sugar cane (Miwa)
2 Beans (Maharagwe)	11 Bell pepper (Pilipili hoho)	20 Sorghum
3 Kale (Sukuma wiki)	12 Potatoes (Viazi)	21 Green grams (Dengu)
4 Spinach	13 Sweet potatoes (Viazi tamu)	22 Watermelon (Tikiti maji)
5 Onion (Kitunguu)	14 Pumpkin (Malenge)	23 Terere (Local leafy green)
6 Tomato (Nyanya)	15 Yams (Kikwa)	24 Pigeon peas (Mbaazi)
7 Cow peas (Kunde)	16 Eggplants (Biringanya)	25: Other (Nyingine):
8 Tobacco (Tumbako)	17 Cassava (Muhogo)	Refused to answer (Amekataa kusema)
9 Carrots (Karoti)	18 Hot peppers (Pilipili kali)	Don't know or cannot say (Sijui na siwezi kusema)

Q44N: In general, how big of a problem is soil erosion on your farm? (Kwa ujumla, mmomonyoko wa udongo ni shida wa kiasi kwa shamba lenu?)					
A lot (Sana)	Some (Kiasi)	A little (Kidogo)	None (Hakuna)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

Q45P: Do you use irrigation for farming (generator, pipes, ditches)? (Mnanyunyizia shamba lenu (generator, pipes, mitaro)?) *(Select all that apply)*	
No (Hapana)	0
Generator (Genset, water pump)	1
Pipes	2
Ditches (Mitaro ama farrow)	3
Other (Nyingine):	4
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Interviewer: If **NO** skip questions Q46P and Q47P

Q46P: In general, is the current irrigation system in this area fair and equitable? (Kwa ujumla, jinsi ambaye mnashaushiwa kunyunyizia maji kwa mashamba yenu ina usawa na haki?)					
No (Hapana)	A little (Kidogo)	Some (Kiasi)	Very (Sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

Q47P: How important is irrigation for maintaining your ability to farm? (Kunyunyizia shamba maji ina umuhimu wa kiasi gani kwa kukuwezesha kulima?)					
Not important (Siyo muhimu)	A little important (Muhimu kidogo)	Somewhat important (Muhimu kiasi)	Very important (Muhimu sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

Q48N/F: Does your household have livestock and how many (cows, goats, sheep, camels)? (Je, mko na mifugo na wako wangapi (ng'ombe, mbuzi, kondoo, ngamia?))				
	Cattle (Ng'ombe)	Goats/Sheep Mbuzi/Kondoo	Camels (Ngamia)	Donkey (Punda)
No (Hakuna)	0	0	0	0
Yes, 1-5 (Ndiyo, 1-5)	1	1	1	1
Yes, 6-20 (Ndiyo, 6-20)	2	2	2	2
Yes, 21-50 (Ndiyo, 21-50)	3	3	3	3
Yes, 51-100 (Ndiyo, 51-100)	4	4	4	4
Yes, more than 100 (Ndiyo, zaidi ya 100)	5	5	5	5
Refused to answer (Amekataa kujibu)	98	98	98	98
Don't know or cannot say (Sijui ama siwezi kusema)	99	99	99	99

Q49: Where is your <u>MAIN</u> source of firewood for home use? (Mnapata wapi <u>asilimia kubwa</u> ya kuni mnayotumia nyumbani?) (Read, Select ONLY one)	
We do not use firewood (Hatutumii kuni)	0
Buy firewood (Tunanunua kuni)	1
From trees on our farm (Kutoka kwa miti ndani ya shamba letu)	2
From bushland areas near us (Kutoka kichaka cha karibu)	3
From the bushland far away (Kutoka kichaka cha mbali)	4
Other (Nyingine):	5
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui na siwezi kusema)	99

SECTION 3: Agroforestry

Q50: Have you or your family planted trees on your land? (Wewe ama familia yako mmewahi kupanda miti kwa ardhi yenu?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

<u>INTERVIEWER:</u>
* If **<u>NO</u>** skip all the questions with a ♣ in front of them in all sections, go to Section 4
* If **<u>YES</u>** continue asking all the questions

♣Q51: About how many trees have been planted on your land? (Mko na kama miti ngapi kwa ardhi yenu?) *(Write a number)*

♣Q52: What tree species have you or your family planted? (Mmepanda aina gani za miti?) *(Read, select all that apply)*		
1 Papaya (Pai pai)	9 Tamarind (Hamar)	17 Mathenge
2 Mango (Maembe)	10 Custard Apple (Matomoko)	18 Indigenous trees (Miti ya kienyiji)
3 Guava (Mapera)	11 Banana (Ndizi)	19 Other (Nyingine):
4 Avocado (Parachichi)	12 Jacaranda	20 Other (Nyingine):
5 Orange (Machungwa)	13 Pigeon peas (Mbaazi)	21 Other (Nyingine):
6 Cassava (Muhogo)	14 Greveria	98 Refused to answer (Amekataa kujibu)
7 Blue Gum / Eucalyptus	15 Neem (Mwarobaini)	99 Don't know or cannot say (Sijui ama siwezi kusema)
8 Lemon (Ndimu)	16 Miraa	

♣Q53: How many years ago were the first trees planted on your land? (Miti ya kwanza kupandwa kwa ardhi yenu ilipandwa miaka mingapi iliyopita?)

♣Q54: In general, what benefits do you currently receive from your trees? (Kwa ujumla, mnapata faida gani siku hizi kutoka kwa miti yenu?) *(DO NOT READ CHOICES, Select all that apply)*	
1 Selling fruit/ food (Kuuza matunda ama mazao)	11 Windbreak (Kuzuia upepo)
2 Fruit or food for household consumption (Matunda ama mazao kula nyumbani)	12 Livestock fodder (Chakula cha mifugo)
3 Shade (Kivuli)	13 Beautification of land (Kuboresha mazingira)
4 Poles or timber for the household (Mbao ama vikingi ya kutumia nyumbani)	14 Attract the rain (Kuvuta mvua)
5 Selling poles or timber (Kuuza mbao ama vikingi)	15 Source of income during drought (Kupata pesa wakati wa ukame)
6 Soil erosion prevention (Kuzuia mmomonyoko wa udongo)	16 Other (Nyingine):
7 Compost or fertilizer (Mbolea)	17 I have not received benefits because my trees are still small (Bado sijapata faida kwa sababu miti yangu ni midogo)
8 Firewood for household consumption(Kuni)	
9 Selling firewood (Kuuza kuni)	98 Refused to Answer (Amekataa kujibu)
10 Medicine (Dawa)	99 Don’t know or cannot say (Sijui na siwezi kusema)

INTERVIEWER: If respondent answered choice <u>**17**</u> in **Q54** skip all the ♣ tree questions because the respondent has yet to receive any benefits from their tree seedlings

♣Q55: After having planted trees has your household’s income improved because of these trees? (Baada ya kupanda miti, je, miti imeweza kuinua hali yenu ya kifedha?)					
None (Hakuna)	A little (Kidogo)	Some (Kiasi)	A lot (Sana)	Refused to answer (Amekataa kujibu)	Don’t know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

♣Q56: After having planted trees has your household's life/wellbeing improved because of these trees? (Baada ya kupanda miti, je, miti imeweza kuinua hali yenu ya maisha?)					
None (Hakuna)	A little (Kidogo)	Some (Kiasi)	A lot (Sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

SECTION 4: Drought

Q57: In your opinion, what is the definition of drought? (Kwa mawazo yako, ukame ni nini?)

Q58: When was the last major drought? (Ukame kubwa iliyopita ilikuwa lini ama mwaka gani?)

Q59: In your opinion, do you think that the frequency of drought is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya marudio ya ukame ukilinganisha na miaka kumi iliopita?)	
Yes, there are more droughts than there were before (Ndiyo, kuna ukame zaidi sasa kuliko miaka kumi iliopita)	1
Yes, there are fewer droughts than there were before (Ndiyo, kuna ukame chache sasa kuliko miaka kumi iliopita)	2
No, there has been no change in the frequency of drought (Hapana, hakuna mabadiliko)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q60: In your opinion, do you think that the severity of drought is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya ukali wa ukame ukilinganisha na miaka kumi iliopita?)	
Yes, droughts are more severe than 10 years ago (Ndiyo, ukali wa ukame imeongezeka zaidi kuliko miaka kumi iliopita)	1

Yes, droughts are less severe than before (Ndiyo, ukali wa ukame imepumgua kuliko miaka kumi iliopita)	2
No, there has been no change in the severity of drought (Hapana, hakuna mabadiliko)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q61: What activity does your household PRIMARILY depend upon for your livelihood during times of drought? (Wakati wa ukame, ni njia gani ya kujimudu kimaisha muhimu zaidi ya yote kwa familia yako?) *(Chose only one activity)*	
Livestock keeping (Mifugo)	1
Poultry farming (Kufuga kuku)	2
Crop farming (Kilimo)	3
Tree farming (Kilimo cha miti)	4
Small business (Biashara ndogondogo)	5
Casual labor (Kibarua)	6
Salaried employment (Kazi ya mshahara)	7
Charcoal production (Kuchoma makaa)	8
Selling firewood (Kuuza kuni)	9
Aid or Relief (Msaada)	10
Other (Kazi nyingine):	11
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui na siwezi kusema)	99

♣**Q62: What are all the ways that trees help support your livelihood during times of drought? (Wakati wa ukame, miti inawasaidiaje kujimudu kimaisha?)** *(DO NOT READ CHOICES, Select all that apply)*	
We sell produce (Tunauza mazao)	1
We eat produce at home (Tunakula mazao)	2
We sell timber and/or poles (Tunauza mbao ama vikingi)	3
We use timber and/or poles at home (Tunatumia mbao ama vikingi nyumbani)	4
Firewood for home use (Kuni kwa kutumia nyumbani)	5
Firewood for sales (Kuni ya kuuza)	6
Provide fodder for livestock (Chakula cha mifugo)	7
Making charcoal (Kuchoma makaa)	8
Other (Nyingine):	9
Nothing, trees do not support our livelihood during drought (Miti haitusaidii kujimudu kimaisha wakati wa ukame)	0
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

♣**Q63: What are some environmental benefits that you receive from your trees during times of drought? (Kuna faida gani ya kimazingira mnapata kutokana na miti yenu wakati wa ukame?)** *(DO NOT READ CHOICES, Select all that apply)*	
Windbreaker (Kuzuia upepo)	1
Shade for people (Kivuli kwa binadamu)	2
Shade for the farm / prevent water from evaporating (Kivuli kwa shamba ama kuzuia maji kuvujwa na miale ya jua)	3
Prevents soil erosion (Kuzuia mmomonyoko wa udongo)	4
Brings the rain (Kuvuta mvua)	5
Provide a cool/nice environment (Kuleta hewa baridi ama hewa safi)	6
Provides compost (Mbolea)	7
Other (Nyingine):	8
No environmental benefits (Hakuna faida ya kimazingira)	0
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

♣**Q64: What is the most important tree for your household during drought? (Mti gani muhimu zaidi kwenu wakati wa ukame?)**

♣**Q65: Why is the tree named above the most important during times of drought? (Kwa nini hii mti ni muhimu zaidi kwenu wakati wa ukame?)** *(DO NOT READ CHOICES, Select all that apply)*	
Uses less water (Inatumia maji kidogo)	1
Drougth resistant (Inastahimili ukame)	2
Income (Pesa)	3
Food (Chakula)	4
Shade (Kivuli)	5
Fast production (Inatoa mazao haraka)	6
Produces year round (Inatoa mazao kila wakati)	7
Firewood (Kuni)	8
Timber and poles (Mbao na vikingi)	9
Does not require pesticides (Haihitaji kunyunyiziwa dawa)	10
Livestock fodder (Chakula cha mifugo)	11
Other (Nyingine):	12
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

♣**Q66: Did you plant trees thinking they could help support your livelihood in times of drought? (Wakati ulipanda miti ulikuwa na fikra kwamba itawasaidia kujimudu kimaisha wakati wa ukame?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

♣**Q67: In general, how important are trees in supporting your household in times of drought? (Kwa ujumla, miti iko na umuhimu wa kiasi gani kuwasaidia kujimudu kimaisha wakati wa ukame?)**					
Not important (Siyo muhimu)	A little important (Muhimu kidogo)	Somewhat important (Muhimu kiasi)	Very important (Muhimu sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

SECTION 5: Floods

INTERVEIWER to read to respondent: Mafuriko ni hali ya kuwa na maji mengi yanayofunika nchi kavu pasipo na maji kwa kawaida. (A flood is a condition where there is an overflow of water and water covers land that is typically dry)

Q68: When was the last major flood? (Mafuriko kubwa iliyopita ilikuwa lini ama mwaka gani?)

Q69: Has your household, livelihood, farm, or livestock been impacted by floods? (Mafuriko imewahi kuwaathiri kwa njia yoyote (nyumbani, shambani, kwa mifugo)?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

INTERVIEWER: If **NO**, skip to SECTION 6

Q70: In your opinion, do you think that the frequency of floods is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya marudio ya mafuriko ukilinganisha na miaka kumi iliopita?)	
Yes, there are more floods than there were before (Ndiyo, kuna mafuriko zaidi sasa kuliko miaka kumi iliopita)	1
Yes, there are fewer floods than there were before (Ndiyo, kuna mafuriko chache sasa kuliko miaka kumi iliopita)	2
No, there has been no change in the frequency of flood (Hapana, hakuna mabadiliko)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q71: In your opinion, do you think that the severity of flood is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya ukali wa mafuriko ukilinganisha na miaka kumi iliopita?)	
Yes, floods are more severe than 10 years ago (Ndiyo, ukali wa mafuriko imeongezeka zaidi kuliko miaka kumi iliopita)	1
Yes, floods are less severe than before (Ndiyo, ukali wa mafuriko umepungua kuliko miaka kumi iliopita.)	2
No, there has been no change in the severity of floods (Hapana, hakuna mabadiliko)	3
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q72: In your opinion, do you think that the predictability of the rains is changing since approximately 10 years ago? (Kwa mawazo yako, kuna mabadiliko ya utabiri wa mvua ukilinganisha na miaka kumi iliopita?)	
Yes, rains are more predictable than 10 years ago, they always come when they are predicted to. (Ndiyo, kulingana na miaka kumi iliopita mvua inaweza kutabiriwa zaidi wakati wa kunyesha.)	1
Yes, rains are less predictable than 10 years ago, it is hard to predict when they will come. (Ndiyo, kulingana na miaka kumi iliopita mvua haiwezi kutabiriwa wakati wa kunyesha.)	2
No, there has been no change in the predictability of the rains (Hapana, hakuna mabadiliko ya utabiri wa mvua.)	3
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

Q73: What activity does your household <u>PRIMARILY</u> depend upon for your livelihood during times of flood? (Wakati wa mafuriko, ni njia gani ya kujimudu kimaisha muhimu zaidi ya yote kwa familia yako?) *(Chose only one activity)*	
Livestock keeping (Mifugo)	1
Poultry farming (Kufuga kuku)	2
Crop farming (Kilimo)	3
Tree farming (Kilimo cha miti)	4
Small business (Biashara ndogondogo)	5
Casual labor (Kibarua)	6
Salaried employment (Kazi ya mshahara)	7
Charcoal production (Kuchoma makaa)	8
Selling firewood (Kuuza kuni)	9
Aid or Relief (Msaada)	10
Savings of money and/or food (Akiba ya pesa ama chakula)	11
Nothing (Hakuna)	12
Other (Kazi nyingine):	13
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui na siwezi kusema)	99

Q74: Had your household planted trees before the last big flood in the area? (Kabla ya mafuriko kubwa iliyopita kwa sehemu hili, mlikuwa mmepanda miti kwa shamba yenu?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don’t know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

INTERVIEWER: If **NO**, skip to SECTION 6

♣**Q75: What are all the ways that trees help support your livelihood during times of flood? (Wakati wa mafuriko, miti inawasaidiaje kujimudu kimaisha?)** *(DO NOT READ CHOICES, Select all that apply)*	
We sell produce (Tunauza mazao)	1
We eat produce at home (Tunakula mazao)	2
We sell timber and/or poles (Tunauza mbao ama vikingi)	3
We use timber and/or poles at home (Tunatumia mbao ama vikingi nyumbani)	4
Firewood for home use (Kuni kwa kutumia nyumbani)	5
Firewood for sales (Kuni ya kuuza)	6
Provide fodder for livestock (Chakula cha mifugo)	7
Making charcoal (Kuchoma makaa)	8
Other (Nyingine):	9
Nothing, trees do not support our livelihood during flood (Miti haitusaidii kujimudu kimaisha wakati wa mafuriko)	0
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣**Q76: What are some environmental benefits that you receive from your trees during times of flood? (Kuna faida gani ya kimazingira mnapata kutokana na miti yenu wakati wa mafuriko?)** (DO NOT READ CHOICES, *Select all that apply)*	
Windbreaker (Kuzuia upepo)	1
Shade for people (Kivuli)	2
Reduces water speed (Kupunguza mwendo wa maji)	3
Prevents soil erosion (Kuzuia mmomonyoko wa udongo)	4
Other (Nyingine):	5
No environmental benefits of trees during flood (Hakuna faida ya kimazingira kutokana na miti wakati wa mafuriko)	0
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣**Q77**: **What is the most important tree for your household during floods? (Mti gani ni muhimu zaidi kwenu wakati wa mafuriko?)**

♣**Q78: Why is this tree as the most important during times of flood? (Kwa nini hii mti ni muhimu zaidi wakati wa mafuriko?)** *(DO NOT READ CHOICES, Select all that apply)*	
Prevent soil erosion (Kuzuia mmomonyoko wa udongo)	1
Income (Pesa)	2
Food (Chakula)	3
Flood resistant (Inastahimili mafuriko)	4
Fast production (Inatoa mazao haraka)	5
Produces year round (Inatoa mazao kila wakati)	6
Windbreaker (Kuzuia upepo)	7
Firewood (Kuni)	8
Timber and poles (Mbao na vikingi)	9
Reduces speed of flood water (Inapunguza mwendo wa maji)	10
Shade (Kivuli)	11
Other (Nyingine):	12
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

♣**Q79: Did you plant trees thinking that they could help support your livelihood in times of flood? (Wakati ulipanda miti ulikuwa na fikra kwamba itawasaidia kujimudu kimaisha wakati wa mafuriko?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

♣**Q80: In general, how important are trees in supporting your household in times of flood? (Kwa ujumla, miti iko na umuhimu wa kiasi gani kuwasaidia kujimudu kimaisha wakati wa mafuriko?)**					
Not important (Siyo muhimu)	A little important (Muhimu kidogo)	Somewhat important (Muhimu kiasi)	Very important (Muhimu sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

♣**Q81: Did your family have trees on your farm during the El Nino floods? (Familia yako mlikuwa na miti wakati wa mafuriko ya El Nino?)**			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

♣**Q82: If YES, how important were trees to supporting your household during the El Nino floods? (Kama ndiyo, miti ilikuwa na umuhimu wa kiasi gani kuwasaidia kujimudu kimaisha wakati wa mafuriko ya El Nino?)**					
Not important (Siyo muhimu)	A little important (Muhimu kidogo)	Somewhat important (Muhimu kiasi)	Very important (Muhimu sana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

<u>SECTION 6: Wildlife</u>

Q83: Have you experienced wildlife disturbance on your household's farm? (Kwa shamba yenu, mmewahi kusumbuliwa na wanayama pori?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

<u>INTERVIEWER</u>: If **NO**, skip to SECTION 7

Q84: Is there a time of year when wildlife disturbance is more serious or occurs most often? (Kuna wakati uharibufi wa shamba kutokana na wanyama pori inakuwa zaidi ama inazidii?)	
Yes, during dry periods (Ndiyo, msimu wa kiangazi)	1
Yes, during the rainy periods (Ndiyo, msimu wa mvua)	2
No, it is the same throughout the year (Hapana, ni sawa tu kwa mwaka mzima)	3
Other (Nyingine):	4
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q85: What is the most common wildlife that destroys your farm? (Mnyama pori yupi ambaye anakusumbua kwa shamba lako zaidi ya wanyama wengine?) *(Select all that apply)*	
Porcupine (Nungu nungu)	1
Dik Dik (Digidigi)	2
Gazelle (Swara)	3
Monkeys (Nyani)	4
Buffalo (Nyati)	5
Elephant (Tembo)	6
Other (Nyingine):	7
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣Q86: To what extent do wildlife destroy tree crops on your farm? (Wanyama pori wanaharibu kwa kiasi gani mitu yenu shambani?)					
A lot (Sana)	Some (Kiasi)	A little (Kidogo)	None (Hakuna)	Refused to answer (Amekataa kujibu)	Don’t know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

♣Q87: Which types of crops are most effected by wildlife? (Ni mimea ipi inaharibiwa zaidi na wanyama pori?) *(Read choices)*	
Tree crops (Miti)	1
Ground crops (Mimea ya chini)	2
Both the same amount (Yote ni sawa)	3
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣Q88: In case of wildlife disturbance on your farm, do trees help provide income when other crops are destroyed? (Wakati mnasumbuliwa na wanyama pori shambani, miti inawasiaida kupata mapato wakati mimea za chini zimeharibiwa?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don’t know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

SECTION 7: Conflict

Q89: Was your household impacted by the violence and conflicts around 2012? (Familia yenu mliathiriwa wakati wa vurugu, mwaka wa 2012?)			
Yes (Ndiyo)	No (Hapana)	Refused to answer (Amekataa kujibu)	Don't know or cannot say (Sijui ama siwezi kusema)
1	0	98	99

INTERVIEWER: If **NO**, skip this section and end the interview

Q90: How was your household impacted? (Familia yenu mliathiriwa vipi?) *(DO NOT READ CHOICES, Select all that apply)*	
Forced to relocate for a short period of time (less than a month) (Tulihama kwa muda mfupi (chini ya muda wa mwezi moja)	1
Forced to relocate for an extended period of time (more than a month) (Tulihama kwa muda mrefu (zaidi ya mwezi moja)	2
Our buildings were burned (Manyumba yetu ilichomwa)	3
Our buildings were looted (Vitu vya nyumba yetu viliibiwa)	4
Our building were destroyed (Manyumba yetu iliharibiwa)	5
Family member was injured (Mtu wa familia yetu aliumia)	6
Family member was raped (Mtu wa familia yetu alibakwa)	7
Family member was killed (Mtu wa familia yetu aliuawa)	8
Livestock were stolen (Uwizi wa mifugo)	9
Farm produce was stolen or destroyed (Uharibifu wa mazao shambani)	10
Household trees were cut or destroyed (Uharibifu wa miti yetu)	11
Other (Nyingine):	12
Refused to answer (Amekataa kujibu)	98
Don't know or cannot say (Sijui ama siwezi kusema)	99

Q91: How did your household support yourself during this conflict? (Mliwezaje kujimudu kimaisha wakati wa vurugu hiyo?) *(Select all that apply)*	
Aid or relief (Msaada)	1
Help from relatives and friends (Msaada kutoka kwa familia na marafiki)	2
Casual labor (Kibarua)	3
Salaried employment (Kazi ya mshahara)	4
Livestock (Mifugo)	5
Poultry farming (Kufuga kuku)	6
Crop farming (Kilimo)	7
Tree farming (Kilimo cha miti)	8

Small business (Biashara ndogondogo)	9
Charcoal production (Kuchoma makaa)	10
Selling firewood (Kuuza kuni)	12
Other (Nyingine):	13
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣Q92: Did trees on your farm help support your household during this conflict? (Miti shambani iliwasaidia kujimudu kimaisha wakati ya hiyo vurugu?) *(Select all that apply)*	
No (Hapana)	0
Yes, we could harvest produce (Ndiyo, tulivuna mazao)	1
Yes, we could harvest firewood (Ndiyo, tulikata kuni)	2
Yes, we could harvest poles or timber (Ndiyo tuliweza kupata mbao ama vikingi)	3
Yes, we could hide in our trees (Ndiyo, tulijificha kwa miti)	4
Other (Nyingine):	5
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

♣Q93: How important were trees to supporting your household during this conflict? (Miti ilikuwa na umuhimu wa kiasi gani kuwasaidia kujimudu kimaisha wakati wa vurugu?)

Not important (Siyo muhimu)	A little important (Muhimu kidogo)	Somewhat important (Muhimu kiasi)	Very important (Muhimu sana)	Refused to answer (Amekataa kujibu)	Don’t know or cannot say (Sijui ama siwezi kusema)
1	2	3	4	98	99

♣Q94: How did trees help your family after the conflict ended? (Miti yenu iliwasaidia vipi familia yako wakati vurugu ilipoisha?) *(Select all that apply)*	
Trees did not help in any way (Miti haikusaidia kwa njia yoyote)	0
We used trees to rebuild our house (Tulitumia miti kwa kujenga nyumba)	1
Food (Chakula)	2
We sold fruit (Tuliuza matunda)	3
We sold lumber or poles (Tuliuza mbao ama vikingi)	4
Other (Nyingine):	5
Refused to answer (Amekataa kujibu)	98
Don’t know or cannot say (Sijui ama siwezi kusema)	99

Questions For Volunteer:

Q95: Overall, do you think the respondent answered the questions honestly and truthfully?			
Very honest	Somewhat honest	Only a little honest	Not very honest
1	2	3	4

Q96: In your opinion, was the respondent willing and happy to answer the questions?			
Very willing	Somewhat willing	Only a little willing	Not very willing
1	2	3	4

APPENDIX B. SUSTAINABLE LIVELIHOODS APPROACH INDICATOR RESULTS

FINANCIAL CAPITAL

- Salaried job (yes or no)
  - yes = 1, no =0.
  - Salaried job should increase resilience of the household
- Access to a bank account (yes or no)
  - yes = 1, no =0
  - having a bank account means that, as long as they have money there, they could rely on that money in an emergency, making them more resilient to sudden shocks and losses
- Remittances (yes or no)
  - yes = 1, no =0
  - Remittances increase resilience of hh
- Household belongings (# of belongings)
  - there are six potential responses, including none = 0). For the other items, add up how many household items are owned.
  - 1 = .2, 2 = .4, 3 = .6, 4 = .8, 5 = 1
- Livestock (# of livestock)
  - add up, do quantiles or percentages
- Size of farmland (# of acres)
  - total number of acres. From here the surveys were grouped into approximately groups of 66.2 with the following rankings:
  - 0=0, 0.2 = .25-1, 0.4 = 1.25 – 2, 0.6 = 2.5 – 3.5, 0.8 = 4,5,6, 1 = 7 or above
- Ownership of farm equipment (yes or no)
  - for each piece of equipment assign own = 1, 2rent = .66, 3lend/borrow = .33, none =0
  - I deleted sprinklers for both Kinna and Burat because only 1 respondent had sprinklers
  - for Burat I will average tractor, oxen plow, generator, and pipes because all four of those pieces of farming equipment is used regularly in the area. However for Kinna I will only use tractor and oxen_plow because people there do not farm with generators and pipes but canals instead.

HUMAN CAPITAL

- Labor availability (number of hh members between 18 – 55)
  - -- the more household members of prime labor ages the greater the labor ability of the household
  - -I got a count for each value (how many hh have 1, 2, 3, etc). Then divided it into as even as possible groupings to get 1, .2, .4, .6, .8, 1).
  - Math is on excel sheet. 0 =0 , 1= 0.2, 2= 0.4, 3= 0.6, 4,5=.8, 6 and above = 1
- Education (level of education of hh head)
  - no schooling = 0, 8 religious studies = .125, 1 some primary = .25, 2 completed primary = .375, 3 some secondary = .5, 4 completed secondary = .625, 7 adult learning = .75, 5 some university= ..875, 6 university completed = 1
- General health of family (scale of poor to good)
  - 5 point likert scale from good to poor.

- on the scale lets have 1very bad = 0, 2 poor = .25, not poor and not good3 = .5, good4 = .75, and very good5 = 1.

- Health problems impact on ability to practice livelihoods (Scale of no to very much)
  - 4 point likert scale
  - 1 not at all = 1, 2 a little = .66, 3 average = .33, 4 very much = 0
  - the less health problems impact the ability to work the more resilient the household

SOCIAL CAPITAL

- Family living nearby (yes, how close)
  - No 0 = 0, yes 3 = .33, yes 2 area = .66, yes neighbors = 1
  - having family nearby would increase resilience in times of stress, they can rely on family for resources
- Political influence or power (scale of none to a lot)
  - None 1 = 0, A little 2 = .33, Average 3 = .66, 4 a lot = 1
- Participation in groups (# of groups)
  - add together number of groups. This group was bottom heavy with a lot of households either not being involved in a group or only 1 group. After subtracting the households not involved in any groups, I tried to split the groups into equal numbers of about 44. Because the number of hh's involved in only 1 group was so large, I gave every household in one group a .5 ranking. This makes sense because even involvement in 1 group could significantly increase social capital.
  - Therefore, the groups are split up: 0=0, 1=0.5, 2,3= 0.75, 4,5,6,7,8= 1
  - more group participation builds social networks and that helps hh resilience
- Participation in agriculture or tree group group (yes or no)
  - yes = 1, no = 0
- Strength of relationship with neighbors (# of activities)
  - add up number of activities for each household. Divide the rankings into groups of 66 respondents to get the following rankings:
  - 0 = 0, 1,2,3= 0.2, 4 = 0.4, 5,6= 0.6, 7,8 = 0.8, 9 = 1
  - more involvement with neighbors increases social network which helps hh resilience

PHYSICAL

- Normal road conditions (scale of bad to good)
  - 5 point likert scale, very bad to very good
  - 1 very bad = 0, 2 fairly bad = .23, 3 average =.5, 4 fairly good = .75, 5 very good =1
- Rainy season road conditions (scale of good to bad)
  - 4 point likert scale, good to impassable
  - 1 good condition = 1, 2 muddy = .66, 3 bad = .33, 4 impassable = 0.
- Presence of facilities (schools, hospitals, etc) near home (yes or no)
  - add up number of facilities from home. This was fairly top heavy with a large number of households having all 11 things within 3 km of their house. There were no households with nothing, so no households will receive a 0 value. The households were broken up into groups of roughly 66.8 households. The break up is:
  - 0=0, 1,2,3,4 = 0.2, 5,6= 0.4, 7,8 = 0.6, 9,10 = 0.8, 11 = 1

- easier access to facilities should build resilience

- Access to irrigation schemes (yes or no)
  - no = 0, generator, pipes, ditches = 1
- Ownership of farming equipment (yes or no)
  -for each piece of equipment assign own = 1, 2rent = .66, 3lend/borrow = .33, none =0

  - I deleted sprinklers for both Kinna and Burat because only 1 respondent had sprinklers

  - for Burat I will average tractor, oxen plow, generator, and pipes because all four of those pieces of farming equipment is used regularly in the area. However for Kinna I will only use tractor and oxen_plow because people there do not farm with generators and pipes but canals instead.

NATURAL

- Size of farmland (# of acres)
  - total number of acres, figure out percentages or quantiles. See FINANCIAL CAPITAL
- Own farmland (yes or no)
  - bough land 1, inherited land 4 = 1, rent 2, community 3, relative 5, cleared and claimed land 6, and squatting 7 = 0
- Diversity of farm crops (# of different crops planted)
  - add up number of crops owned. There was no one with 0 crops since all the hh's were farmers. There was a big range of number of crops here ranging from 1 to 21 different crop species. I assigned all households with only 1 crop a 0 since they have no diversity. Breaking the rest into groups of about 64.4. gave me the following break up:
  - 1= 0, 2= 0.2, 3,4= 0.4, 5,6,7= 0.6, 8,9= 0.8, 10 and above = 1
  - more diverse farm can deal with more stresses and shocks
- Livestock (# of livestock)
  - add total from all categories. I took away the 13 surveys with 98 and the 97 surveys without any livestock. The other ranking were then aimed to be grouped into 45.8 households per ranking.
  - 0=0, 1=0.2, 2= 0.4, 3=0.6, 4,5=0.8, 6 and above = 1
- Soil erosion (rank of severity of soil erosion on farm)
  - 4 point likert scale
  - 1 a lot = 0, 2 some = .33, 3 a little = .66, 4 none = 1

APPENDIX C: QUALITATIVE CODE BOOK

Qualitative Code Book

Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
Drought	All things drought related	38	774
Impacts of drought	General comments about how droughts impacts the area	29	192
Agriculture productivity decrease	Impacts of drought that cause agricultural production to decrease or stop (mostly due to lack of water)	23	47
Agroforestry, low fruit production or dries up	Impacts of drought relevant to trees drying up or fruit production being low	6	13
Conflict, general	Various types of conflict included here: 1. Farmers and pastoralists over water resources, 2. Farmers and pastoralists over livestock entering farms, 3. Wildlife entering farms, and 4. Cattle raiding.	8	19
Human disease	Negative impacts of drought on human health	3	4
Human hunger	Impacts that include causing hunger or death for humans	11	22
Lack of water in rivers	Water dries up or decreases significantly in local waterways	12	20
Livestock disease	Impacts of livestock diseases during drought	2	3
Livestock hunger, death, relocation	Impacts of drought relevant to livestock relocation, hunger, and death. These impacts are included together because they can be related	22	64
General coping strategies	General statements about livelihoods utilized during drought and ways to cope and survive	30	197
Agriculture, general	Coping with drought through farming	17	38
Agroforestry	Relying on fruit or trees during drought for food or money	3	4
Beekeeping	Beekeeping helping during drought	1	1
Business	Relying on running a business during drought	2	5
Casual labor	Coping with drought through casual, short-term, labor	10	18

Code	Description	Sources (# of interviews)	References (# of quotes)
Charcoal burning	Burning or making charcoal to survive drought	11	29
Cutting crop residue or grass for livestock	Having to use agricultural crop residues for feeding livestock or cutting grass for livestock	4	6
Entering Meru National Park	Entering the park during drought to find fodder for livestock	3	5
Irrigated agriculture	Access to irrigation lessens the impact of drought on agriculture	17	37
Livelihood diversification	Diversifying livelihoods to cope with drought, or how having a diversity of livelihoods helps with drought	4	12
Poultry keeping	Keeping poultry during drought	4	6
Relief food or aid	Institutions, organizations, or the government helping them cope by providing food or aid	12	24
Selling livestock	Selling livestock during drought	3	4
Stock of food or money	Putting away stocks of food or money for times of drought	4	6
Traditional or forest foods	Use of traditional foods during drought	1	2
<u>Trees during drought</u>	General comments about trees during drought with a focus on the benefits of agroforestry during drought	31	316
<u>Benefits of trees during drought</u>	Focused on benefits of trees during drought, how trees help households, or households livelihoods during drought	30	204
Attracts the rain	Trees attract the rain during drought	8	8
Beautification	Trees make the environment look better during drought	2	3
Compost or fertilizer	Trees providing compost or fertilizer during drought	3	4
Construction materials	Utilizing construction materials from agroforestry to cope during times of drought	6	11
Firewood	Trees provide firewood during drought	9	13
Fruit and food	General comments about trees providing food or fruit during drought	17	42
Fruit for children	Fruit specifically providing food for children	6	8

Code	Description	Sources (# of interviews)	References (# of quotes)
Livestock fodder	Trees being used for livestock fodder during drought	7	12
Money for school fees	Trees providing money for school fees	2	3
Money from fruit sales	General comments about trees providing money through fruit sales during drought	16	31
Prevents soil erosion	Trees prevent soil erosion during drought	6	8
Selling firewood	Selling firewood during drought	4	4
Shade for farm	Trees helping to shade the farm	8	13
Shade or cool environment for people	Generally, how nice and cool it is to relax under trees during drought	20	32
Windbreaker	Trees serving as a windbreaker during drought	7	12
Characteristics of drought-important trees	Quotes about characteristics of trees (and specific tree species) that make them useful or important during drought	22	112
Able to plant crops near trees	Being able to plant other crops nearby trees	4	8
Fast production or growth	Trees that grow and produce benefits quickly	3	4
Good production	Trees that produce a lot of fruit during times of drought	1	1
Provide fruit during dry times or year round	Trees provide fruit year round or they provide fruit even during drought times	14	32
Uses less water or drought resistant	Trees that do not use much water or are mentioned to be drought resistent	20	67
Drought is better than in the past	General comments about drought being better, less severe, or less frequent than it used to be	11	20
Drought is worse than in the past	General comments about drought being worse, more severe, or more frequent than it used to be	18	49
Flood	All things flood related	23	493
Narratives of 1997 El Nino	Narratives about the impacts of El Nino 1997 and coping strategies	12	27

Code	Description	Sources (# of interviews)	References (# of quotes)
Did not plant trees with floods in mind	General quotes about people no really thinking or planning for floods when they planted their trees	11	11
Impacts of flood	General statements about the impacts of floods	21	144
Destruction of crops	Floods destroying agricultural crops on farms	23	96
Destruction of property and buildings	Floods destroying physical structures	14	29
Destruction of trees	How floods impact trees on farms	9	18
Destruction of roads or transport	How roads are impacted or how transportation becomes difficult during floods	11	19
Human death	Humans dying or being carried away by flood water	9	13
Human disease	Floods leading to human disease	16	30
Human hunger	Floods leading to human hunger	7	8
Livestock death	Floods leading to livestock death, being swept away by water	8	11
Livestock disease	Floods causing livestock disease	5	6
Livestock hunger	Livestock going hungry during floods	3	3
Price increases of basic goods	Prices of basic goods increasing	1	1
Soil erosion	Floods causing soil erosion	7	13
General coping strategies	General strategies used to cope during times of flood	20	57
Building dams or digging canals	Preventing destruction by floods by digging or building	3	5
Business	Relying on business during times of flood	2	2
Casual labor	Relying on casual labor in times of flood	5	7
Charcoal burning	Relying on charcoal burning during floods	5	11
Crops not destroyed by flood	Relying on agriculture and crops not destroyed by floods	7	9
Livelihood diversification	Relying on a diversified livelihood to support the household during flood	1	1

Code	Description	Sources (# of interviews)	References (# of quotes)
Milk from livestock	Relying on milk from livestock during floods	1	2
Moving	General comments about having to move during times of flood	2	2
Relief or aid	Relying on relief food or aid during floods	6	8
Remittances or help from family or neighbors	Relying on money from family or neighbors during floods	3	4
Selling livestock	Selling livestock during floods to cope	1	1
Stock of food or money	Relying on a stock of food or money to survive during flood	4	5
Trees during flood	General comments about the benefits of trees during flood and characteristics of trees that are helpful during flood	19	168
Benefits of trees during flood	Benefits of trees during flood	19	142
Brings clean air	Trees bringing clean air during flood	3	4
Climb trees to escape floods	Climbing trees to escape flood waters	1	1
Compost	Trees provide compost	1	2
Construction materials, home and sales	Trees helping provide construction materials during times of flood	6	11
Cover from rain	Trees provide shade and cover during flood and rains	5	6
Firewood, home and sales	Trees providing firewood during flood	9	25
Fruit and food	Trees providing food or fruit during flood	18	35
Fruit for children	Tress providing fruit for children during floods	2	2
Medicine	Using trees during floods for medicine to treat illness	1	2
Money from fruit sales	Selling fruit for money during floods	11	25
Prevents soil erosion	Trees preventing soil erosion	12	19

Code	Description	Sources (# of interviews)	References (# of quotes)
Reduces water flow or speed	Trees slowing down water or blocking water from causing destruction	3	4
Windbreaker	Trees serving as windbreakers during floods	6	6
Characteristics of flood important trees	Things about trees that make them important during floods	11	26
Fast or continuous production	Fast, good, continuous production of fruit during floods	5	9
Flood resistant or not easily damaged	Trees surviving when there are floods, being flood resistant	9	21
Perceptions of changes in floods and rain	Comments on changes in floods and rain over the past 10 years	22	86
Floods are better or less frequent	Floods being better than they used to be 10 years ago	20	43
Floods are worse or more frequent	Floods being worse than they used to be 10 years ago	6	6
No change in floods	Frequency and severity of floods have not changed over the past 10 years	2	2
Timing of the rains is changing	Patterns of the rains have changed since 10 years ago	20	32
Timing of the rains is not changing	Patterns in the rains are not changing, they are just as they were	2	3
Do floods or drought have a bigger impact	Answers to the question of if floods or droughts have a bigger impact on livelihoods and households	21	44
Droughts have a bigger impact	Droughts have a bigger impact than floods	18	21
Floods have a bigger impact	Floods have a bigger impact than drought	3	5
Trees that do well during both	Answers to which trees do best during both floods and droughts	14	18
Agroforestry	General comments about agroforestry	42	263
Timber trees still small	Comments about how timber trees have not matured yet and therefore	3	4

	the benefits have not been received yet		
Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
General benefits	General benefits of agroforestry	36	216
Beekeeping	Using trees for hanging beehives for beekeeping	1	1
Make charcoal from trees to sell	Trees being used to make charcoal	2	4
Construction materials	Trees being used for building and construction	19	42
Firewood	Benefit of trees for firewood	19	28
Fruit and food	Benefits of fruit and food	24	37
Fruit for children	Children benefiting from fruit, eating fruit	8	11
Land tenure demarcation	General comments about trees showing that the land is owned	3	4
Livestock fodder	Trees being used for livestock fodder	4	4
Medicine	Trees providing medicine	2	2
Money, general	Trees providing money	14	30
Provides fruit full time and fast	Trees producing fruit quickly or year round	8	9
Selling construction materials for money	Selling construction materials from trees for money	9	12
Selling fruit for money	Selling fruit from trees to earn money	16	21
Shade	Benefits of shade	8	9
Factors preventing tree planting	Comments about things that prevent or hinder tree planting	24	42
Insecure land tenure or security	How people have not planted trees because of insecurity for humans or insecurity of land tenure from the local military base	3	4
Lack of access to seedlings or bags	Lack of materials to plant trees	2	2
Lack of water prevents tree planting	Lack of water preventing tree planting or causing trees to dry up	6	7
People stealing fruit	People stealing fruit from trees	1	3

Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
Pests or disease	Pests or tree diseases preventing trees from growing well	5	5
Previous or current lack of knowledge	Quotes or stories about not knowing about the benefits of trees in the past or how trees were not a traditional culture practice	9	15
Seedlings eaten by livestock	Seedlings being destroyed by livestock	3	3
Small farm size	Farm is too small to plant a lot of trees, not enough land	3	3
Livelihood capitals	Comments relating to the five livelihood capitals	45	290
Financial capital	The livelihood capital financial capital	23	50
Aid or relief	Getting help from aid organizations, not necessarily during flood or drought, but just generally	7	9
On-farm diversification has financial benefits	Having a diversity of activities helps financially	3	3
Trees have improved the household's finances	Having trees has improved the financial resources of the household	15	30
Trees as a store of wealth	Trees storing wealth	6	6
Trees use less money to grow	Trees do not need a lot of money or inputs to grow	2	2
Human capital	The livelihood capital human capital	31	76
Trees do not require much labor or effort	Trees not requiring labor to grow	5	6
Household not meeting on-farm labor requirements	Quotes about putting in effort and hard work on the farm but it is not enough	6	13
Trees help pay for education	Trees helping provide funds to educate family members	6	11
Trees require a lot of labor or effort	Trees requiring a lot of effort to grow	3	4

Code	Description	Sources (# of interviews)	References (# of quotes)
Education or seminars about agriculture	People receiving education or seminars about agriculture and agroforestry	20	35
Children are an important source of agricultural labor	Children are important for helping out on the farm	5	7
Physical capital	The livelihood capital physical capital	33	107
Importance of farm equipment or inputs	Comments about farm equipment, tools, and inputs	5	6
Roads or bridges destroyed or unpassable due to rains	Transportation difficult during rainy season or floods	10	19
Use or importance of irrigation	Quotes about irrigation and irrigation infrastructure	25	56
Conflicts over irrigation or water	Conflicts over irrigation water	1	3
Market for farm and tree produce	General comments about markets for tree products (availability, accessibility, distance)	11	26
Good market or prices for tree crops	There being good markets and/or prices for tree crops	3	5
Poor market or low prices for tree crops	There being poor markets and/or prices for tree crops	3	4
Benefits of selling in groups or bulk	Selling crops in groups or in bulk	3	4
Crops market	General comments about selling agricultural crops at market	6	7
Poor agricultural market in Kinna	How there is no market or very low prices for crops in Kinna	3	6
Natural capital	The livelihood capital natural capital	19	29
Lack of water prevents tree planting	Lack of water prevents tree planting or causes trees to dry up	6	7
Property rights through trees	Planting trees to prove tenure or show land tenure	3	4

Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
River water dries up	Water in the rivers or canals drying up	14	18
Social capital	The livelihood capital social capital	15	28
Social networks important during drought	Statements about social capital or social relationships helping during drought	3	3
Agriculture or tree planting groups	Tree planting groups helping teach people to plant trees	13	22
Merry-go-rounds	Financial-based social groups called merry-go-rounds	2	3
Conflict	General comments about conflict in Burat	23	150
Kenya Army conflict narratives	Conflicts over land with the Kenya Army base neighboring the area	5	10
Other Burat conflicts	Quotes that pertain to conflicts other than with the Kenya Army or the 2013 conflict	1	1
Burat 2011- 2012 conflict	General quotes about the 2011-2012 conflict in Burat	21	139
Narratives of the events and impacts	Quotes talking about what happened and how they were impacted	17	65
General livelihood coping strategies	How people survived during this time	15	36
Relief or aid	Receiving aid to survive the conflict	6	11
Agriculture	Harvesting farm produce	9	13
Savings of money or food	Relying on the bank or savings to survive	3	4
Help from relatives or friends	Receiving assistance from friends, family, neighbors to survive during conflict	3	3
Casual labor	Using casual labor to survive during the conflict	4	5
Trees and conflict	Comments about agroforestry during the conflict	16	38

Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
Trees helping the family during	Trees assisting the family during times of Burat conflict	10	21
Trees helping the family after	Trees helping the family after the conflict	8	10
Trees were cut or dried up during conflict	Trees drying up or being cut by bandits during the 2012 burat conflict	6	7
Wildlife	General comments about wildlife crop raiding	7	51
Trees being more resilient to wildlife	Trees being disturbed less than ground crops by wildlife	3	6
Impacts of wildlife	General comments about wildlife impacting the farm	7	45
Impacts are worse during dry season	Wildlife being more bothersome during the dry season than the rainy season	4	6
Wildlife eating fruit from trees	Wildlife disturbing trees	6	15
Wildlife coming from Meru National Park	Wildlife coming to bother households from Meru National Park	1	1
Wildlife eating farm crops	Wildlife eating farm crops such as corn or vegetables	7	20
Wildlife threatening human safety	Wildlife threatening the safety and wellbeing of humans	2	3
Institutions and Government	General quotes about institutions and government	28	81
Irrigation	Institutions or government helping with irrigation	8	11
Aid or relief	Institutions or government that provide aid or relief	7	9
Agriculture or tree planting organizations	NGOs that have assisted with agriculture or tree planting	18	31
Agriculture or tree planting government Departments, initiatives, or projects	Government assisting in agriculture or tree planting	13	30

Code	**Description**	**Sources** (# of interviews)	**References** (# of quotes)
Historical narratives about agriculture	Narratives about the history of tree planting in Kinna and Burat	15	23
Tree planting has decreased	There being less tree planting now than in the past	7	8
Tree planting has increased	Tree planting has increased compared with the past	11	13
Great Quotes	Comments that address the major research questions	21	33

APPENDIX D: FIELD NOTES AND PHOTOS

Burat

While the entire area of Burat is quite large, the research took place along the two rivers, Isiolo River and Aye Nakore, which run through the area from south to north. Isiolo River is the boundary between Isiolo Town and Burat, and Aye Nakore is farther from town (Figure 1) Burat is a diverse ethnic community with the major ethnicities including Turkana, Borana, Somali, Samburu, and Meru. However, the different ethnicities often live in segregated groups and small centers instead of being completely mixed. While Burat is located in close proximity to Isiolo town, it still has a very rural atmosphere, and the major livelihoods are agriculture and pastoralism. Cattle rustling is a big problem in Burat and many community members have stopped keeping livestock because of it. Additionally, Burat is a hot bed for violence. There were serious conflict in 2011 and 2012 that resulted in relocation, death, and looting in the area. Even during field work there were ethnic clashes between Turkana and Samburu that made part of Burat inaccessible for short periods of time.

Burat is the main agricultural area near Isiolo. While some people still attempt rain-fed agriculture, most farmers rely at least partially on irrigation. This is largely because there are big differences in vegetation growth between the dry and wet seasons (Figure 2). There are pipes that draw water from the rivers that aid in irrigation (Figure 3). Other farmers that live near the river simply rely on their own pipes and generator for irrigation. Most agriculture in Burat is cash crop vegetables such as tomatoes, onions, kale, and spinach. However, on larger farms farmers will plant a wider variety including maize, beans, bell peppers, sugar cane, green grams, French beans, and tree crops. The organization Action Aid has been heavily involved in agriculture in Burat and they helped form two farmers groups: Bidii and Kiitos. Action Aid has provided much of the piping used for irrigation, helped promote French bean farming and connected farmers with the multinational company Finlays, and promoted tree planting in the area. Agroforestry in Burat is shown in Figure 4.

Figure 1. Isiolo River (top) and Aye Nakore River (bottom). The top photo of Isiolo River after the rainy season had started. The bridge pictured is one of only two bridges that cross Isiolo River between Burat and Isiolo Town. This bridge has been rebuilt a few times after being washed away during floods. During the year I spent in Isiolo Town I never saw the water level higher than it is pictured here. The bottom photo of the Aye Nakore River was taken June 2015 during a dry period. The water level here is extremely low and in the background are local women trying to wash clothes in the little water that remains. (Photo credit: Amy Quandt)

Figure 2. Photos of Burat during the dry season (top) and wet season (bottom). Dry season photos were taken August 17, 2014. The wet season photos were taken January 26, 2015. Photo credit: Amy Quandt

Figure 3. Irrigation pipes in Burat. (Photo credit: Amy Quandt, August 17, 2014)

Figure 4. Agroforestry in Burat. Top, right photo is of a big field of papaya trees. Top, left photo shows some dispersed timber trees on the farmland and in the background. Bottom, right photo is a line of papaya trees intercropped with pigeon peas. Lastly, the bottom, left photo is banana trees. (Photo credit: Amy Quandt)

Kinna

Kinna is a small pastoral community down 16km of dirt road from a “paved” road. The majority of the population is from the Borana ethnic group, with a minority Meru population also. Most residents are Muslim. Overall, Kinna is more homogenous than Burat, with most of the community being Muslim Borana. Kinna has a small commercial center at the crossroads where the roads to Maua and Garbatulla intersect. There is a variety of small shops in the commercial center as well as many stands that sell miraa or khat in the afternoon. Kinna is split into Kinna north and Kinna south, each with separate chiefs and offices. Kinna is big enough to have a small hospital and both primary and secondary schools. Most of the agricultural area is in Kinna south, between the center of town and Meru National Park. It is in this area that the majority of the rivers and canals are located. Two of the three rivers flow from Meru National Park directly, and the third is a spring just outside the park fence. There was a wide variety of farming practices taking place including agroforestry, maize cultivation, and vegetable farming (Figure 1). Through a series of canals and ditches water is diverted from the rivers and carried throughout the farming area (Figure 2).

There is a 15 km fence that separates Meru National Park and the Kinna farmland area (Figure 3).   During field visits, we would occasionally see wildlife on the other side of the fence including baboons and elephants (Figure 4). The residents of Kinna appeared to have a strained and troubled relationship with the Kenya Wildlife Service (KWS), who have a small camp in the park just bordering Kinna. During one of our field visits we had to postpone research activities due to a protest against KWS who was accused for making residents suspected of being involved in poaching “disappear”. Following this incident in May 2014 KWS shot at villagers, killing one and injuring 14.

Figure 1. Agroforestry in Kinna. The top photo shows a line of trees along the border of a farm with a fish pond in the foreground. The tree species shown here include *Grevillea robusta*, papaya, mango, and avocado. The bottom photo shows pigeon peas planted in a line with some banana trees visible in the background. (Photo credit: Amy Quandt)

Figure 2. Irrigation canals in Kinna. These photos were taken on September 1, 2014. (Photo credit: Amy Quandt)

Figure 3. Meru National Park fence/boundary during the wet (right, December 7, 2014), and dry seasons (left, September 1, 2014). This photo was taken at where the main road from Kinna Town meets Meru National Park. The fence in the foreground is electric but only on at night. Farms included in this research run along the fence in either direction. (Photo credit: Amy Quandt).

Figure 4. Elephant siting in Kinna at the Meru National Park fence. (Photo credit: Noor Hussein)