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Farmer Perceptions of Climate Change and Variability in Villages Adjacent to the Udzungwa Mountains National Park, Tanzania

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by

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ABSTRACT

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by

Britta Lee Schumacher

Climate change and variability pose incredible challenges to the livelihoods of resource-dependent, smallholder farmers in sub-Saharan Africa. Smallholder farmers are resilient, knowledgeable, and capable of adapting their practices to new and changing environmental conditions. If, however, climatic conditions move outside the range of past experience, farmers may be unable to adapt rapidly enough. As such, farmers across agroecological zones in forested regions of Tanzania may turn to forest resources to supplement and sustain their livelihoods. This makes understanding the current and future vulnerabilities of smallholder livelihoods imperative. One way we can do this is by exploring the environmental and climatic perceptions of smallholder farmers. Several studies have been conducted on farmers perceptions of climate change and variability in semi-arid Tanzania, but little attention has been paid to forest adjacent households across agroecological zones. This study addresses this gap by assessing forest adjacent farmers' perceptions of climate change and variability in one semi-arid, irrigated village and two humid/alluvial plain, rainfed villages in south-central Tanzania. Data collection involved a household questionnaire, which was administered to n = 202 total respondents. This questionnaire was analyzed using qualitative (theme

identification) and quantitative (chi-square, logistic regression) techniques. Results suggest that farmers perceive changes in their environment, including increased temperature, decreased precipitation, and increased incidence of crop pests and diseases. These perceptions differed significantly between the semi-arid (irrigated) and humid/alluvial plains (rainfed) zones, where irrigated farmers are insulated from negative impacts of climate change. Results also demonstrate that farmers' environmental perceptions are strongly associated with their socio-economic, livelihood, and agroecological contexts. This study concludes that there are changes in climate and variability occurring across Tanzania's diverse landscapes, and calls for locally situated, farmer-informed agricultural and livelihood policies that increase resilience in these vulnerable systems.

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1. Introduction

Global environmental change poses incredible challenges to resource-dependent, smallholder farmers in sub-Saharan Africa (Thornton et al., 2008). Of interest in this paper are the global environmental changes posed by *global climate change*. In particular, global climate change in sub-Saharan Africa is projected to increase temperature, change the intensity and timing of the rains (McSweeney, New, & Lizcano, 2010; McSweeney, New, Lizcano, & Lu, 2010; Thornton, Ericksen, Herrero, & Challinor, 2014), contributing to an increase the incidence of pests, and disease, weeds and extreme climatic events (Dai, 2011; Deutsch et al., 2018; Gregory, Johnson, Newton, & Ingram, 2009; Hirabayashi et al., 2013; New et al., 2006; Patterson, Westbrook, Joyce, Lingren, & Rogasik, 1999). The erratic and rapid changes introduced by global climate change to the bio-physical and agroecological context of smallholder systems produce novel socio-environmental pressures (Mbow, Mertz, Diouf, Rasmussen, & Reenberg, 2008; Mora et al., 2015; Schlenker & Lobell, 2010; Schmidhuber & Tubiello, 2007; Thornton, Jones, Ericksen, & Challinor, 2011; Zhang & Cai, 2011) that contribute to increases in migration (Barrios, Bertinelli, & Strobl, 2006; Henderson, Storeygard, & Deichmann, 2017; Marchiori, Maystadt, & Schumacher, 2012), urbanization (Parnell & Walawege, 2011), agricultural expansion (Tilman, 1999), land degradation (Huang, Yu, Guan, Wang, & Guo, 2016) and loss of biodiversity (Hole et al., 2009; IPBES, 2018), as well as increased risks to human health (Patz, Capbell-Lendrum, Holloway, & Foley, 2005) in the form of hunger and malnutrition (Grace, Davenport, Funk, & Lerner, 2012; Kotir, 2011; J. Liu et al., 2008; Schmidhuber & Tubiello, 2007), and civil war and conflict (M. B. Burke, Miguel, Satyanath, Dykema, & Lobell, 2009; Von Uexkull, 2014).

Though smallholder farmers' resilience, knowledge, and capacity to adapt practices to new and changing environmental conditions is well documented, the present scale, both temporal and agroecological, that global climate change poses is unprecedented. If environmental conditions, especially climatic conditions, move outside the range of past experience, as they are expected to throughout the tropics (Battisti & Naylor, 2009; Marshall B. Burke, Lobell, & Guarino, 2009; Fischer, Shah, Tubiello, & van Velhuizen, 2005), farmers may be unable to adapt rapidly enough. For this reason, it is crucial to the development of adequate agricultural and livelihood policy that we understand both the perceived *and* measured impacts of global environmental change, and particularly climate change, in these regions.

Globally, the role and value of farmers' place-based knowledge in designing situated, appropriate intervention strategies has been recognized for decades (Agrawal, 1995; Chambers et al., 1989; Pretty et al., 1999). There is a considerable body of literature regarding the importance of farmers knowledge and perceptions of environmental changes, particularly changes in climate and variability. However, the body of literature regarding climate perceptions across Tanzania's diverse landscape is limited. For instance, several studies have focused specifically on smallholders in semi-arid regions (Kangalawe & Lyimo, 2013; Kihupi, Chingonikaya, Mahonge, Mwalimu, & Memorial, 2015; Lema & Majule, 2009; Lyimo & Kangalawe, 2010; M. Mkonda & He, 2017; Mongi, Majule, & Lyimo, 2010; Nelson & Stathers, 2009; Swai, Mbwambo, & Magayane, 2012). Few studies have explored the perceptions of smallholders in humid and sub-humid regions, particularly those forest adjacent farmers whose mitigative and adaptive strategies have the potential to threaten forest health (Balama, Augustino, Eriksen, & Makonda, 2016). Fewer studies still have compared the perceptions of farmers across agroecological zones (M. Y. Mkonda, He, & Festin, 2018).

Considering the current state of research, the objectives of this study are to: 1) understand the environmental perceptions of farmers; 2) test for differences in environmental perceptions of farmers across agroecological and livelihood zones; and 3) determine the socio-demographic, livelihood, and village characteristics associated with perceptions of environmental change. The aim of this research is to inform research and policies that increase system resilience (both agricultural and ecological) and improve smallholder livelihoods. The study will use a comparative case study approach in the hopes to reveal any influence of site-specific determinants on farmers' perceptions in the Udzungwa Mountains National Park (henceforth referred to as *the UMNP*) region of south-central Tanzania. To our knowledge, this is the first study to date that compares the perceptions of forest adjacent farmers across agroecological zones (henceforth referred to as *AEZs*) in Tanzania, filling an important gap in the literature around these highly vulnerable populations.

This paper is organized as follows: Section 2 discusses global environmental change and its impacts on the lives and livelihoods of farmers in sub-Saharan Africa and Tanzania. Section 3 describes the theoretical perceptions framework that guides our analysis. Section 4 presents the methodology, study area, data, analysis and empirical specifications of our logistic models. Section 5 discusses the results of our analysis. And finally, Section 6 presents the conclusions and policy implications of our work.

2. Motivation and Background

Current scientific knowledge, in conjunction with overwhelmingly negative projections for agricultural production (see Knox et al., 2012 for a review of crop yield futures; Kotir, 2011 for a review of impacts across the agricultural commodity chain; and Thornton et al., 2014 for a review of current impacts and literature), suggest that sub-Saharan Africa is, and will remain, one of the most vulnerable regions to the impacts of global environmental change, and particularly global climate change and variability (henceforth referred to as *climate change and variability*) (Niang et al., 2014). Climate change and variability are among the main factors limiting sub-Saharan Africa's efforts to achieve food security and sustainable livelihoods. This is due in great part to the region's dependence on rainfed agriculture and smallholder's limited capacity to adapt to radically unfamiliar conditions (Thornton et al., 2008). These communities of smallholder's are already vulnerable due to widespread poverty, migration and population change, a heavy disease burden, and limited or degraded arable land (Slingo, Challinor, Hoskins, & Wheeler, 2005). Climate change and variability are threat multipliers, exposing the world's most vulnerable populations to environmental threats that further burden them (Niang et al., 2014).

2.1 Global environmental change: Climate change and variability in Tanzania

Tanzania lies just south of the equator along the Indian Ocean, between 1° and 12°S and 29° and 41°E. The country has a tropical climate that varies annually due to regional, physical heterogeneity and seasonally due to the complex interaction of the Western Indian Ocean, the Intertropical Convergence Zone (ITCZ), the tropical Pacific Ocean, and the Congo air mass (Black, 2005; Black et al., 2003). Average temperatures range from 17°C to 32°C, with the warm part of the year beginning in October and continuing through

February/March, and the cooler part of the year from May to August (Agrawala et al., 2003; Luhunga, Kijazi, Chang, & Kondowe, 2018).

Tanzania experiences two types of rainfall patterns: unimodal and bimodal. These rainfall patterns are influenced seasonally by the migration of the ITCZ, a narrow belt of low pressure that forms at the thermal equator (Barry & Chorley, 2010; McSweeney, New, & Lizcano, 2010). The ITCZ moves southwards in October and reaches southern Tanzania in January/February, returning northwards in March, April and May. This movement causes the relatively wet, highlands region (of interest in this study) to experience two distinct seasonal rains—the short '*vuli*' rainfall season from October to December (OND) and the long '*masika*' rainfall season which starts in March and continues to May (MAM) (Koutsouris, Chen, & Lyon, 2015). The dryer, semi-arid central region (also of interest in this study) experiences one rainy season from February to May. Average annual precipitation ranges from 200 to 2,800 mm across the country, depending on geographic location, and is highly variable. Variability is higher during the *vuli* rains than the *masika* rains and is also high across regions. That said, in general an average of 50 to 200 mm falls each month during the rainy season(s) (McSweeney, New, & Lizcano, 2010; Zorita & Tilya, 2002).

According to the United Nations Development Program, a mean annual increase of 1.0°C was recorded in Tanzania from 1960 to 2006, with most warming occurring during January and February, the dry season following the *vuli* rains (McSweeney, New, & Lizcano, 2010). This is the period of the year when many smallholders in south-central Tanzania find themselves most vulnerable, when stored food supplies and savings have dwindled and most new crops have just been planted. Observations have also demonstrated that annual average rainfall has decreased by 2.8 mm per month (3.3% per decade countrywide over the same period) (*ibid*.).

Climate projections suggest that average annual surface temperatures across Tanzania will rise by 1.5 to 4.5°C by the end of this century (2070-2100) (Goujon, Lutz, & Samir, 2015; Luhunga et al., 2018; McSweeney, New, & Lizcano, 2010; Rowhani, Lobell, Linderman, & Ramankutty, 2011b). Both minimum and maximum average daily temperatures are expected to increase substantially across the country. Projections also suggest that precipitation will become less predictable and increasingly variable over the next century (Conway et al., 2017). The ways in which seasonal patterns will change is complex and not entirely understood. In general, however, the unimodal, semi-arid central region is expected to see a substantial decrease in rainfall (by some estimates, up to 50 percent); and the wetter, central highlands region is expected to see a substantial increase in annual average rainfall (again, up to 50 percent) (Agrawala et al., 2003; Luhunga et al., 2018). There is also strong agreement between models for fewer rainy days and greater rainfall intensity (Conway et al., 2017), whereby the average volume of rain that falls in 5-day rainfall events may increase by nearly 40 mm by 2100 (McSweeney, New, & Lizcano, 2010). These changes in temperature and precipitation, along with associated changes in growing season length and geographic suitability for crop production, will have significant implications for agricultural production and rural farmer livelihoods.

2.2 Agricultural change and livelihood vulnerability

Rural farmer livelihood security depends on successful and stable harvests year after year. This is especially true in regions where smallholder and subsistence farmers, for whom on- and off-farm agricultural production provides the main source of food and income, dominate the agricultural sector. Such is the case in Tanzania, where the vast majority of those participating in agricultural production (three quarters of the population) qualify as

smallholder farmers (Ahmed et al., 2011; M. Y. Mkonda et al., 2018; Rowhani, Lobell, Linderman, & Ramankutty, 2011a). Of these smallholders, nearly all rely on rainfed agricultural production, and thus depend on the timing, intensity, and amount of rainfall for planting and harvesting (Lobell et al., 2008; Rowhani et al., 2011a). Far fewer rely on irrigation technology, which is not widely developed in Tanzania. Unsurprisingly, irrigated communities are less sensitive to climate change and variability due to consistent water availability (Kurukulasuriya et al., 2006).

Of the diverse regions where Tanzanian farmers make their livelihoods, it is widely recognized that those in arid and semi-arid zones are highly vulnerable to the impacts of climate change and variability, especially its impacts on water availability (Niang et al., 2014). Much of the literature has focused on these regions, to the exclusion of farmers in humid and sub-humid zones. However, farmers in humid or sub-humid zones are no less vulnerable; they are simply vulnerable to different *effects* of climate change. This gap must be addressed, and these differential vulnerabilities (Neil Adger, 1999) understood, for the creation of comprehensive resilience building policy.

Smallholder farming in Tanzania often occurs in previously forested or forest adjacent areas, and access to forest resources has long played a role in enabling livelihood adaptation (Robledo, Clot, Hammill, & Riché, 2012). This is certainly the case for the tens of thousands of smallholders that make their livelihoods in the fertile lands adjacent to the highly biodiverse and ecologically important UMNP. Here, access to timber, wild fruits and vegetables, medicines, and small animals helped farmers sustain their livelihoods for decades (Harrison, 2006; Marshall, 2008; Nyundo, Mtui, & Kissaka, 2006). Formal access to these forest resources, resources that insulated farmers from socio-environmental shocks to their livelihoods, was closed to villagers in 2011. As climate change continues to make livelihoods

more vulnerable, farmers may turn again to the vast resource base offered by the UMNP, further threatening forest health. This makes it imperative that we understand how global environmental change, and specifically climate change and variability, impact the livelihoods of these farmers. Increasing system resilience here will not only improve smallholder livelihoods, but also ensure forest health.

A number of regional and national studies have highlighted the impacts of current and future climate change and variability on agricultural productivity and smallholder livelihoods (Adhikari, Nejadhashemi, & Woznicki, 2015; Connolly-Boutin & Smit, 2016; Koutsouris et al., 2015; McSweeney, New, & Lizcano, 2010; Mongi et al., 2010; Shemsanga, Nyatichi, & Gu, 2010; Thornton, Jones, Alagarswamy, & Andresen, 2009). These studies often focus on yields in critical staple grains (e.g., sorghum, maize, rice) as they are the primary source of calories (and cash) for many smallholder farmers. These threats to grain production become especially evident as thresholds of heat and water stress are surpassed (Adhikari et al., 2015; Niang et al., 2014; Slingo et al., 2005). Heat stress during flowering, for example, can reduce grain count and weight, and result in lower crop yield and quality (Bita and Gerats, 2013). Even short periods of heat and water shocks can reduce crop yield substantially, especially when these shocks arrive during critical development stages (Teixeira et al., 2013).

In maize, for example, arguably the most important staple grain grown in Tanzania, each degree day spent over 30°C can reduce yields by 1.7 percent under drought conditions (Lobell et al., 2011; Rowhani et al., 2011). Maize yields are expected to decrease by about 23 percent by 2100 with a warming of 1 to 4°C or a doubling of carbon dioxide (Mwandosya et al. 1998; Jones and Thornton 2003; Rowhani et al. 2011; Thornton and Cramer 2012; Mbungu et al. 2014). Arguably the most important source of calories in the communities around the UMNP is rice, yields of which are also expected to decrease. Projections suggest

that rice yields may decline by 23 percent by 2070 in Tanzania due mainly to a shortened growing season from increases in temperature (van Oort & Zwart, 2017); this is consistent with other estimates suggesting that an increase in temperature of 2°C by 2050 in Tanzania will decrease yields by 19.3 percent (Rowhani et al., 2011a). These and other yield declines will compromise smallholder livelihoods, and in the communities around the UMNP, potentially threaten forest health.

These changes are not just *projected* to occur but have already been documented. Studies across Tanzania, for instance, have found that climatic stress and variability are key factors in reduced agricultural productivity (Lema & Majule, 2009; Slegers, 2008). Thus, it is exceedingly important that current vulnerabilities are understood. One way we can do this is by exploring the environmental and climatic perceptions of smallholder farmers.

Smallholder farmers have extensive knowledge about local environmental and climate conditions and variability (Slegers, 2008; Tengo and Belfrage, 2004). Their intimate and place-based ecological knowledge is constantly evolving, as their livelihoods depend directly on timely and innovative responses to various environmental and climatic stimuli each season. An in-depth understanding of the multiple factors that shape environmental perceptions is a prerequisite for the creation of well-targeted agricultural and livelihood resilience-building policy (Below, Schmid, & Sieber, 2015; Debela, Mohammed, Bridle, Corkrey, & McNeil, 2015). This study seeks to complicate the narrative of differential vulnerability across the aforementioned groups by comparing the environmental and climatic perceptions of rainfed forest adjacent farmers (*high vulnerability*) in the alluvial, humid/sub-humid zone (*low vulnerability*) with irrigated forest adjacent farmers (*low vulnerability*) in the semi-arid zone (*high vulnerability*) around the UMNP.

3. Climate perceptions framework

There is a considerable body of literature regarding how farmers perceive environmental change, including perceptions of: intense rainfall, changes in the seasonality/timing of the rains and drought frequency, changes in temperature and extremes, increased occurrence of landslides, crop pests, thunderstorms, hailstorms, winds, floods and other "natural" disasters. Environmental perceptions drive how smallholder farmers choose which strategies to employ when planting, harvesting, consuming, and adapting (e.g., Abid et al., 2015; Deressa et al., 2011; Elum, Modise, & Marr, 2017; Thomas, Twyman, Osbahr, & Hewitson, 2011); they are often consistent with meteorological station data (e.g., Balama, Augustino, Eriksen, & Makonda, 2016; Chepkoech, Mungai, Stöber, Bett, & Lotze-Campen, 2018), with the caveats of recall bias and a tendency towards exaggeration of severity in more recent events (e.g., Debela, Mohammed, Bridle, Corkrey, & McNeil, 2015; Pauline & Grab, 2018). Adequately responding to the challenges posed by climate change and variability requires knowledge of farmers' environmental perceptions (Fosu-Mensah, Vlek, & MacCarthy, 2012a). Without this knowledge, and without farmer consultation, proposed solutions may not be properly situated and may very well cause undue harm to the smallholders whose lives and livelihoods they seek to improve (Below et al., 2015; Debela et al., 2015).

Different household- and farm-level characteristics influence whether, and to what extent, smallholders perceive climate change and variability and its impacts on local agriculture and livelihoods (Deressa et al., 2011). For instance, the age and residence period (reported number of years living in the study area) of respondents is often indicative of experience as a farmer (Debela et al., 2015) and is closely related to their knowledge about

agricultural experiences and environmental change (Balama et al., 2016). More experienced farmers are often more likely to perceive environmental and climatic changes (Abid et al., 2015; Maddison, 2007). The education of respondents is also associated with increased awareness and perception of climate change (Balama et al., 2016; Deressa et al., 2011; Uddin, Bokelmann, & Dunn, 2017). Thus, we hypothesize that age, residence period, and education will have a positive relationship with perceptions.

Livestock and land ownership are assets to smallholder farmers (Herrero et al., 2010). Chickens, ducks, goats and cattle often act as livelihood 'insurance', providing farmers with a small business venture or a secondary livelihood strategy during thin months. We expect livestock ownership to positively influence climate perceptions. We also expect, as demonstrated in the literature, that land ownership will have a positive relationship with perceptions, considering that land owners may have a deeper understanding of changes on land that they farm consistently (Roco, Engler, Bravo-Ureta, & Jara-rojas, 2015).

The agroecological setting of farmers also influences their perceptions of climate change and variability (Deressa et al., 2011). The infrastructural buffer that irrigation provides farmers in irrigated regions may decrease their sensitivity to the effects of climate change and variability (Kurukulasuriya et al., 2006). Irrigation buffers crops from rainfall shortages and farmers from one of the key determining factors of agricultural success in rainfed zones—precipitation timing and availability. Thus, we predict that both: 1) living in the irrigated zone (semi-arid AEZ) will have a negative effect on climate perceptions (i.e. farmers will not perceive changes); and 2) that farmers across these AEZs will have significantly different environmental perceptions.

We additionally assessed how long-term changes in agricultural shocks may play a role in perceptions. The influence of recent agricultural shocks on perceptions has been

demonstrated in the literature (Teklegiorgis Habtemariam, Gandorfer, Abate Kassa, & Heissenhuber, 2016), but the impact of long-term changes in persistent agricultural challenges has not. Thus, we included farmers' perceptions of drought frequency change, crop pest and disease incidence change, and animal disease incidence change in our final model. We expect that farmers who experienced changes in each of these variables will also be more likely to report changes in the environment.

Smallholder farmers make household- and plot-level decisions based on a combination of historical seasonal calendars, environmental, agronomic and climatic perceptions, and agroecological science. Gaining a deeper understanding of each of these pieces, and how they interact, will be crucial for co-producing (farmers, scientists and policy makers) innovative, place-based policies that support more resilient systems. That said, more empirical studies are needed to understand: 1) who knows what and why; 2) how community-level attributes are associated with individual- and household-level decision-making; and 3) how local knowledge might be integrated with scientific knowledge, to increase resilience in smallholder systems.

This paper addresses one of the aforementioned issues, namely, environmental, agronomic and climatic perceptions. It does so using a place-based case study approach to assess smallholder farmers' understandings of environmental change in villages near the UMNP in south-central Tanzania. This region was chosen to illustrate the perceptions of high-biodiversity, forest adjacent households. Because of their relationship to forests, it is imperative that we understand how global environmental change, and specifically climate change and variability, impacts the livelihoods of these farmers. Increasing system resilience here will not only improve smallholder livelihoods, but also ensure forest health. To be clear, this research highlights the environmental and climatic perceptions of forest adjacent farmers,

but does not seek to explore the past, present, or future relationship of these farmers to the forest. This exploration offers a window into forest adjacent farmers' perceptions in order to inform future research on the human-environmental interactions that determine forest and smallholder health and well-being in this region.

Although the significance of perceptions has been explored extensively in the literature (see Juana, Kahaka, & Okurut, 2013, for a review of the literature in Africa), especially as they relate to meteorological station data and to adaptative strategies, *our understanding of perceptions across agroecological and livelihood zones in forest adjacent households is less well understood*. The focus of this study is not, then, on how perceptions influence adaptation strategies, or how they relate to climatological data. Instead, this paper seeks to elucidate differences in environmental perceptions of farmers across agroecological and livelihood zones near the UMNP in south-central Tanzania.

Currently, a major obstacle in the field is a lack of data with which we can ask questions about differences across these highly vulnerable groups, and a lack of established models through which we can explore them. This project seeks to address this gap in the literature by answering the following research questions:

1) How do forest adjacent smallholder farmers (henceforth referred to as *farmers*) perceive climate change and variability in the UMNP region of south-central Tanzania?
2) To what extent are farmers' perceptions associated with their agro-climatic location?
3) How are socio-demographic, livelihood, and village characteristics of farmers associated with their environmental perceptions?

4. Methodology

4.1 Description of the study site

This research takes place in three villages—Magombera, Mang'ula A and Msosa—in two districts, Kilombero and Kilolo, located in the Morogoro and Iringa regions of south-central Tanzania (see Figure 1). These villages lie adjacent (or nearly adjacent in the case of Magombera) to the UMNP. The park spans over 1,900 square kilometers. It is one of only a few areas with protected status within the Eastern Arc Mountains of Tanzania, conserving and supporting biodiversity and endemism within the Eastern Afromontane Biodiversity Hotspot. These mountains are globally renowned for their high concentrations of endemic species and biodiversity (Bunting et al., 2011; Burgess et al., 2007) and stretch from the Taita Hills of Kenya, southward to the Mahenges of Tanzania (Dinesen, Lehmberg, Rahner, & Fjeldså, 2001). The 13 forest blocks, composing less than a third of the forests' estimated historical extent, are virtually unparalleled in importance for the preservation of biodiversity and endemicity on the African continent (Dinesen et al., 2001; Topp-Jørgensen, Reinhardt Nielsen, Marshall, & Pedersen, 2009).

The Udzungwa Mountains (henceforth referred to as the *Udzungwas*), are the largest block of fragmented forest in the Eastern Arc, covering more than 10,000 square kilometers of moist forest interspersed with grassland, woodland, human settlements and agricultural areas (Burgess et al., 2007). With a total forest area of more than 1,300 square kilometers and altitudinal forest range of 300-2580 meters, the Udzungwas are home to remarkable levels of endemism, which, according to recent studies, are under increasing threat (Burgess et al., 2007; Harrison, 2006; Rovero, Mtui, Kitegile, & Nielsen, 2012). These threats result, in great part, from the proximity of tens of thousands of smallholder farmers to the mountains (Cordeiro et al., 2007).

Magombera Village & Mang'ula A lie in the northwestern part of the Kilombero Valley Floodplain, in the shadow of the Udzungwas, in the lowlands of the Rufiji River Basin. The floodplains of the valley form one of Africa's largest wetland systems and support some of Tanzania's most fertile agricultural lands (Kangalawe & Liwenga, 2005). Rains that fall to the east of the Udzungwas inundate the valley's marshes and swamps seasonally, leaving upland areas dry with only a few annually inundated rivers during the dry seasons following the monsoonal *masika* (MAM) and *vuli* (OND) rains. Lowland areas have saturated soil year-round, attracting many in-migrant farmers.

The floodplain (see Figure 1) is also recognized on the List of Wetlands of International Importance, also known as the Ramsar List, for its international importance in conserving biological diversity (Wilson, McInnes, Mbaga, & Ouedraogo, 2017). These wetlands, like the natural forest and grasslands of the Udzungwas, are under increasing threat from agricultural encroachment, land conversion for agriculture and grazing (Bunting et al., 2011; Wilson et al., 2017).

Msosa Village lies to the north of the UMNP, along the Msosa and Ruaha Rivers, in the Great Ruaha River Wetland of the Rufiji River Basin. To the north of the UMNP, rains fall in a unimodal pattern from February to May, causing the Ruaha and Msosa Rivers to swell and passage to become dangerous (personal communication, Msosa Villager, 14 September 2017). These farmers encounter a unique set of challenges due to the agroecology of the region and their dependence on irrigation for farming. The invasion of agricultural fields by elephants searching for food and water during the dry season is one of the most dangerous of these challenges. Defending farms from elephant invasion keeps many farmers from their homes during these times. While completing field work in September 2017, many farmers walked past camp to their fields at dusk, prepared to defend their crops. In

comparison to the communities on the leeward side of the mountains, relatively little research has been published on the irrigated communities immediately bordering the UMNP to the north, and most of these focus on wetland and forest management (e.g., Mamiro et al., 2014, Munishi et al., 2012). Therefore, research focused on agricultural and climatic experience is novel and necesary in Msosa. At the same time, it is important to consider intensive irrigation's impact on climatic experience and perceptions—the potential 'buffering' effect of irrigation technology on farmer perceptions in Msosa is explored throughout this research.

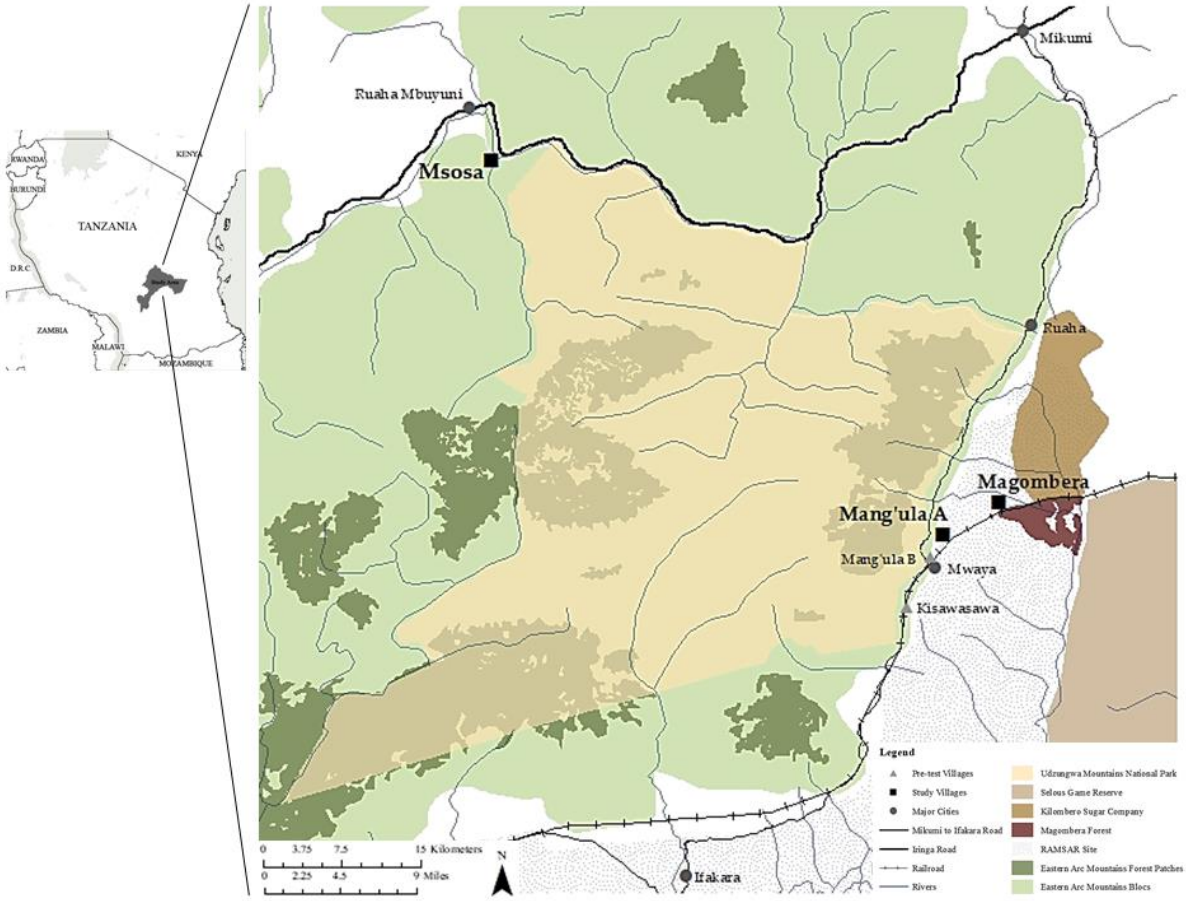

Figure 1. Map of research area. *Source*: Authors elaboration, Open Street Map, Platts et al. (2001), Tanzania National Bureau of Statistics, World Database on Protected Areas (WDPA).

All three study sites lie in the Southern Agriculture Growth Corridor of Tanzania (SAGCOT), which stretches from Dar es Salaam through Morogoro, to Iringa and Mbeya,

and finally to Sumbawanga on the border with Zambia. SAGCOTs mission is to achieve rapid and sustainable agricultural growth through commercialization, intensification, and large scale investment from agribusiness ventures (Herrmann, 2017). This program will have mixed implications for smallholder farmers and their future livelihoods (Serraj et al., 2016), making research on current challenges and perceptions particularly relevant to future agricultural policy.

Three large-scale conservation or agricultural processes/parameters make this specific region interesting. First, all three villages border forested areas of high conservation value. Mang'ula A sits directly adjacent to the UMNP headquarters, Magombera lies against Magombera Forest and Msosa borders the park to the north. Second, all three communities lie within the Rufiji River Basin and depend directly on wetland ecosystem health to support village livelihoods (Rebelo, McCartney, & Finlayson, 2010). In the cases of Mang'ula A and Magombera, villagers rely directly on natural inundation of man-made rice paddies and seasonal rivers, and in Msosa, villagers depend on both gravity and sophisticated pump irrigation schemes from the Ruaha and Msosa Rivers. Third, villagers are all subject to the agricultural policies and investments made under SAGCOT for agricultural growth, development and market integration. These factors will act as constraints on farmers as they continue to adapt their livelihoods in a changing climatic and agricultural context.

Of key interest in this study is the potential for future research that exposes the relationship between villagers and the UMNP. Should climate change shift the viability of local farming livelihoods, which support 96 percent of individuals in the area, it is likely that farmers will adapt their relationship to the park and its resources (Harrison, 2006). Considering the conservation value of this region, both *agroecolgocially* in relation to local smallholder farming and *ecologically* in relation to the Udzungwas, it is important to

demonstrate how farmers here perceive environmental, climatic, and livelihood changes, to begin thinking about potential future impacts and conservation-livelihood strategies.

4.2 Village description

4.2.a Magombera Village

Magombera Village (see Figure 2) lies at 36 º, 56” east; 7º, 49” south on the Kilombero Floodplain in the Kilombero District of the Morogoro Region, just north of the Magombera Forest. This small forest is one of the last remaining tropical lowland forest fragments between the Udzungwas and the Selous Game Reserve, a protected area of exceptional conservation value in south-eastern Tanzania (Gillingham & Lee, 2018). Magombera Forest itself has long been recognized for its exceptional conservation value, as well as for its potential to help connect the Selous to the UMNP. Conservation scientists have demonstrated various threats via encroachment and use of forest resources and are calling for its improved protection (Marshall, 2008).

Magombera Village is isolated from the main road (from Ifakara to Morogoro) by about 6 km of uneven, sometimes impassable (during the *masika* rainy season) dirt road. This location has remained a barrier to market entry in Mwaya and Mang’ula B, small towns with large markets just a 45-minute motorbike ride away. Due to these geographic barriers and mobility constraints during the wet seasons, there have been few opportunities for villagers to accumulate market goods or cash income, which is evident in the relative poverty (as measured by reported annual income, $\bar{x}$ (29) = 235,000 Tsh/$103 USD) of villagers.

Based on fieldwork conducted in 2014, Larry Gorenflo and Mohamed Kambi found 340 occupied households, across three clustered settled areas in the Magombera. Each of these settled areas is small and isolated, interspersed with sparse vegetation, household

gardens '*bustanis*' where vegetables are grown, and small houses constructed primarily of wattle and daub (stick frames plastered with mud) with thatched or corrugated rooves. Most villagers rely primarily on subsistence, rainfed agriculture as their primary livelihood strategy, though many partake in alternative strategies (e.g., livestock rearing, weaving, brewing) to supplement farming.

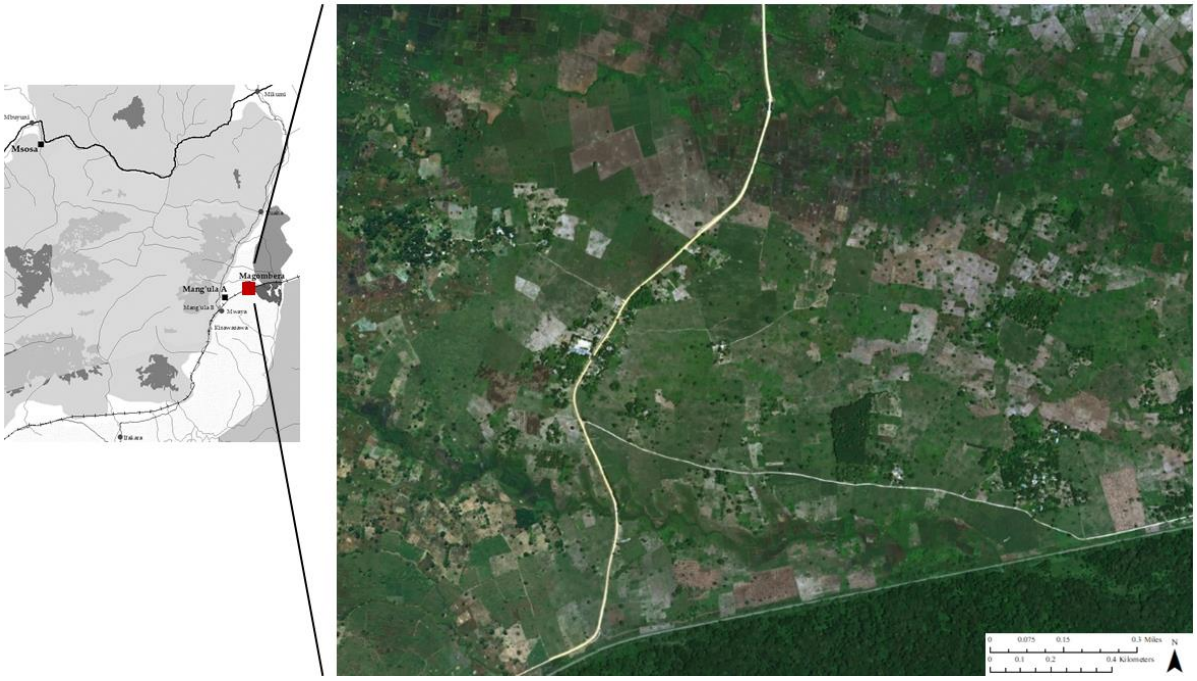

Figure 2. 2018 Satellite Imagery of Magombera Village. *Source*: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, 2018.

The village lies in the lowlands, at about 250 m above sea level (Marshall, 2008; see Table 1). Many farmers grow rice on an annual basis. Elevation, human-made wetland rice paddies, and annually saturated soils in some parts of Magombera Village provide an opportunity to grow rice throughout seasons when rice production is impossible in other nearby villages. This attracts additional in-migrants to Magombera, as well as farmers who live elsewhere but maintain farm fields in Magombera. Agroecologically, the village lies at the transition zone between rice and sugar cane (see Table 1). These crops are grown as

monocultural stands in the large (> 1 acre) plots '*shambas*' that farmers keep on the outskirts of the settled areas. Despite the long daily, and/or seasonal commutes, some farmers purchase or rent land in neighboring villages where land is more affordable.

Just to the northeast of Magombera lands, along the rail line from Dar es Salaam to Capirimposhi, Zambia, the village is bordered by the Kilombero Sugar Company, a subsidiary of Illovo Sugar Africa. Though very little commercial activity exists due to the geography of the region, Magombera's proximity to Kilombero Sugar has motivated some to become small scale sugar cane out-growers. These out-growers receive anywhere from 45-65,000 Tsh (USD $19.71- 28.47) per ton sugar cane produced, depending on market fluctuations, from Illovo for the crop they harvest. While completing field work in September 2017, pre-harvest burns were crackling through the fields, preparing cane for harvesting.

4.2.b Mang'ula A Village

Mang'ula A (see Figure 3) lies at 36 º, 54" east; 7º, 50" south on the Kilombero Floodplain, directly to the east of the UMNP entrance. The eastern side of the national park is comprised primarily of dense mountain forest and borders the main road from Ifakara to Morogoro and Dar es Salaam. Until 2011, the UMNP was the only national park in Tanzania that allowed local people to practice traditional worshipping by collecting dead wood, medicinal plants and grass for thatching (Nyundo et al., 2006). Formal collection has since been entirely restricted in the interest of maintaining park ecological health.

Mang'ula A is one of two villages in the Mang'ula Ward of the Kilombero District. The village is bordered to the south by Mang'ula B (see Figure 3), a sprawling agricultural village with a booming market, and Mwaya, a small town with a large, diverse market economy, and the UMNP to the north and west. In 2014, the village had 880 occupied

households. The village is large, with one main settlement. The settlement consists of mostly homes, kitchens and latrines, many of which are made of brick or wattle and daub, occasionally covered stucco, with corrugated or thatched rooves. Many villagers rely on a mixed wage-subsistence livelihood, where farming is supplemented by other livelihood strategies that produce liquid assets (e.g., owning a small business, participating in microfinance schemes). The influence from the market economy is evident, driving relative economic prosperity (average reported annual income, $\bar{x}$ (73) = 774,000 Tsh/$339 USD), as indicated in the building materials used in houses, piped water and availability of electricity throughout the village.

Table 1. Characteristics of the three case study villages

	Characteristics							
						Main Crops		
Village	Agro-ecological Zone	Altitude (m asl)	Rainy Season	Average rainfall (mm/year)	Temperature extremes (°C)	Food crops	Cash crops	Type of Farming
Magombera	Alluvial plains	250-300	October – May (*vuli*, OND; *masika*, MAM)	1,600-2,000	18.5 – 32.5	Rice, maize, pumpkin leaves	Rice, sugar cane	Rainfed farming in inundated lowlands
Mang'ula A	Alluvial plains	290-315	October – May (*vuli*, OND; *masika*, MAM)	1,600-2,000	16.5 – 31.5	Rice, maize, pigeon peas	Rice	Both rainfed and irrigated, but mostly rainfed farming in lowlands of surrounding villages
Msosa	Semi-arid	510-550	February - May	1,000-1,400	16 – 31	Beans, maize	Onions, beans, ground nuts	Irrigated farming (both gravity and motorized pumps)

Source: Tanzania Meteorological Agency, personal elaboration.
Note: OND = October/November/December; MAM = March/April/May.

The village lies at the transition zone between rice, sugarcane and maize (see Table 1). There is very little room for agricultural activity within the village itself. Most land in the village has been purchased or is rented for settlements and most agriculture has moved away from the settled area. There are still patches of *bustanis* and *shambas* creating a border

between Mang'ula A and Mang'ula B (see Figure 3), but most farmers own plots to the southeast in neighboring villages with more available farmlands. Many fields are inundated and appropriate for rice production seasonally, during the long, *masika*, rains which occur from March to May, but some farmers own or rent land in the lowlands, where rice farming is appropriate all year. Farmers in Mang'ula A plant rice in November/December/January depending on the onset of the *vuli* rains and harvest in April/May/June depending on the time of sowing and type of grain (long/short) planted (personal communication, Mohamed Kambi, 28 August 2018).

Figure 3. 2018 Satellite Imagery of Mang'ula A Village. *Source*: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, 2018.

Mang'ula A lies directly on the main road from Dar es Salaam through Morogoro Town to Ifakara, three large markets where rice can be trucked and sold for cash. Previous research has proposed that its location is partly responsible for rice production's market- rather than subsistence-orientation in Mang'ula A (Mwaseba, Kaarhus, Johnsen, Mattee, &

Mvena, 2007). Additional, moderate commercial activity and entrepreneurial ventures in Mang'ula A are supported by the nearby towns of Mang'ula B and Mwaya.

4.2.c Msosa Village

Msosa Village (see Figure 4) lies at 36 º, 31" east; 7º, 30" south on the northwestern edge of the UMNP. This leeward side of the Udzungwas has tropical dry forest vegetation. Ancient boabob trees lie along the main road from Mikumi to Iringa. This makes the gradual transition from tropical wet to tropical dry forest evident moving west along the Iringa Road, which runs from Mikumi to Iringa (see Figure 1). There are very few settlements along this stretch of highway. Those that do exist are remote and well-removed from the nearest market economies in Mikumi and Iringa. Woven baskets filled with charcoal, onions and stone line settled stretches of the highway, some of the cash 'crops' of the remote area.

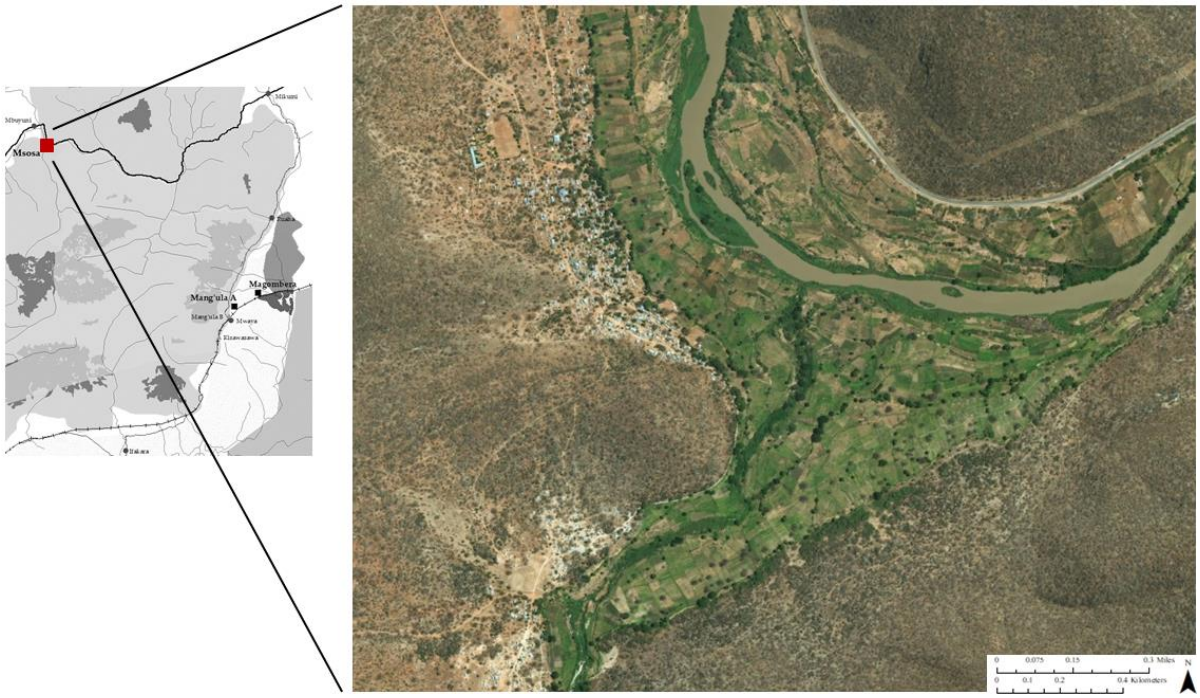

Figure 4. 2018 Satellite Imagery of Msosa Village. *Source*: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, 2018.

When mapped in 2016, the village had 800 households, across two clustered settlements. The first settlement lies to the west of the Great Ruaha River, and the second along the smaller Msosa River, both set back from the rivers' edge by agricultural fields. These settlements are connected to the main highway by a 6 km dirt road that extends from the Msosa Ranger Station for the UMNP to the Iringa Road near Ruaha Mbuyuni. The settlements are sparse, with very little vegetation, consisting mostly of homes made from fired or mud brick or plaster with corrugated or thatched rooves, latrines, kitchens, and communal, raised stalls for storing onions. The settlements are dotted with boabob trees that provide shade during the heat of the day. Unlike Mang'ula A and Magombera, few residents have household *bustanis* as all farming requires irrigation and cannels do not extend to households.

Some of the structures are extensive, with multiple rooms, windows and modern toilets, all evidence of the influences of land ownership and market-oriented production (average reported annual income, $\bar{x}$ (80) = 690,000 Tsh/$302 USD). Msosa Village experiences unimodal rains that dictate cultivation and harvesting strategies, where onions are planted in March/April and again in June/July, beans are planted in April/May and groundnuts are planted in November (personal communication, Mohamed Kambi 28 August 2018). All crops are harvested after three months' time. Most villagers rely on farming as their main livelihood strategy, though many partake in alternative strategies (e.g., retail shops, livestock keeping) to supplement their livelihoods. Unlike Mang'ula A and Magombera, however, villagers primarily grow crops to sell in major markets (primarily Iringa and Dar es Salaam), not for subsistence use. Primary commodities include onions, beans, and ground nuts. Farmers often hold and store cash crops in communal storage facilities for sale during the *thin* months of April and May, when prices are higher and food supplies are low.

4.3 Research approach

To investigate farm-level perceptions of climate change and variability in the greater Udzungwa region, we chose three contrasting study villages that neighbor the UMNP. Local experts were consulted to ensure that the villages selected gave adequate representations of local differences in agroecology, farming systems and climate around the UMNP. By using a comparative case study approach, we hope to reveal the influence of site-specific determinants on farmers' perceptions.

The area surrounding the UMNP is generally characterized by fertile soils and locally distinct and historically reliable, microclimatic conditions (Harrison, 2006). In recent years, however, farmers have reported more variable rains, decreased soil fertility and environmental degradation (personal communication, Mang'ula A Village Council, 12 June 2014). These make farming, the main livelihood strategy of village dwellers, a challenge. To understand these dynamics near the UMNP, research sites were selected by assessing AEZs, dominant livelihood situation and microclimatic conditions to identify the most representative villages for the socioeconomic and biophysical conditions of their respective districts. The three study villages, Mang'ula A, Magombera and Msosa border (or nearly border in the case of Magombera) the UMNP.

Mang'ula A and Magombera lie in a sub-humid/alluvial and Msosa in a semi-arid AEZ (see Table 1). A combination of the agroecological and climatic conditions in each village determine production potentials, which, in great part, dictate livelihood security. Agroecologically, Mang'ula A and Magombera represent systems of relatively high production potential and Msosa represents a system of low agricultural potential. However, Mang'ula A and Magombera rely almost entirely on rainfed production, while Msosa Village relies on pump and gravity irrigation, which provide reliable access to water throughout the

growing seasons. Changing climatic conditions will invariably impact agricultural production and farmer livelihoods, considering the precipitation/water and temperature dependence of farmer livelihoods; however, irrigated farmers are likely to be insulated from these changes until water sources are dramatically affected.

4.3.b Data collection

All villages were mapped by Professor Larry Gorenflo, of The Pennsylvania State University's Landscape Architecture Department and Mohamed Kambi, Gorenflo's data coordinator housed at the Udzungwa Ecological Monitoring Center, using GeoEye1 satellite imagery. Using community mapping techniques (Fahy & Cinnéide, 2009), all structures from the satellite imagery and any additional structures were labeled in the field (e.g., latrine, kitchen, house, onion storage) and coded into a GIS. Magombera and Mang'ula A Villages were mapped in 2014 and Msosa Village was mapped in 2016 (see Figure 5, for research timeline). All study samples for the present project were taken from these original village-level surveys by Gorenflo and Kambi using a 10% random spatial sample of all occupied household structures.

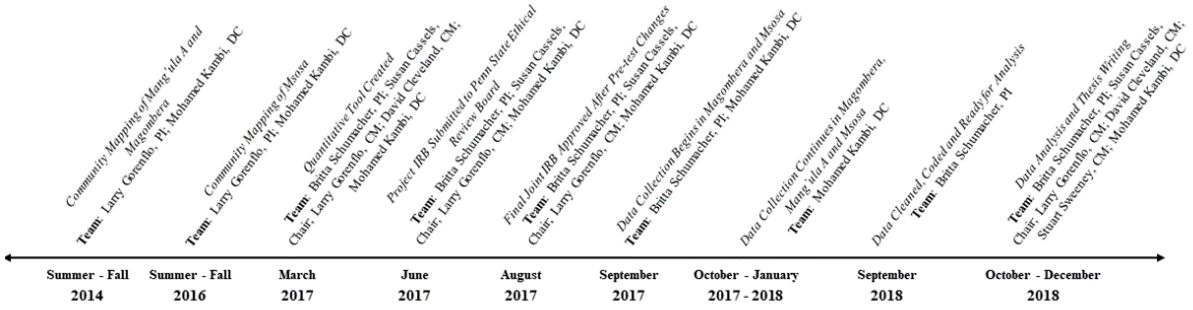

Figure 5. Timeline depicting the series of events and teams that made this research possible, including: Susan Cassels (MA committee chair); Larry Gorenflo (MA committee member; PI of IRB, and PI for community mapping and sampling methodology); Mohamed Kambi (full-time data coordinator and interpreter on this project, and on Gorenflo's community mapping project); David Cleveland (MA committee member); Stuart Sweeney (MA committee member).

Note: PI ~ Principle Investigator; DC ~ Data Coordinator; Chair ~ MA Committee Chair; CM ~ MA Committee Member

The primary instrument for data collection was a household questionnaire survey, which was administered to 202 total households in Magombera (n = 34), and Mang'ula A (n = 88),

and Msosa (n = 80) Villages. As a few interviews were interrupted due to sickness or weather, and a few respondents were not farmers (either as their primary or secondary livelihood strategy) the total sample size for analysis was n = 194 (Magombera (n = 33), Mang'ula A (n = 81), and in Msosa (n = 80)). Depending on missing data, respondents were removed completely from certain analyses; this accounts for all n less than 194 (e.g., n = 150 in the logistic analysis).

The household was used as the primary unit of analysis because decisions about production, consumption and on- and off-farm investments are primarily made at the household level (Thomson and Metz, 1998). The household survey was conducted from September 2017 to January 2018 in two-steps, where a pre-test (n = 10) was followed by actual data collection. Mohamed Kambi, Gorenflo's data coordinator who is both fluent in Swahili and English as well as aware of local customs and practices, was hired to conduct and translate the household surveys in all three study villages. Before interviews were carried out, Kambi contributed to the survey instrument by offering advice about questioning and translation. Before the survey was finalized and again after the survey was approved by the Institutional Review Board (IRB) at Penn State, Kambi and the Principal Investigator of this project (Britta Schumacher) worked together (iteratively) to understand the purpose of each module (1. Demographic; 2. Environmental perceptions; 3. Agricultural production and change; 4. Migration), individual questions, and ethical considerations. The survey instrument was administered in Swahili. Each survey contained 94 questions and took an average of 75 minutes to complete.

The fully structured questionnaire was designed after a review of the literature regarding farmer perceptions of climate change and its impacts on agriculture and livelihoods (see literature review, above). The tool gathered information on socioeconomic

characteristics, migratory behavior, crop management techniques and climate perceptions in the study area. The initial instrument was pre-tested in the neighboring villages of Kisawasawa and Mang'ula B (see Figure 1) to identify and address potential problems (e.g., confusing questions) and to ensure that questions were relevant to local circumstances and practices. The tool was adjusted accordingly.

After receiving IRB approval (August 31, 2017) for the revised questionnaire, administration began in Magombera Village. The survey was administered to the first eligible household member (n = 1 per household, in all cases), regardless of their status as head of household. We recognize the importance of the household head in decision-making, but because the interviews took place within the growing season and many household heads were already gone to their *shambas* by the time interviews began, this could not be avoided. We do not see this as a significant limitation to our study, considering the primary focus of this research is farmers' perceptions of climate change and variability, not the strategies farmers' employ, or decisions farmers' make to adapt to, or mitigate its impacts both on and off the farm.

4.4 Survey data analysis

Quantitative data were compiled and analyzed using R. Farmers were asked to report their understandings of both long-term (over the course of their lifetime/residency in the region) and recent (over the course of the previous year) changes in climate and variability. Percentages and frequencies were used to represent farmers' perceived changes in temperature and rainfall, as well as perceived effects of a changing and more variable climate. Qualitative data were collected during the climate module of the structured questionnaire. Farmers were asked to explain their responses to the standardized module

questions. These explanations were recorded verbatim in the notes section of the paper-based survey for each respondent.

4.4.a Qualitative data analysis

Qualitative data collected during the climate module of the structured questionnaire were translated directly from Swahili to English during questionnaire administration by Kambi (i.e. Kambi wrote all farmers' responses in the notes section as direct quotes, in English). These responses were studied repeatedly and systematically assessed via theme identification, whereby farmer responses were coded and grouped into themes (e.g., years ago it was cold enough to need jackets and blankets at night and in the morning, but not anymore; all farms must now use pesticides and herbicides to harvest any yields). These themes, with examples of quotes from respondents, which depict the similarities and differences in perceptions of farmers across the three study villages, are presented in tabular form (see Table 4).

4.4.b Chi-squared test

Chi-squared tests were performed to test for associations between farmers' perceptions of environmental change and their AEZ. In all cases, the more conservative Fisher's exact test was paired with the chi-squared test for significance. Only chi-squared test statistics are reported as the tests yielded similar results. Each pairing tested the following hypothesis for a given perception variable:

H_0: There is no relationship between farmers' perceptions of *X* and their AEZ.

H_A: There is a statistically significant relationship ($p < 0.05$) between farmers' perceptions of *X* and their AEZ.

4.4.c Logistic regression

During the environmental perceptions module of the questionnaire, farmers' perceptions on past climate trends were recorded as categorical data (see Table 2 for an example). For our analysis, the categorical variables of past perceptions (perceptions of temperature change during the day, perceptions of *masika* rains volume change, and perceptions of changes in household hunger) were converted to binary variables to assess factors associated with these perceptions. The binary perception variables were thus created to represent whether a respondent perceives environmental change (1 = perceived environmental change) or does not (0 = no changes perceived).

We assessed perceptions over the residency of respondents, which varies from one to sixty-nine years ($\overline{x}$ ~ 17 years). We recognize this variability as a limitation of our chi-square analysis, but, because residency is included in the logistic model, we are controlling for the variability in perceptions introduced by varying residency length.

The outcome variables on perception are as follows:

1. Whether a farmer perceived changes in daytime temperature (either increased or decreased) over their residency,
2. Whether a farmer perceived changes in *masika* rainfall volume (either increased or decreased) over their residency,
3. Whether a farmer perceived changes in hunger (either increased or decreased) over their residency.

Table 2. Summary of questions that address the variables used to create a logistic regression for climate perceptions of forest adjacent farmers' across three villages in south-central Tanzania

		Agroecological Zone (AEZ) (n = 150)			
		Alluvial Plains (n = 89)		Semi-Arid (n = 61)	
(a) Dependent variables Question	Answer Options	Magombera (n = 23)	Mang'ula A (n= 66)	Msosa (n = 61)	Total
Perceptions of temperature change during the day					
	Increased	73.9	87.9	59.0	*74.0*
	Decreased	4.4	0	0	*0.7*
	No change	21.7	12.1	40.1	*25.3*
Perceptions of *masika* rains volume change					
	Increased	4.3	0	1.6	*1.3*
	Decreased	60.9	92.4	47.5	*69.3*
	No change	34.8	7.6	50.8	*29.3*
Perceptions of hunger change	Increased	65.2	51.5	29.5	*44.7*
	Decreased	8.7	6.1	1.6	*4.7*
	No change	26.1	42.4	68.9	*50.6*
(b) Independent variables Question	Answer Options				
Sex	Female	65.2	37.9	55.7	*49.3*
	Male	34.8	62.1	44.3	*50.7*
Age	In years (median)	50	37	38	*38*
Education	At least primary	47.8	68.2	75.4	*68.0*
	None	52.2	31.8	24.6	*32.0*
Residence	In years (median)	30	10.5	5	*9.5*
Livestock ownership	Yes	73.9	72.7	65.6	*70.0*
	No	26.1	27.3	34.4	*30.0*
Land ownership	Rent	13.0	22.7	37.7	*27.3*
	Own	87.0	77.3	62.3	*72.7*
Agroecological zone	Semi-arid	-	-	*n* = 61	n = *61*
	Alluvial Plains	*n* = 23	*n* = 66	-	n = *89*
Summary yield variable	Small	73.9	19.7	14.8	*26.0*
	Average	21.7	47.0	55.7	*46.7*
	Large	4.4	33.3	29.5	*27.3*
Perception of crop pests and disease incidence change	Increased	95.7	90.9	54.1	*76.7*
	Decreased	0	0	0	*0*
	No change	4.3	9.1	45.9	*23.3*
Perception of drought frequency change	Increased	87.0	42.4	60.7	*56.7*
	Decreased	0	0	0	*0*
	No change	13.0	57.6	39.3	*43.3*
Perception of animal disease change	Increased	95.7	92.4	86.9	*90.7*
	Decreased	0	0	0	*0*
	No change	4.3	7.6	13.1	*9.3*

Note: Summaries given as percentages, medians or *n*

We investigate how a set of demographic, economic, agroecological and other relevant variables influence farmers' perceptions on each of the above categories of change via a logistic regression (see Equation 1, below) whose general form is:

Equation 1. General form logistic model

$$\text{LogOdds(Perception)} = \beta_0 + \beta_1(\text{Sex}) + \beta_2(\text{Age}) + \beta_3(\text{Education}) + \beta_4(\text{Residence}) + \beta_5(\text{Livestock Ownership}) + \beta_6(\text{Land Tenure}) + \beta_7(\text{AEZ}) + \beta_8(\text{Summary Yield Variable}) + \beta_9(\text{Crop Pests and Disease Incidence}) + \beta_{10}(\text{Drought Frequency}) + \beta_{11}(\text{Animal Disease Incidence}) + \varepsilon$$

In selecting explanatory variables for the analysis, we considered and prioritized variables considered in the literature review section of this paper (see Table 2). In addition to the variables previously mentioned, we assessed whether and how perceptions of agricultural shocks and agricultural yields relate to environmental perceptions. Here, we define agricultural shocks as any changes that had a large effect on agricultural production in the past, including drought, incidence of crop pests and diseases, and animal diseases. We derived the agricultural yield metric from farmers' self-reported agricultural yields (during the previous year). These yields were reported by respondents in bags (a Tanzanian measure equivalent to 6 to 10 *debe*), *debes* (a Tanzanian measure equivalent to 18 to 20 kilograms), or kilograms. These yields were then coded as kilograms and categorized as small (below first quartile), average (between first and third quartile), and large (above third quartile) as related to agricultural yields reported by other farmers for the same crop. If a respondent farmed more than one crop type, the largest coded yield was used as the summary yield variable in the logistic model. In other words, if Farmer A harvested *both* maize and rice, and they had an *average* yield in comparison to other maize farmers, but a *large* yield in comparison to other rice farmers, Farmer A is coded as having a large yield in the logistic model under the variable for yields (this is their 'summary yield variable'). We included this variable as a measure of relative agricultural productivity. An example of the process can be found below in Figure 6.

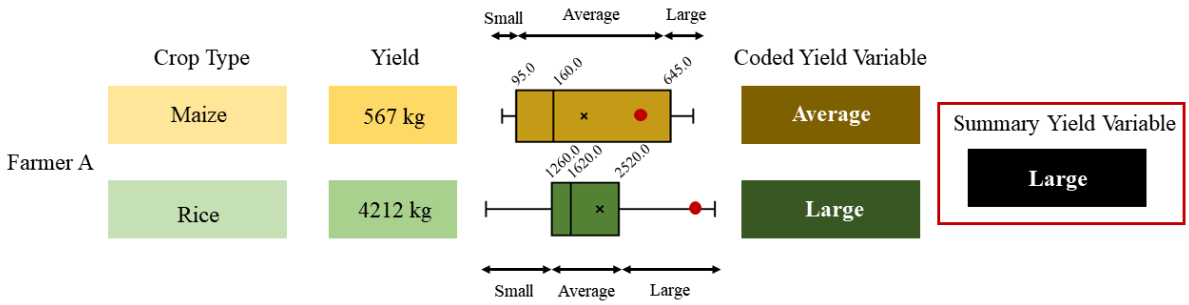

Figure 6. Example of cleaning and coding process for the author's own elaborated agricultural yield metric, where agricultural yields of farmers are compared to yields of the same crop across villages and assigned a coded *summary* yield variable.

The specific explanatory variables included in the model are presented and explained in Table 3. We hypothesize that farmers' perceptions relate to demographic, economic, agroecological and agricultural shock variables as per the expected effects identified in Table 3.

Table 3. Description of variables used to create a logistic regression for climate perceptions of forest adjacent farmers' across three villages in south-central Tanzania

(a) Outcome variables	Description	
Perceptions of temperature change during the day	Dummy variable = 1 if the respondent perceives changes, otherwise 0	
Perceptions of *masika* rains volume change	Dummy variable = 1 if the respondent perceives changes, otherwise 0	
Perceptions of hunger change	Dummy variable = 1 if the respondent perceives changes, otherwise 0	
(b) Independent variables	**Description**	**Expected Effect**
Sex	Dummy variable = 1 if female, otherwise 0	*(-)*
Age	Age of respondent (continuous)	*(+)*
Education	Dummy variable = 1 if respondent attained at least primary education, otherwise 0	*(+)*
Residence	Period of residence of respondent (continuous)	*(+)*
Livestock ownership	Dummy variable = 1 if respondent owns livestock (chickens, goats, ducks, sheep, cattle), otherwise 0	*(+)*
Land tenure	Dummy variable = 1 if respondent rents agricultural land, otherwise 0	*(-)*
Agroecological zone	Dummy variable = 1 if respondent lives in the semi-arid region, otherwise 0	*(-)*
Agricultural yield	Categorical variable of agricultural yield (coded 0 = average yield, 1 = large yield, 2 = small yield)	*(- / +)*
Perception of crop pests and disease incidence change	Categorical variable of perception (coded 0 = no change in incidence, 1 = incidence increased)	*(+)*
Perception of drought frequency change	Categorical variable of perception (coded 0 = no change in frequency, 1 = frequency increased)	*(+)*
Perception of animal disease change	Categorical variable of perception (coded 0 = no change in incidence, 1 = incidence increased)	*(+)*

The influences of the explanatory variables on the outcome variable are summarized using odd ratios (ORs) which is the ratio of the odds of an outcome level (perceived changes) relative to a reference outcome level (no perceived changes). We can think of this model as identifying characteristics of individuals that influence environmental perceptions, and the coefficients produced as representing the direction each variable shifts the outcome, if all else is held equal.

5. Results and discussion

5.1 Farmers' perceptions of changing climate and variability

Forest adjacent farmers near the UMNP have perceived notable changes in climate and variability across the three study villages. These perceptions are assessed at the household and village scales, as well as across AEZs. Farmers across AEZs reported noticeable changes in temperature. In the alluvial plains, for example, farmers agreed that temperatures were much higher throughout the day, and especially during the dry season from July to October. They also reported that temperatures in the morning were once quite cold, but that they no longer need a jacket in the morning or blankets at night because the temperatures have increased so dramatically (Table 4). Approximately 65 percent of all farmers perceived an increase in morning temperature, while only four percent perceived a decrease in morning temperature. The perceptions of farmers differed significantly (p = 0.002) between the alluvial plains and semi-arid AEZs, however (Table 5). An equal proportion of farmers perceived temperature as increasing and remaining the same in the semi-arid zone, whereas farmers in the alluvial plains were much more likely to perceive temperature as increasing. Changes in temperature may be less obvious in irrigated zones because irrigation mutes its negative effects on irrigated crops (Kurukulasuriya et al., 2006).

The majority of farmers also perceived an increase in daytime temperature. Farmers in Msosa noted how "hot the sunshine is these days" compared to when they were young, as did farmers in Mang'ula A (Table 4). Despite this common theme, there was a significant difference between farmers' perceptions across AEZs (p < 0.001). In the semi-arid zone, similar proportions (56 and 44 percent, respectively) of farmers perceived daytime temperature as increasing and not changing, whereas over 80 percent in the alluvial plains

Table 4. Respondents statements on environmental change parameters

	Characteristic			
Village	Temperature	Precipitation	Drought and Drying Rivers	Pests, Disease and Other Changes
Magombera				
Amount and frequency	Before there was extreme coldness in the morning, this has disappeared until AMJ It is especially hot in the evening throughout JASON	Long rain volume has decreased	Increased drought frequency	Every crop is now attacked by disease (Rice, maize, pigeon peas); no crop is disease free
Duration and intensity	We receive too much sunshine these days We cannot sleep with blankets anymore, it is too hot during the evening	Long rains used to secede in June, but now they stop in May	During the dry season (JASO) many rivers are completely dried out	There are more crop diseases than ever before; they are resistant to pesticides
Variability and change	Temperature has increased sharply in the morning & remains high in the evening The sun seems to rise early nowadays, with stronger heat happening during the day	Long rains are erratic and come in a very short period with high volume that destroys crops	Much less water in the rivers compared to years past Little and sporadic rains leading to drought in the valley, it was never like this before	We must use pesticides and herbicides with every crop to get reasonable yields More livestock disease outbreaks than ever before; chickens are experiencing more disease than other animals There has been massive tree cutting in the valley and increasing bare land
Mang'ula A				
Amount and frequency	Increased heat in the morning and evening, especially during the dry season (JASO)	Long rain volume has decreased	Higher occurrence of drought than ever before The severity of rivers drying has intensified	Increased occurrence of crop disease in cash and food crops; rice, sugar cane, legumes, greens and other crops are more affected than ever before
Duration and intensity	We used to need jackets in the morning, but now it is too hot Only cold in the evening in MJ, all other times we do not need to sleep with blankets	----	Many farms have been converted to dry and barren land due to drought and little rains	Crops are highly attacked by diseases and pests that are resistant to pesticides and herbicides Chickens are the most affected, but goats, cattle and ducks are also suffering from disease; many are dying without medicine
Variability and change	Increased temperature in the morning and rapid increase in the sun's heat at noon than when we were young The sun starts rising earlier in the morning	The long rains have become more sporadic and unpredictable When we were young it would rain very hard, but not anymore	During the dry season nowadays, many crops are dying out in the fields Lower water levels in rivers during the dry season than ever before	Many years ago our elders used to get high yields from a small parcel of land, not nowadays There has been massive deforestation in recent years
Msosa				
Amount and frequency	Increased temperature in the morning	Long rain volume has decreased; rains are not coming as they used to some years back	Increased drought frequency	Increased occurrence of crop disease and animal disease; especially attacking onions and beans, triggering lower yields
Duration and intensity	We are receiving too much sunshine at noon, which makes temperatures hot during the evening	Little and sporadic rain	Long dry spells, due to little rain and high sunshine During the dry season JJASON the volume of water in the Msosa and Ruaha is much lower than when we were young	We must spray our onions twice per week, otherwise we will get no yields due to pests and diseases; this is very expensive Goats and chickens never had to be treated before, but nowadays vaccines are necessary to keep them alive
Variability and change	The heat from the sun is higher nowadays than ever before	We are receiving less rain than ever before We see rains coming in months that are not typical	We now have a prolonged dry season as compared to years back	We used to plant crops without using any pesticides, but now we must use them to get any yields There has been a massive use of pumped water for irrigation

perceived daytime temperatures as increasing (Table 5). Studies across Tanzania have demonstrated similar findings (e.g., Balama, Augustino, Eriksen, & Makonda, 2016; Below, Schmid, & Sieber, 2015; Kangalawe & Liwenga, 2005; Kihupi, Chingonikaya, Mahonge, Mwalimu, & Memorial, 2015; Lema & Majule, 2009; Mayala et al., 2015; Mnimbo,

Mbwambo, Kahimba, & Tumbo, 2016; Mongi, Majule, & Lyimo, 2010; Msalilwa, Augustino, & Gillah, 2013; Swai, Mbwambo, & Magayane, 2012). In the Great Ruaha River Sub-Basin, for example, farmers observed an increase in average temperature (Pauline & Grab, 2018). In Mkonda et al.'s 2018 study, 57 percent of respondents in the Mang'ula Ward (of which Mang'ula A is a part) perceived temperature as increasing (M. Y. Mkonda et al., 2018).

Farmers in all three villages also reported changes in the amount of rainfall during the *masika* rains. Farmers in both the alluvial and semi-arid zones perceived that the volume of rains had generally decreased over the years, but there was a significant difference across AEZs ($p < 0.001$). In the alluvial plains, nearly 83 percent of farmers reported the volume of rains as decreasing, while only 49 percent of farmers reported the same in the semi-arid region. In general, this finding is consistent with the literature in Tanzania (Kangalawe & Lyimo, 2013; Kihupi et al., 2015; Lyimo & Kangalawe, 2010; M. Y. Mkonda et al., 2018; Mongi et al., 2010). However, Balama found that farmers in the Kilombero Valley reported increased rainfall, despite a shortened rainy season (Balama et al., 2016). It is important to note that in this study, all farmers in the semi-arid region use gravity and pumped irrigation to water their *shambas*. Because the Msosa and Ruaha Rivers are a constant source of ample irrigation water, farmers in the semi-arid region are not dependent on the rains for successful harvests and may be less cognizant of year-over-year variability and/or changes in rainfall volume. Thus, reliance on irrigation may very well explain the significant difference in farmers' perceptions between AEZs.

In addition to changing volume, many farmers expressed that the long rains had become erratic and unpredictable. It is notable that many farmers observed the rains as more variable, with clear changes in rain onset and cessation. These findings are consistent with

studies across Tanzania where respondents reported delays in the onset of the rains (Balama et al., 2016; Lema & Majule, 2009; Lyimo & Kangalawe, 2010), early cessation of the rains

Table 5. Percentage distribution and correlation between forest adjacent farmers' perceptions of climate and agroecological zone across three villages in south-central Tanzania

	Agroecological Zone (AEZ)			
Perception	Alluvial Plains %	Semi-Arid %	Total %	X^2 (*p*-value)
Morning temperature				***n* = 192**
Increased	74.1	52.5	65.1	12.14***
Decreased	4.5	2.5	3.6	(0.0023)
No change	21.4	45.0	31.3	
Daytime temperature				***n* = 192**
Increased	83.0	56.3	71.9	18.32***
Decreased	0.9	0.0	0.5	(0.0001)
No change	16.1	43.7	27.6	
Evening temperature				***n* = 193**
Increased	49.6	52.5	50.8	5.14
Decreased	6.2	0.0	3.6	(0.0764)
No change	44.2	47.5	45.6	
Sun's heat				***n* = 191**
Increased	78.6	70.9	75.4	1.09
Decreased	0.0	0.0	0.0	(0.2965)
No change	21.4	29.1	24.6	
Long rainy season: volume				***n* = 186**
Increased	2.7	2.7	2.7	24.13***
Decreased	82.3	49.3	69.3	(<0.0001)
No change	15.0	48.0	28.0	
Long rainy season: onset				***n* = 158**
Early	63.7	87.7	71.5	11.24***
Late	36.3	12.3	28.5	(0.0008)
Long rainy season: cessation				***n* = 152**
Early	55.4	69.8	59.7	3.25
Late	44.6	30.2	40.3	(0.0714)
Long rainy season: variability				***n* = 124**
Greater variability	52.3	89.2	63.2	13.72***
Less variability	47.7	10.8	36.8	(0.0002)

Note: *** and * indicate a statistical significance at $p < 0.01$ and $p < 0.05$ respectively

(Balama et al., 2016), a shortened growing season (Kangalawe & Lyimo, 2013; Kihupi et al., 2015; Lyimo & Kangalawe, 2010), fewer rainy days and higher rainfall intensity (Balama et

al., 2016; Below et al., 2015; Pauline & Grab, 2018), and general unreliability of the rains (Below et al., 2015; Lema & Majule, 2009; Mayala et al., 2015; M. Mkonda & He, 2017; M. Y. Mkonda et al., 2018; Mnimbo et al., 2016; Msalilwa et al., 2013; Pauline & Grab, 2018; Swai et al., 2012). More than half suggested that the rains were beginning and ending at different times than they had in years prior, reporting complications for agricultural production. For example, in Magombera, farmers reported that the rains used to end in June, but now they stop in May; and in Msosa, farmers felt that the rains were coming in months that were not typical. Pauline and Grab's study in Ruaha Mbuyuni, just 6 km from Msosa village, found meteorological evidence for a shortened growing season (Pauline & Grab, 2018). Crops in this region each take about three months to mature. Thus, a shortened growing season has the potential to decrease agricultural production, despite irrigation technology. Farmers generally agreed that the rains were beginning and ceasing earlier than in years past, though there was a significant difference between farmers' perceptions of rain onset across AEZs ($p < 0.001$).

5.2 Farmers' perceptions of the effect of changing climate and variability on food production and livelihoods

Farmers also perceived notable environmental, agroecological, and household changes over their residency across AEZs. For instance, the majority observed an increase in the incidence of drought in their community, and none observed drought as decreasing. Farmers in Mang'ula A (which relies on rainfed production) reported that many farms in the uplands have become dry and barren due to drought and little rains. In Msosa, farmers reported a prolonged dry season as compared to years back, attributing the change to little rains and high sunshine (Table 4). These findings are, again, consistent with the literature in Tanzania regarding drought (Below et al., 2015; Kangalawe & Lyimo, 2013; Kihupi et al.,

2015; Mongi et al., 2010; Swai et al., 2012) and dry spells (Balama et al., 2016). In Ruaha Mbuyuni, for example, respondents perceived drought over the past two decades as increasing (Pauline & Grab, 2018).

About half of the interviewed farmers reported an increase in drying rivers (Table 6). All three villages across AEZs depend on the ecosystem services from rivers throughout the year. Older farmers in Msosa reported significant changes in the Msosa and Ruaha River's water volume during the dry season from June to November as compared to when they were young. Farmers in Mang'ula A and Magombera also believed that water levels in the rivers were lower during the dry season (June to October) than ever before (Table 4).

Table 6. Percentage distribution and correlation between forest adjacent farmers' perceptions of effects and agroecological zones across three villages in south-central Tanzania

	Agroecological Zone (AEZ)			
Perception of Effect	Alluvial Plains %	Semi-Arid %	Total %	X^2 (*p*-value
Drought				***n* = 186**
Increased	58.3	59.0	58.6	0
Decreased	0.0	0.0	0.0	(1)
No change	41.7	41.0	49.4	
Drying Rivers				***n* = 185**
Increased	45.3	49.4	47.0	0.16
Decreased	0.0	0.0	0.0	(0.688)
No change	54.7	50.6	53.0	
Incidence of crop pests and disease				***n* = 189**
Increased	93.7	61.5	80.4	30.24***
Decreased	0.0	1.3	0.5	(<0.0001)
No change	6.3	37.2	19.1	
Incidence of animal disease				***n* = 192**
Increased	94.7	88.6	92.2	1.62
Decreased	0.0	0	0	(0.2033)
No change	5.3	11.4	7.8	
Household hunger				***n* = 194**
Increased	54.4	33.8	45.9	14.45***
Decreased	8.8	2.5	6.2	(0.0007)
No change	36.8	63.7	47.9	

Note: *** and * indicate a statistical significance at $p < 0.01$ and $p < 0.05$ respectively

One of the most striking observations made by the interviewed farmers was just how drastically their experiences with crop pests and diseases, and animal diseases had changed. Though the survey asked farmers to report their experience over their residency in the area, many expressed significant changes as happening in very recent memory. These agroecological changes were consistent across AEZs. In Msosa, farmers stated that in order to keep their goats and chickens alive, vaccines were now necessary; previously livestock in Msosa and surrounding villages were never vaccinated. Farmers in Mang'ula A and Magombera expressed similar sentiments, stating that chickens, goats, cattle, and ducks were all suffering from diseases and that many were dying without medicine. One respondent in the alluvial plains reported having to slaughter her entire flock of chickens because of a disease ("SOTOCA", or Newcastle disease), that attacks chicken's feet and wings and made them very weak. She slaughtered them just two weeks before our interview and was unable to eat or sell them because the disease made their meat taste rotten and could have made people sick. Approximately 92 percent of all farmers felt animal disease had increased and none felt it had decreased (Table 6).

The majority of farmers also reported an increase in the incidence of crop pests and diseases (Table 6). In Magombera, farmers stated that all crops they grow (e.g., rice, maize, pigeon peas, pumpkin leaves) were now affected by disease and that no crop was disease free (Table 4). This was also the case in Mang'ula A, where farmers experienced an increase in the occurrence of crop diseases in both cash (e.g., onions, beans, groundnuts, and rice) and food crops (e.g., rice, legumes, sugar cane, greens, and vegetables). Farmers in Msosa, despite growing very different crop types, also reported that diseases are impacting onions and beans, triggering lower yields. The emergence of new pests and diseases in crops and livestock (Balama et al., 2016; Kangalawe & Lyimo, 2013; Kihupi et al., 2015; Lema &

Majule, 2009; Mongi et al., 2010), and subsequent yield loss (Kangalawe & Lyimo, 2013; Mongi et al., 2010) is also consistent across Tanzania. Across all three villages, farmers reported that nowadays they must use pesticides and herbicides (purchased from agricultural extension agents, in most cases) to harvest any yields, and that this was not the case even a decade ago. Though the majority of farmers in the alluvial plains (94 percent) and semi-arid (62 percent) zones perceived an increase in crop pests and diseases, there was a significant difference between zones ($p < 0.001$).

Farmers were also asked to consider whether or not household hunger has changed in frequency over their residency. Approximately half of the farmers perceived household hunger as increasing, and half perceived household hunger as remaining the same over their time living in the area (Table 6). There was a significant difference in perceptions across AEZs, however ($p < 0.001$). Approximately 54 percent of farmers in the alluvial plains believed household hunger had increased, while only 34 percent in the semi-arid zone did.

The environmental and livelihood changes discussed in the preceding paragraphs for villages in the vicinity of the UMNP are being reported by smallholders and urbanites all over the world. In Pakistan (Abid et al., 2015), India (Banerjee, 2014), Kenya (Chepkoech et al., 2018; Rao, Ndegwa, Kizito, & Oyoo, 2011), Ghana (Fosu-Mensah, Vlek, & MacCarthy, 2012b), Providencia (Altschuler & Brownlee, 2015), and Bangladesh (Uddin et al., 2017), for instance, temperatures have increased, affecting coral reefs in Providencia and agricultural yields in Kenya. In Chile (Roco et al., 2015) and Kenya (Chepkoech et al., 2018), there has been an increase in the frequency and duration of dry spells, and in India less water is available to farmers during critical times of the year (Banerjee, 2014). In Uganda (Okonya, Syndikus, & Kroschel, 2013) and South Africa (Thomas et al., 2011) people have reported variations in the amount and distribution of rainfall, and in Nigeria (Ayanlade, Radeny, &

Morton, 2017) and Kenya (Chepkoech et al., 2018; Rao et al., 2011) delays in rainfall onset and shortened seasons have affected planting, flowering, and agricultural yields. In short, the impacts reported for localities near the UMNP are not isolated to Tanzania or to sub-Saharan Africa but are being reported to various degrees all over the world.

5.3 Logistic regression

A summary of the result of each of six logistic models is shown in Table 7. Two models were run for each outcome variable: 1) temperature during the day; 2) volume of *masika* rain; and 3) household hunger. The first model (1, 3, and 5) included only household socio-demographic (sex, age, education, residency), livelihood (livestock ownership, land tenure, yield), and village (AEZ) characteristics. The second model (2, 4, and 6) included perceived measures of long-term agricultural and livelihood changes (crop pests and diseases, drought incidence, and animal diseases), in addition to the socio-demographic, livelihood, and village characteristics included in models 1, 3, and 5. We recognize that the inclusion of crop pests and diseases, drought incidence, and animal diseases may introduce statistical bias as we are modeling these *reported perceptions of changes* as determinants of environmental perceptions. Despite this, we believe their inclusion is important. Including them allows discussion of how these long-term changes in persistent agricultural challenges could be associated with other environmental perceptions.

5.3.a Models 1 and 2: Temperature during the day

Nearly 75 percent of all farmers used in the logistic regression (n = 150), across AEZs perceived changes in temperature during the day. According to the logistic models (Table 7), farmers who: 1) are men; 2) are livestock owners; 3) have small agricultural yields; 4) perceived crop pests and diseases as increasing; and/or 5) perceived animal disease as

increasing are all more likely to perceive temperature during the day as increasing. On the other hand, farmers who: 1) are older; 2) have at least a primary education; 3) rent the land they farm; 4) live in the semi-arid zone; and/or 5) have large agricultural yields, are all less likely to perceive these same changes. In model 1, land renters have about 60 percent (Odds Ratio [OR] = 0.398, 95% C.I. = 0.159 - 0.981) and farmers in the semi-arid AEZ about 67 percent (OR = 0.330, 95% C.I. = 0.137 - 0.766) lower odds of perceiving changes in temperature than land owners or those farmers in the alluvial plains. In model 2, men (OR = 2.519, 95% C.I. = 1.036 - 6.514), land renters (OR = 0.430, 95% C.I. = 0.161 - 1.140) and farmers who perceive crop pests and diseases as increasing (OR = 3.982, 95% C.I. = 1.273 - 13.010) all have higher odds of perceiving changes in temperature than women, land owners, or those farmers that did not perceive a change in crop pests and diseases.

5.3.b Models 3 and 4: Volume of *masika* rain

Over 70 percent of all farmers in the logistic sample perceived changes in the volume of rain during the *masika* rainy season. According to the logistic models (Table 7), farmers who: 1) have at least primary education; 2) are livestock owners; 3) are land renters; 4) perceived crop pests and diseases as increasing; 5) perceived drought incidence as increasing; and 6) perceived animal diseases as increasing, are all more likely to perceive changes in the volume of *masika* rain. Farmers who: 1) live in the semi-arid AEZ; and/or 2) have small agricultural yields are both less likely to perceive these changes in rainfall volume. In model 3, semi-arid farmers have about 89 percent (OR = 0.111, 95% C.I. = 0.040 - 0.276), and farmers with small yields about 70 percent (OR = 0.301, 95% C.I. = 0.100 - 0.845), decreased odds of perceiving changes in the volume of *masika* rains in comparison to farmers in the alluvial plains and farmers with average agricultural yields, respectively. In model 4, farmers

who perceived an increase in crop pests and diseases have 3.37 times higher odds (OR = 3.370, 95% C.I. = 1.051 - 11.130) and those who perceived an increase in drought incidence have 2.75 times higher odds (OR = 2.751, 95% C.I. = 1.049 - 7.517) of perceiving changes in *masika* rain volume than those who did not perceive changes in these long-term agricultural challenges. Conversely, semi-arid farmers have 88 percent (OR = 0.120, 95% C.I. = 0.037 - 0.352) and farmers with small yields 79 percent (OR = 0.211, 95% C.I. = 0.060 - 0.672) lower odds of perceiving change than those in the alluvial plains and farmers with average agricultural yields, respectively.

Table 7. Multivariate logistic regression analysis, to examine the association between socio-economic, livelihoods, and agro-ecological characteristics and environmental perception of farmers in Tanzania

	Dependent Variable					
	Temperature During the Day		Volume of *Masika* Rain		Household Hunger	
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Male	1.897 (0.843, 4.401)	2.519* (1.036, 6.514)	0.815 (0.359, 1.824)	1.057 (0.432, 2.599	0.818 (0.397, 1.676)	0.856 (0.411, 1.774)
Age	0.980 (0.933, 1.028)	0.985 (0.936, 1.036)	0.994 (0.950, 1.040)	0.994 (0.943, 1.047)	0.985 (0.943, 1.029)	0.981 (0.936, 1.026)
At Least Primary Education	0.775 (0.277, 2.057)	0.611 (0.197, 1.770)	1.642 (0.628, 4.350)	1.375 (0.464, 4.092)	1.153 (0.486, 2.780)	1.132 (0.472, 2.752)
Residence Period	1.004 (0.977, 1.034)	0.992 (0.962, 1.024)	1.010 (0.982, 1.040)	1.000 (0.970, 1.032)	1.029* (1.004, 1.056)	1.030* (1.004, 1.058)
Livestock Owner	1.084 (0.434, 2.625)	1.145 (0.429, 2.973)	1.433 (0.596, 3.409)	1.444 (0.549, 3.743)	2.295* (1.052, 5.158)	2.377* (1.080, 5.404)
Land Renters	0.398* (0.159, 0.981)	0.430 (0.161, 1.140)	1.205 (0.484, 3.103)	1.569 (0.568, 4.675)	0.859 (0.357, 2.053)	0.836 (0.340, 2.032)
Agroecological Zone (Semi-arid)	0.330* (0.137, 0.766)	0.514 (0.189, 1.394)	0.111*** (0.040, 0.276)	0.120*** (0.037, 0.352)	0.347** (0.159, 0.741)	0.331* (0.137, 0.768)
Large Yield	0.855 (0.321, 2.307)	0.621 (0.213, 1.799)	1.178 (0.427, 3.352)	0.858 (0.279, 2.659)	0.658 (0.269, 1.575)	0.653 (0.265, 1.580)
Small Yield	1.548 (0.541, 4.775)	1.857 (0.572, 6.611)	0.301* (0.100, 0.845)	0.211* (0.060, 0.672)	1.145 (0.464, 2.829)	1.072 (0.427, 2.685)
Crop Disease (Increased)		3.982* (1.273, 13.010)		3.370* (1.051, 11.130)		1.012 (0.312, 3.377)
Drought Incidence (Increased)		0.991 (0.376, 2.551)		2.751* (1.049, 7.517)		1.473 (0.675, 3.265)
Animal Disease (Increased)		3.281 (0.722, 16.129)		2.183 (0.413, 12.635)		0.739 (0.154, 3.468)
Constant	11.100* (1.149, 119.925)	1.310 (0.080, 19.763)	6.062 (0.635, 60.547)	0.913 (0.045, 15.871)	1.038 (0.127, 8.303)	1.311 (0.101, 16.212)
Observations	150	150	150	150	150	150
Log Likelihood	-75.114	-67.124	-74.847	-65.819	-91.071	-90.576
Akaike Inf. Crit.	170.229	160.247	169.695	157.638	202.142	207.153

Note*:* ***, **, and * indicate a statistical significance at $p < 0.05$, $\boldsymbol{p < 0.01}$, and $p < 0.001$ respectively

5.3.c Models 5 and 6: Household Hunger

Just over 49 percent of all farmers in the sample perceived changes in household hunger during their residency. There is a significant difference ($p < 0.001$) in perceptions across AEZs in the logistic sample, however. Like farmers in the full study sample (Table 6) farmers in the semi-arid region are significantly less likely to perceive changes in household hunger (31.1 versus 61.8 percent of farmers). According to the logistic models (Table 7), farmers who: 1) have at least a primary education; 2) are livestock owners; 3) have small yields; and/or 4) perceived changes in drought incidence, are all more likely to perceive changes in household hunger. In contrast, farmers who: 1) are men; 2) are land renters; 3) have large agricultural yields; and/or 4) perceived changes in animal diseases, are all less likely to perceive changes in household hunger. In models 5 and 6, farmers who have lived in the area longer (OR = 1.029, 95% C.I. = 1.004 - 1.056; and OR = 1.030, 95% C.I. = 1.004 - 1.058, respectively) and farmers who own livestock (OR = 2.295, 95% C.I. = 1.052, 5.158; and OR = 2.377, 95% C.I. = 1.080, 5.404, respectively) have increased odds of percieving changes in household hunger than farmers with a shorter residence period or farmers that do not own livestock. In both models, farmers in the semi-arid AEZ had about 65 lower odds (OR = 0.347, 95% C.I. = 0.159 - 0.741; and OR = 0.331, 95% C.I. = 0.137 - 0.768) of percieving household hunger as changing in comparison to farmers in the alluvial plains.

5.3.d A discussion of perceptions by indicator

5.3.d.1 Sex

Based on the literature, it was our expectation that male respondents would have an increased likelihood of perceiving environmental change. This was true in only half of our models (1, 2, and 4). We suspect that this may be related to two of the limitations of this

study. Firstly, we interviewed the first eligible household member, not the household head. Secondly, we based our hypothesis on the adaptation literature. It may be that male heads of household are more likely to perceive and/or adapt to changes, but we did not explicitly interview heads of household or ask questions about adaptation. It has also been shown that female headed households are both more affected by agricultural stressors and shocks (Below et al., 2015) and more conscious of changes in household well-being (Z. Liu, Smith Jr., & Safi, 2014; Teklegiorgis Habtemariam et al., 2016). Thus, it may be that women are more, or equally as likely to perceive change as men.

5.3.d.2 Age

Contrary to prior expectations, the age of respondents decreased their likelihood of perceiving changes in the environment, but only slightly (see tables 6 and 7). Thus, the younger a respondent was, the more likely they were to report changes in the environment. This was true across all six models, though not significantly in any model. This finding is consistent with a study by Roco et al. in Chile (Roco et al., 2015), but is inconsistent with studies in Ethiopia (Debela et al., 2015; Deressa et al., 2011; Teklegiorgis Habtemariam et al., 2016) and Nigeria (Mustapha, Sanda, & Shehu, 2012) that found age to influence environmental perceptions positively. In other studies, age of respondent (Debela et al., 2015; Teklegiorgis Habtemariam et al., 2016) has been used as a proxy for years of experience as a farmer, while other models have paired age and experience in agriculture (Roco et al., 2015). Though age may relate to farmer experience (Balama et al., 2016), using it as a proxy may be misguided. It may be that younger farmers are more able to access information about environmental change via the smart phone boom in East Africa, or that older farmers have

greater experience with the variability of climate and thus are less likely to perceive long-term changes.

5.3.d.3 Education

The educational attainment of farmers was both positively and negatively associated with environmental perceptions (see tables 6 and 7). Respondents with at least a primary education were found to be more likely to perceive changes in the volume of *masika* rains and household hunger, but were less likely to perceive changes in temperature. In no cases was this influence significant. Our expectation was that higher educational attainment would positively influence environmental perceptions (see table 7). Studies across the global south have demonstrated the overwhelmingly positive influence of education on environmental perceptions, arguing that farmers with more formal education are more likely to observe, interpret and predict changes in their environment (Debela et al., 2015; Roco et al., 2015; Teklegiorgis Habtemariam et al., 2016; Uddin et al., 2017). Studies of adaptation to environmental change have also highlighted the importance of education in adopting adaptation strategies (Abid et al., 2015; Balama et al., 2016). The negative relationship between education and perceptions in the temperature logistic model may indeed relate to meteorological changes not discussed in this paper.

5.3.d.4 Residence Period

In almost all cases, the number of years a respondent lived in the study area had a zero or positive influence on the likelihood of perceiving environmental change (see tables 6 and 7). In the case of changes in household hunger, this influence was significant. This result reflects our expectations. We speculate that this relationship is due to the increased experience and knowledge about agronomic practices and the local environment that farmers

gain by living in the study area. Though this has not been demonstrated to our knowledge in studies of perception, it is supported by studies regarding agricultural adaptation (Balama et al., 2016). We also recognize that the residence period over which respondents were to recall environmental changes varied across respondents. Of the respondents over age 55 (n = 14), the average residence period was 34 years. In comparison, of the respondents under the age of 30 (n = 30), the average residence period was nearly 12 years. We recognize this is a limitation of our study. Ideally, we would have asked questions over a short, uniform recall period (e.g., 5 or 10 years) to avoid issues with recall bias.

5.3.d.5 Livestock Ownership

Respondents who owned livestock were more likely in all cases to perceive environmental changes. In the case of household hunger, respondents who were livestock owners were significantly more likely to perceive changes than those who were not livestock owners. This result is consistent with the findings of Debela et al., 2015 in Ethiopia. Livestock owner's in the study villages may have a heightened sense of environmental change due to the qualitative changes (e.g., sickness, stunted growth) and quantitative changes (e.g., number of animals who have suffered or died) they have seen in their cattle, sheep, goats, chickens, and ducks.

5.3.d.6 Land Tenure

In the logistic models for temperature and household hunger, land renters were less likely to perceive changes than land owners, while in the *masika* rains logistic models, land renters were more likely to perceive change in comparison to land owners. This is partially consistent with our hypothesis that land owners would be more likely to perceive environmental change due to increased geographically specific agricultural experience. This

finding is also supported by Roco et al.'s study in Chile (Roco et al., 2015). We suspect that land insecurity, diversified experience on different plots of land, and micro-scale geographic and microclimatic influences in land renters increases their likelihood of perceiving changes in the *masika* rains. Land owners see the effects of environmental and climatic change on the same agricultural plots year-after-year, which is certainly advantageous in observing site-specific changes; but renters have the advantage of seeing the effects of environmental and climatic changes on multiple plots, which may expose them to changes land owners are not experiencing.

Table 8. Summary of Expected versus Modeled Effects in Logistic Regression Models

	Dependent Variable							
	Temperature During the Day		Volume of *Masika* Rain		Household Hunger		Effect	
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)	Expected	Modeled
Male	(+)	(+)*	(-)	(+)	(-)	(-)	*(-)*	(+) / (-)
Age	(-)	(-)	(-)	(-)	(-)	(-)	*(+)*	***(-)***
At Least Primary Education	(-)	(-)	(+)	(+)	(+)	(+)	*(+)*	***(+)*** / (-)
Residence Period	(+)	(-)	(+)	(0)	(+)*	(+)*	*(+)*	***(+)*** / (-)
Livestock Owner	(+)	(+)	(+)	(+)	(+)*	(+)*	*(+)*	***(+)***
Land Renters	(-)*	(-)	(+)	(+)	(-)	(-)	*(-)*	(+) / ***(-)***
Agroecological Zone (Semi-arid)	(-)*	(-)	(-)***	(-)***	(-)**	(-)*	*(-)*	***(-)***
Large Yield	(-)	(-)	(+)	(-)	(-)	(-)	*(-)*	(+) / ***(-)***
Small Yield	(+)	(+)	(-)*	(-)*	(+)	(+)	*(+)*	***(+)*** / (-)
Crop Disease (Increased)		(+)*		(+)*		(+)	*(+)*	***(+)***
Drought Incidence (Increased)		(-)		(+)*		(+)	*(+)*	***(+)*** / (-)
Animal Disease (Increased)		(+)		(+)		(-)	*(+)*	***(+)*** / (-)

Note*:* ***, **, and * indicate a statistical significance at $p < 0.05$, $\boldsymbol{p < 0.01}$, and $p < 0.001$ respectively; all majority effects are **bolded** and *italicized* in the final "modeled" column, above

5.3.d.7 Agroecological Zone (AEZ)

In all cases, farmers in the semi-arid region were less likely to perceive environmental change. Across 5 of the 6 models, AEZ had a significant and negative effect on the odds of perceiving change. Prior to this study, we hypothesized that farmers across AEZs would have different perceptions of environmental change due to actual differences in climatic influences

and the microclimatic and livelihood security influences of agricultural technologies. These findings are consistent with our hypotheses. For example, farmers in Msosa are relatively insulated from any changes in the *masika* rains due to their reliance on pump and gravity irrigation from the Msosa and Ruaha Rivers. Farmers here are not yet reliant on seasonal rains for agricultural production, at least directly, recognizing that irrigation depends on available surface water (including pumped water, which moves surface water up hill) which, in turn, varies during the various seasons of the year. This of course could change as climate shifts and rivers become dry or swell seasonally with precipitation changes. This is different than farmers in Mang'ula A or Magombera, where irrigation technologies do not play a role and harvest success relies heavily on the timing and volume of the rains. Our findings are consistent with Deressa et al., where farmers in the dryer lowlands of Ethiopia were less likely to perceive changes in climate than those in the wetter highlands (Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009). The idea that farmers in dryer areas would perceive environmental changes more readily is intuitive, as they receive less rainfall to begin with (this of course depends on relative magnitudes of rainfall and its relation to production). However, in our study, farmers in the semi-arid region have access to a technology that buffers them against change in ways farmers in the alluvial plains are not.

5.3.d.8 Agricultural Yield

The agricultural yield metric we derived from farmers' self-reported yields was included as a measure of relative agricultural productivity. Our prediction was that farmers with higher agricultural yields would be less likely to perceive environmental changes. In 5 of the 6 logistic models, farmers with large yields (as compared to farmers with average yields) were *less* likely to perceive environmental changes, and in 4 of the 6 models, farmers with

small yields were *more* likely to perceive environmental changes. These findings are consistent with our hypothesis. In contrast, in both models relating to the volume of the *masika* rains, farmers with small yields were significantly less likely to perceive changes. Interestingly, of the 39 small yielding farmers, 43.6 percent (n = 17) are in Magombera, which lies in the seasonally (and sometimes annually) inundated lowlands. Whereas, farmers from Magombera only represent 2.4 percent of large (n = 1) and 7.1% of average large (n = 5) yielding farmers. It is our conjecture that farmers in Magombera are currently insulated from changes in the *masika* rains due to high water tables and annual soil saturation, and thus are, less likely to perceive change. It is also a large possibility that yield as we have measured it does not accurately capture a meaningful metric for relative productivity. It may be that yield stability (Cleveland, 2001), a measure of yield from year to year, or a measure of proportion of yields actually consumed, would be more significantly associated with perceptions.

5.3.d.9 Crop Pests and Disease

Across models 2, 4, and 6 reported changes in crop pests and diseases positively influence perceptions of environmental change. In the case of temperature and precipitation, this relationship is significant (see tables 6 and 7). This is consistent with our hypothesis. It is our understanding that as farmers experiences with agricultural pests and diseases increases, they will be more likely to perceive climatic and household changes. This is due to the empirical and observational association between increasing pests and diseases, and changing temperature/precipitation. Increased crop pests and diseases also have the potential to decrease agricultural yields, impacting household food security and hunger. The addition of the crop pests and disease variable made land renters and AEZ non-significant, and caused residence period to switch direction in model 2.

5.3.d.10 Drought Incidence

Reported perceptions of increases in drought incidence positively influence perceptions of changes in household hunger and the *masika* rains, but negatively influence perceptions of changes in temperature (see tables 6 and 7). Our hypothesis was that experiences of increased drought would positively influence the likelihood of farmers perceiving environmental change. Thus, the results of models 4 and 6 are consistent with our expectations. Were it the case that farmers who reported experiencing increased drought frequency perceived the rains as remaining the same, we might worry, because of the necessary relationship between rains and drought. But, in reflecting, we feel our hypothesis about experiences of drought impacting perceptions of temperature change may be a bit misguided. Drought and hot temperatures are often conflated but are not necessarily related. Model 2 is demonstrative of farmers' ability to track the nuanced ways in which the environment is changing. Drought may in fact be increasing, but this does not necessarily mean that temperatures are changing. The addition of the drought incidence variable did not change the significance of any explanatory variable, but did change the direction of the odds ratios in the sex and yield metric.

5.3.d.11 Animal Disease

Increased animal diseases positively influenced the likelihood of farmers perceiving temperature and the *masika* rains as changing, but negatively influenced the likelihood of farmers perceiving household hunger as changing. The latter is inconsistent with our original hypothesis. The additional of the animal disease variable in model 6 did not change the direction of any odds ratios and also did not impact the significance of any other explanatory variables.

6. Conclusions

Regional contexts are incredibly important in understanding agricultural change. In an area surrounded by near unparalleled levels of endemism and biodiversity, the strategies farmers choose for a resilient future will have huge impacts on the conservation of surrounding natural resources, the regeneration of soils and micro-biota, the improvement of food security, and local livelihoods. As such, a more nuanced understanding of household experience with climate change and variability in this area has important implications for the success of resilience and capacity building campaigns regionally.

Farmers across agroecological and livelihood zones have different experiences with environmental and climatic changes. Thus, the almost *exclusive* focus of research and policy in Tanzania on rainfed, semi-arid regions is inadequate for addressing the effects of such changes on vulnerable populations across Tanzania's diverse landscape. For Tanzania to have a comprehensive resilience building strategy, all its vulnerable populations and diverse landscapes must be understood.

This study responds to the call for more empirical, case-based research to shed light on the determinants of, and also the differences in, environmental and climatic perceptions across Tanzania. In addition, this study paves the way for a situated understanding of what change might look like for a resilient future. Our findings contribute to a body of empirical evidence that says that forest adjacent farmers in both semi-arid and humid/alluvial areas are experiencing the adverse impacts of climate change and variability, though to varying degrees. Our conclusions are as follows. First, farmers' environmental perceptions are strongly associated with their socio-economic, livelihood and agroecological contexts. Second, experiences across agroecological and livelihood zones differ, and do so

significantly, in many cases. Third, despite differences in perceptions across the semi-arid/irrigated and alluvial/rainfed zones, the majority of all farmers perceive climate as shifting and its impacts as being primarily negative. Looking ahead, we conclude that future research should work to develop a more sophisticated understanding of the ways in which irrigated technology insulates farmers from the effects of environmental and climatic changes. And finally, that future research should address gaps in the literature surrounding these forest adjacent farmers' changing and complex relationship with areas of high biodiversity. Doing so will complicate conservation-livelihood narratives and have important implications for the kinds of policies that are produced.

Resilience building projects are necessary to secure future livelihoods and *must* address the concerns of the farmers they seek to assist. Previous projects have failed because they have not adequately considered and addressed the needs identified by these local stakeholders. They have often imposed solutions that local stakeholders have not perceived as immediately relevant. Consequently, projects have not been sustained and the very struggles these projects sought to address have continued without redress. Future research and subsequent policy creation should take a bottom-up approach where farmers and researchers co-produce knowledge that is situated in the socio-environmental contexts of the farmers it seeks to understand and whose livelihoods it seeks to improve.

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Appendix A. Written consent (English)

THE UNIVERISITY OF CALIFORNIA, SANTA BARBARA STUDY PARTICIPANT CONSENT FORM
Farmer Knowledge & Decision-making in the Udzungwa Region, Tanzania
Confidential: Data For Research Purposes Only

Principal Investigator
Larry Gorenflo, Professor of Landscape Architecture
Pennsylvania State University, University Park, PA 16802

Investigator's Statement*: You are being asked to take part in a research study. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study. Please review the form with me carefully. You may ask questions about the purpose of the research, what I would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called 'informed consent.'*

A. PURPOSE OF THE STUDY

The purpose of this study is to improve our understanding of farmer knowledge and decision-making in the Udzungwa region. Information from this study will be used to develop future programs and interventions to address any effects on agricultural practices and productivity that are moderated by migration.

B. STUDY PROCEDURES

If you agree to be in this study, this is what will happen:

1. You will participate in a focus group with a staff member. The focus group will address farmer knowledge regarding agricultural production activities and adaptation over your lifetime. It will take up to 120 minutes to complete. The focus group may cover issues that are difficult to talk about. You may refuse to answer any questions for any reason. You may leave the focus group at any time. Any information you provide will be kept confidential.

C. RISKS, STRESS, OR DISCOMFORT

There are minimal risks from being in this study:

1. The survey includes questions about you, your migratory behavior and opinions about climate and agriculture. I will ask you to share what you know to the best of your knowledge. Your views are important to us, but you do not have to answer any questions you do not want to. If you feel a question is too personal, tell me and I will move to the next question. Remember, you can stop the survey at any time.

D. BENEFITS OF THE STUDY

Benefits you may get from being in this study include:

1. Knowing that you have contributed to knowledge that will help mitigate the detrimental consequences of climate change on human well-being.
2. Knowing that your responses will be compiled to ensure that future projects better serve your needs.
3. You will be compensated for your time spent with an interviewer with 5000 Tsh.

E. CONFIDENTIALITY STATEMENT

What you tell us is confidential. Your response will be labeled with a study number only. No one except the study staff will have access to the survey answers. Your response will be grouped with survey answers from other persons. Survey forms will be locked in a file cabinet at the study office. Only the specific study staff will have access to the files.

F. PERSONS TO CONTACT

This study is run by Professor Larry Gorenflo of the Pennsylvania State University. If you have questions at a later time, you can contact me via email, (ljg11@psu.edu) or by phone at +1 814-863-5337. If at any time you have comments regarding the conduct of this research or questions about your rights as a research participant, you should contact the Penn State Office for Research Protections which serves as the Intuitional Review Board (IRB) by email at ovpr@psu.edu, or by phone at +1 814-865-1775.

G. COMPENSATION

You will be given 5,000 Tsh for the time you spend taking part in the study.

H. AGREEMENT

Before we go on, I need to be sure you understand what you have read. Do you have any questions? You have read or had read to you the explanation of this study, you have been given a copy of this form, the opportunity to discuss any questions that you might have and the right to refuse participation. I am now going to ask for your consent to participate in this study.

Participant consents to: ☐ Taking part in the survey ☐ Declined participation		**Participant ID code:**
_____ Signature of Interviewer	_____ Printed Name of Interviewer	_____ Date

Appendix B. Written consent (Swahili)

CHUO KIKUU CHA CALIFORNIA, SANTA BARBARA NA CHUO KIKUU CHA PENNSYLVANIA
FOMU YA RIDHAA YA KUKUBALI USHIRIKI KATIKA UTAFITI
Kuhama, Maoni ya Mabadiliko ya Tabia Nchi & Hali ya Kilimo katika Bonde la Kilombero, TZ: 2017
Siri: Data Kwa Ajili ya Utafiti Tu.

Mtafiti Mkuu
Larry Gorenflo, Profesa wa Usanifu Mazingira
Chuo Kikuu Cha Pennsylvania, University Park 16802

Maneno ya Mtafiti*: Unaombwa kushiriki katika zoezi la utafiti huu. Lengo la Fomu hii ya Makubaliano ni kukupa taarifaitakayokusaidia wewe kukubali au kutokukubali kushiriki katika Utafiti huu. Tafadhali pitia fomu hii kwa umakini sana. Unaweza kuuliza lengo la utafiti huu, nini nitakochokuwa nakuuliza, madhara na faida nitakazoweza kuzipata, haki zako kama mtu unayejitolea, na kitu chochote kile kuhusu utafiti huu au kuhusu fomu hii ambacho hakijaeleweka. Pale ambapo maswali yako yote yameshajibiwa, unaweza kuamua kama ungependa kushiriki kwenye huu utafiti ama la. Mchakato huu unaitwa 'ridhaa ya kutaarifiwa.'*

I. LENGO LA UTAFITI

Lengo la utafiti huu ni kuboresha uwelewa wetu juu ya jinsi gani uhamiaji na mabadiliko ya tabia nchi yanathiri hali ya kilimo na uzalishaji wake katika Bonde la Kilombero. Taarifa kutoka katika utafiti huu zitatumika kuandaa program za baadae na mikakati ya kuelezea madhara ya hali ya kilimo na uzalishaji wake ambayo yanchangiwa na uhamiaji.

J. MCHAKATO WA UTAFITI

Kama utakubali kushiriki katika utafiti huu, haya ndiyo yatakayotokea:

2. Utashiriki katika utafiti ukiwa pamoja na mfanyakazi husika. Utafiti una maswali kuhusu maisha yako, kilimo na madhara yake. Itachukua dakika 90 kumaliza.Utafiti huu una maswali ambayo ni yabinafsi. Yanaweza kuwa ni magumu kuyaongelea. Unaweza kukataa kujibu swali lolote kwa sababu yoyote. Kama ukikataa kujibu swali lolote au kusimama kufaniwa usaili, unawezafanya hivyo muda wowote. Taarifa yoyote utakayotoa itakuwa ni siri

K. ATHARI, HOFU, AU BUGUDHA

Kuna madhara machache sana kushiriki katika utafiti huu:

2. Utafiti unajumuisha maswali kuhusu wewe mwenyewe, tabia yako ya kuhama hama na maoni yako kuhusu mabadiliko ya tabia nchi na kilimo. Nitakuuliza kushea kipi unachofahamu kupitia uelewa wako uliokuwa nao. Maoni yako ni muhimu sana kwetu, Na usijibu swali lolote ambalo hautaki kulijibu. Kama ukihisi swali ni la ndani zaidi, niambie na nitaenda swali lengine. Kumbuka,unaweza kusimama kuhojiwa muda wowote ule.

L. FAIDA ZA UTAFITI HUU

Faida utakazozipata katika kushiriki katika utafiti huu ni:

4. Kutambua kwamba umechangia uelewa ambao utasaidia kutatua madhara ya matokeo ya mabadiliko ya tabia nchi kwa binadamu.
5. Kutambua kwamba majibu yako yatakusanywa ili kuhakikisha kwamba miradi ya baadae itasaidia kutatua matarajio yenu.
6. Utafidiwa kwa muda wako uliotumia kwa kulipwa shilingi **5000**.

M. TAARIFA YA SIRI

Utakachotuambia sisi ni siri. Majibu yako yatawekwa alama ya namba tu. Hakuna mtu yeyote zaidi ya watumishi wa utafiti ndio watakaoweza kuona majibu hayo. Majibu yako yatakusanywa kwenye kundi moja na majibu ya watu wengine. Fomu za utafiti zitafungiwa kabatini ofisini. Watafiti maalumu tu ndio watakaoukuwa na ruhusa yakupata mafaili hayo.

N. **MTU WA MAWASILIANO**

Utafiti huu unafanywa na Larry Gorenflo wa Chuo Kikuu Cha Pennsylvania. Kama una maswali kwa baadae, unaweza kumuandikia barua pepe, (ljg11@psu.edu) au kwa simu +1 814-863-5337. Kama muda wowote ukiwa na maoni au maswali kuhusu haki zako kama mshiriki wa utafiti, unatakiwa uwasiliane na Institutional Review Board (IRB) kwa barua pepe ovpr@psu.edu, kwa simu +1 805-893-3807, au kwa simu +1 814-865-1775

O. FIDIA

Utapewa shilingi 5000 kwa muda wako uliotumia katika utafiti huu.

P. MAKUBALIANO

Kabla hatujaendelea, Nahitaji kujua kama kweli umeelewa ulichosoma. Una swali lolote? Ulisoma au umesoma maelezo ya utafiti huu, umepewa nakala ya fomu hii, fursa ya kujadili swali lolote ambalo labda unaweza kuwa nalo na haki yakukataa kushiriki. Na sasa nataka nikutake ridhaa yako yakushiriki katika utafiti huu.

Ridhaa ya Mshiriki katika: ☐ Kushiriki katika utafiti ☐ Kukataa kushiriki		**Namba ya Mshiriki:**
_____ Saini ya Msaili	_____ Jina la Msaili	_____ Tarehe

Appendix C. Household survey (English)

Migration, Climate Perceptions & Agricultural Practices in the Kilombero Valley, TZ: 2017 Confidential: Data For Research Purposes Only THE PENNSYLVANIA STATE UNIVERSITY			
Interview Information			
Date of interview: Interviewer name: Interview start time: Checker's Initials: Date logged:			
Introduction and Consent			
Hello, my name is _____. I am working with the Pennsylvania State University in the United States. We are conducting a study about migration, climate perceptions, and agricultural practices in the Kilombero Valley, to add to previous data collected on resource use at the household level. The information we collect will be used to improve our understanding of migration, climate, and agriculture in Tanzania. All responses will be anonymous and completely confidential. Your household was selected for the survey. Are you interested in hearing more about the study? **[ADMINISTER CONSENT FORM]**			
RESPONDENT AGREES **[CONTINUE WITH SURVEY]**	RESPONDENT DISAGREES **[STOP]**		
Interviewer: Ensure that the interview takes place in a space that is sufficiently private so that others cannot hear the questions and answers. If this is not possible, STOP the survey. Also, please take notes of anything particularly interesting an interviewee says and include it in the notes section next to the current question, or at the end of the survey.			
SECTION A. Background			
#	**Question**	**Response**	**Notes/Skips**
A1	**DO NOT READ**: Is the respondent a male or female?	Male Female	
A2	How old are you?		
A3	In what month and year were you born?	_____MM 88 DK / 99 REF _____YYYY 8888 DK / 9999 REF	
A4	What is your marital status?	1 Never married 2 Living together/cohabiting 3 Married monogamous 4 Married polygynous 5 Divorced 6 Separated 7 Widowed 88 DK 99 REF	
A5	How many children have you ever		

	had?	_____ Number 88 DK 99 REF	
A6	Have you ever attended school?	1 Yes 2 No 88 DK 99 REF	IF NO, SKIP TO A8
A7	What is the highest level of education that you attained?	1 Primary 2 Secondary 3 Higher 88 DK 99 REF	
A8	What is your religion?	1 Catholic 2 Anglican 3 Methodist 4 Presbyterian 5 Pentecostal/Charismatic 6 Seventh Day Adventist 7 Other Christian 8 Muslim 9 Traditional/Spiritualist 10 No religion 11 Other, specify: 88 DK 99 REF	
A9	To what ethnic group do you belong?	_____ _____ 88 DK 99 REF	
A10	What languages do you or other members of your household speak, and with what level of proficiency?	1 _____ 2 _____ 3 _____ 4 _____ 88 DK 99 REF	1 = no proficiency 2 = elementary proficiency 3 = conversational proficiency 4 = native or bilingual proficiency
A11	Apart from Kiswahili, do you or other members of your household speak a tribal language at home or elsewhere? If **YES**, where, why, and how often?	1 Yes 2 No Where? _____ Why? _____ How Often? _____ 88 DK 99 REF	
A12	Do young members of your household (younger siblings, your children, young people who live with you) speak your tribal language?	1 Yes 2 No 88 DK 99 REF	IF NO, SKIP TO **A16**

A13	How have they learned?	1 Mother/Father 2 Grandparent 3 Friend 4 Neighbor 5 School 6 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST IMPORTANT**
A14	What is your level of proficiency in a tribal language?	1 No proficiency 2 Elementary proficiency 3 Conversational proficiency 4 Native or bilingual proficiency 88 DK 99 REF	
A15	What is the level of proficiency of all other household members (spouse, older members, etc.) in their tribal language?	1 No proficiency 2 Elementary proficiency 3 Conversational proficiency 4 Native or bilingual proficiency 88 DK 99 REF	SKIP TO **B1**
A16	What do you think of their not speaking a tribal language?	_____ _____ 88 DK 99 REF	
SECTION B. Migration and mobility			
#	**Question**	**Response**	**Notes/Skips**
READ: Now I am going to ask you some questions about places that you have lived and the times that you have moved or traveled.			
B1	In which region were you born?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya 14 Morogoro 15 Mtwara 16 Mwanza 17 Njombe 18 Pemba N 19 Pemba S 20 Pwani 21 Rukwa 22 Ruvuma	

		23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar N 30 Zanzibar S and C 31 Zanzibar W 32 Other, specify: 88 DK 99 REF	
B2	What is the name of the place, city, or town you were born?	_____ 88 DK 99 REF	
B3	Was the place you were born rural (village or countryside) or urban (town or city)?	1 Rural 2 Urban 88 DK 99 REF	
B4	How long have you lived in the Kilombero Valley?	_____ Years _____ Months 98 Entire life 88 DK 99 REF	IF ENTIRE LIFE SKIP TO **B9**
B5	Which place, city or town did you live in prior to the Kilombero Valley?	_____ 88 DK 99 REF	
B6	Which region did you live in prior to living in the Kilombero Valley?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya 14 Morogoro 15 Mtwara 16 Mwanza 17 Njombe 18 Pemba N 19 Pemba S 20 Pwani 21 Rukwa 22 Ruvuma	

		23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar N 30 Zanzibar S and C 31 Zanzibar W 32 Other, specify: 88 DK 99 REF	
B7	With whom did you move to the Kilombero Valley?	1 Wife/Husband/Partner 2 Mother/Father 3 Children 4 Family 5 No one (came alone) 88 DK 99 REF	
B8	What was your reason for moving to the Kilombero Valley?	1 Work/financial opportunity 2 Family 3 Education 4 Environment 5 Escape bad conditions 6 Health/medical/illness 7 Climate (rainfall and temperature) 8 Fertile agricultural land 9 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY
B9	In which region did your wife/husband/partner live prior to living in the Kilombero Valley?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya 14 Morogoro 15 Mtwara 16 Mwanza 17 Njombe 18 Pemba N 19 Pemba S	IF NEVER A MIGRANT SKIP TO **B11** IF NO SPOUSE SKIP TO **B11**

		20 Pwani 21 Rukwa 22 Ruvuma 23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar N 30 Zanzibar S and C 31 Zanzibar W 32 Other, specify: 96 No spouse 97 Never a migrant 88 DK 99 REF	
B10	What was your wife's/husband's/ partner's reason for moving to the Kilombero Valley?	1 Moved as a family to Kilombero Valley 2 Work/financial opportunity 3 Family 4 Education 5 Environment 6 Escape bad conditions 7 Health/medical/illness 8 Climate (rainfall and temperature) 9 Fertile agricultural land 10 Other, specify: 97 Never a migrant 88 DK 99 REF	CIRCLE ALL THAT APPLY
B11	In how many different villages have you lived in the Kilombero Valley?	_____ (number of villages) 88 DK 99 REF	IF ONE SKIP TO **B14**
B12	What are the names of the places in which you have lived in the Kilombero Valley?	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 88 DK 99 REF	
B13	How long have you been living continuously in this	_____ Years _____ Months	

	house/structure?	98 Entire Life 88 DK 99 REF	
READ: Now I am going to ask you some question about your experiences over the last year, including questions about your occupation and income.			
B14	What has been your main occupation?	_____ 88 DK 99 REF	
B15	What other strategies do you use to supplement your main occupation?	1 _____ 2 _____ 3 _____ 4 _____ 88 DK 99 REF	
B16	Did you receive and/or send any remittances from and/or to family? If **YES**, how much money did you receive and/or send on average every month?	1 Yes 2 No _____ Tsh received _____ Tsh sent 88 DK 99 REF	If **NO**, read B17A; if **YES**, read B17B
B17	A. What was your income for the past year? B. What was your income for the past year without remittances received and/or sent?	_____ Tsh 88 DK 99 REF	
SECTION C. Temperature and Rainfall Perceptions			
#	**Question**	**Response**	**Notes/Skips**
READ: Now I am going to ask you some questions about your opinions, or perceptions. There are no right or wrong answers. I am only interested in your experience.			
C1	When is the **short rainy season**?	1 January 2 February 3 March 4 April 5 May 6 June 7 July 8 August 9 September 10 October 11 November 12 December 88 DK 99 REF	CIRCLE ALL MONTHS THAT APPLY

C2	When is the **long rainy season**?	1 January 2 February 3 March 4 April 5 May 6 June 7 July 8 August 9 September 10 October 11 November 12 December 88 DK 99 REF	CIRCLE ALL MONTHS THAT APPLY
Interviewer DO NOT READ OUT LOUD: Treat the first two questions the same way. Read the question. If the respondent answers **NO**, circle "No change" and **SKIP** to the next question. If the respondent answers **YES**, **READ** "If so, how?" and record their response.			
C3	During the time you have lived in the Kilombero Valley, has the volume of rainfall changed during the **short rainy season**? If so, how?	1 Increased in amount 2 Decreased in amount 3 No change 4 Other, specify: 88 DK 99 REF	
C4	During the time you have lived in the Kilombero Valley, has the volume of rainfall changed during the **long rainy season**? If so, how?	1 Increased in amount 2 Decreased in amount 3 No change 4 Other, specify: 88 DK 99 REF	
C5	During the time you have lived in the Kilombero Valley, has the timing of rains changed during the **short rainy season**? If so, how?	1 Begins early 2 Begins late 3 Ends early 4 Ends late 5 Greater variability 6 Less variability 7 More predictable 8 Less predictable 9 No change 10 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST IMPORTANT CHANGE**
C6	During the time you have lived in the Kilombero Valley, has the timing of rains changed during the **long rainy season**? If so, how?	1 Begins early 2 Begins late 3 Ends early 4 Ends late 5 Greater variability 6 Less variability 7 More predictable 8 Less predictable 9 No change 10 Other, specify:	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST IMPORTANT CHANGE**

		88 DK 99 REF	
C7	During the time you have lived in the Kilombero Valley, has temperature changed **during the morning**? If so, how?	1 Increased/hotter 2 Decreased/colder 3 No change 4 Other, specify: 88 DK 99 REF	
C8	During the time you have lived in the Kilombero Valley, has temperature changed **during the daytime**? If so, how?	1 Increased/hotter 2 Decreased/colder 3 No change 4 Other, specify: 88 DK 99 REF	
C9	During the time you have lived in the Kilombero Valley, has temperature changed **during the evening**? If so, how?	1 Increased/hotter 2 Decreased/colder 3 No change 4 Other, specify: 88 DK 99 REF	
C10	During the time you have lived in the Kilombero Valley, has the **sun's heat changed during the day**? If so, how?	1 Increased/hotter 2 Decreased/colder 3 No change 4 Other, specify: 88 DK 99 REF	
C11	During the time you have lived in the Kilombero Valley, has the **frequency of drought changed**? If so, how?	1 Increased frequency 2 Decreased frequency 3 No change 4 Other, specify: 88 DK 99 REF	
C12	During the time you have lived in the Kilombero Valley, has the **frequency of drying rivers changed**? If so, how?	1 Increased frequency 2 Decreased frequency 3 No change 4 Other, specify: 88 DK 99 REF	
C13	During the time you have lived in the Kilombero Valley, has the **incidence of crop diseases changed**? If so, how?	1 Increased 2 Decreased 3 No change 4 Other, specify: 88 DK 99 REF	
C14	During the time you have lived in the Kilombero Valley, has the **incidence of animal diseases changed**? If so, how?	1 Increased 2 Decreased 3 No change 4 Other, specify:	

		88 DK 99 REF	
READ: Now I am going to ask you questions about seasonality of rains over the last year. If you recall exact dates, please report them.			
C15	When did the **short rains** begin this year?	1 Early 2 Late 3 Normal _____DAY/MONTH 88 DK 99 REF	
C16	When did the **short rains** end this year?	1 Early 2 Late 3 Normal _____DAY/MONTH 88 DK 99 REF	
C17	How much did it rain during the **short rainy** season this year?	1 Greater than normal 2 Less than normal 3 Normal 88 DK 99 REF	
C18	When did the **long rains** begin this year?	1 Early 2 Late 3 Normal _____DAY/MONTH 88 DK 99 REF	
C19	When did the **long rains** end this year?	1 Early 2 Late 3 Normal _____DAY/MONTH 88 DK 99 REF	
C20	How much did it rain during the **long rainy** season this year?	1 Greater than normal 2 Less than normal 3 Normal 88 DK 99 REF	
SECTION D. Agricultural Practices			
#	**Question**	**Response**	**Notes/Skips**
READ: Now I am going to ask you questions about your own agricultural practices.			
D1	Do you own/rent/other agricultural land?	1 Own 2 Rent 3 Other, specify: _____acre/__ OWN	PLEASE CIRCLE ALL THAT APPLY AND SPECIFY AREA OWNED and RENTED and

		_____acre/__ RENT _____acre/__ OTHER 88 DK 99 REF	OTHER CIRCLE ACRE OR PROVIDE OTHER UNIT
D2	What is the **total** area of the agricultural land you farm?	_____(/acre/___) 88 DK 99 REF	CIRCLE ACRE OR PROVIDE OTHER UNIT
D3	Where do you obtain seeds for the crops you grow?	1 Agricultural extension officer 2 Friend/Neighbor 3 Market 4 Personal store/saved seeds 5 Family 6 Other, specify: 88 DK 99 REF	RANK ORDER **UP TO 3 SOURCES OF SEEDS** (MOST COMMON=1)
D4	How do you obtain seeds for the crops you grow?	1 Purchase 2 Trade 3 Save from previous years 4 Other, specify: 88 DK 99 REF	RANK ORDER **UP TO 3 WAYS TO OBTAIN SEEDS** (MOST COMMON=1)
D5	Do you own chickens or livestock? If **YES**, How many and which animals?	1 Yes 2 No ___ Chickens ____ Cattle ___ Sheep ___ Goats _ ___ Other, specify: 88 DK 99 REF	
D6	What is the area of the small plots (gardens) you farm?	_____(acre/___) 88 DK 99 REF	CIRCLE ACRE OR PROVIDE OTHER MEASURE **IF 0, PLEASE SKIP TO QUESTION D15**
D7	Who in this household is responsible for farming the small plots (gardens)?	1 Wife 2 Husband 3 Children (boys/girls) 4 Mother 5 Father 6 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**
D8	Where is/are the small plot(s) (gardens) located?	_____ 88 DK 99 REF	

D9	What is grown in the small plots (gardens)? Please indicate which of these crops are for cash (C), household (S) and mixed household-cash (M) use.	1 Maize C S M 2 Tomato C S M 3 Pigeon Pea C S M 4 Onion C S M 5 Carrot C S M 6 Cassava C S M 7 Yam C S M 8 Sweet Potato C S M 9 Cow peas C S M 10 Spinach C S M 11 Pumpkin C S M 12 Other, specify: C S M C S M C S M C S M 88 DK 99 REF	CIRCLE ALL THAT APPLY
D10	What strategies do you use when planting the small plots (gardens)?	1 Monocropping 2 Intercropping 3 Agroforestry 4 Till 5 No till 6 Other, specify: 88 DK 99 REF	RANK ORDER **UP TO 3 PLANTING STRATEGIES** (MOST COMMON=1)
D11	How frequently do your small plots (gardens) lie fallow?	1 Every other year 2 Every 2 years 3 Every 3 years 4 Never 5 Other, specify: 88 DK 99 REF	
D12	Why do you use this pattern of fallow for small plots (gardens)?	_____ _____ 88 DK 99 REF	
D13	How often do you shift cultivation in the small plots (gardens)?	1 Every year 2 Every other year 3 Every 2 years 4 Every 3 years 5 Never 6 Other, specify: 88 DK 99 REF	
D14	What external inputs do you use on your small plots (gardens)?	1 Fertilizer 2 Compost 3 Pesticides 4 Herbicides 5 Irrigation	CIRCLE ALL THAT APPLY ***SIGNIFY THOSE YOU ALWAYS USE**

		6 Drip irrigation 7 Other, specify: 88 DK 99 REF	
D15	Have you planted any fruit trees? If **yes**, which types and where?	1 Banana 2 Mango 3 Papaya 4 Lemon 5 Guava 6 Other, specify: 7 None 8 Near household 9 Away from household/in farmland 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST COMMON TREE PLANTED**
D16	What is the area of the large plots (shambas) you farm?	_____(acre/___) 88 DK 99 REF	CIRCLE ACRE OR PROVIDE OTHER UNIT
D17	Who in this household is responsible for farming the large plots (shambas)?	1 Wife 2 Husband 3 Children (boys/girls) 4 Mother 5 Father 6 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**
D18	Where is/are the large plot(s) (shambas) located?	_____ 88 DK 99 REF	
D19	What is grown in these large plots (shambas)?	1 Maize 2 Sugar Cane 3 Rice 4 Other, specify: 88 DK 99 REF	RANK ORDER (GREATEST AREA=1); IF AN "OUTGROWER", PLEASE INDICATE THE AREA YOU DEDICATE TO OUTGROWING SCHEMES & TO WHOM YOUR CROP IS SOLD
D20	What strategies do you use when planting the large plots (shambas)?	1 Monocropping 2 Intercropping 3 Agroforestry 4 Till 5 No till 6 Other, specify:	RANK ORDER **UP TO 3 PLANTING STRATEGIES** (MOST COMMON=1)

		88 DK 99 REF	
D21	How frequently do your large plots (shambas) lie fallow?	1 Every other year 2 Every 2 years 3 Every 3 years 4 Never 5 Other, specify: 88 DK 99 REF	
D22	Why do you use this pattern of fallow for large plots (shambas)?	_____ _____ 88 DK 99 REF	
D23	How often do you plant cover crops on large plots (shambas) between growing seasons?	1 Always 2 Never 3 Other, specify: 88 DK 99 REF	
D24	How do you plant your large plots (shambas)?	1 By hand alone 2 By hand with others 3 Mechanized alone 4 Mechanized with others 5 With animal alone 6 With animal with others 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST COMMON**
D25	What external inputs do you use on your large plots (shambas)?	1 Fertilizer 2 Compost 3 Pesticides 4 Herbicides 5 Irrigation 6 Drip irrigation 7 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THOSE YOU ALWAYS USE**
D26	What is the average yield per acre of crops in the large plots (shambas)?	crop…….. yield/acre _____ /acre _____ /acre _____ /acre _____ /acre _____ /acre 88 DK 99 REF	IF REPORTED IN BAGS, PLEASE HAVE RESPONDENTS SPECIFY WEIGHT OF BAGS; CIRCLE ACRE OR SPECIFY OTHER MEASURE
D27	During the time you have lived in the Kilombero Valley, have yields of staple grains (rice, maize) changed? If so, how?	Rice 1 Increased 2 Decreased 3 Constant Maize 1 Increased	IF INCREASE, READ **D28** IF DECREASE, READ **D29**

		2 Decreased 3 Constant 88 DK 99 REF	IF NO, CIRCLE CONSTANT, SKIP TO **D30**
D28	In your opinion, why have yields increased?	Rice 1 More favorable climate (rainfall and temperature) 2 Improved soil health 3 Better seeds 4 Use of external inputs 5 Other, specify: Maize 1 More favorable climate (rainfall and temperature) 2 Improved soil health 3 Better seeds 4 Use of external inputs 5 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**
D29	In your opinion, why have yields decreased?	Rice 1 Poor climate (rainfall and temperature) 2 Degraded soil health 3 Bad seeds 4 No use of external inputs 5 Other, specify: Maize 1 Poor climate (rainfall and temperature) 2 Degraded soil health 3 Bad seeds 4 No use of external inputs 5 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**
D30	During the time you have lived in the Kilombero Valley, has household hunger changed in frequency? If so, how?	1 Increased 2 Decreased 3 Constant 88 DK 99 REF	IF INCREASED, READ **D31** IF DECREASED, READ **D32** IF NO, CIRCLE CONSTANT, SKIP TO **D33**
D31	In your opinion, why has hunger increased?	1 Poor climate (rainfall and temperature) 2 Degraded soil health 3 Bad seeds 4 Poor market factors 5 Degraded food storage 6 Other, specify:	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**

		88 DK 99 REF	
D32	In your opinion, why has hunger decreased?	1 More favorable climate (rainfall and temperature) 2 Improved soil health 3 Better seeds 4 More favorable market factors 5 Improved food storage 5 Other, specify: 88 DK 99 REF	CIRCLE ALL THAT APPLY ***SIGNIFY THE MOST RESPONSIBLE**
READ: Now I am going to ask you questions about agricultural practices over the last year and in comparison to previous years.			
D33	In the last year, how much money did you spend on external inputs (fertilizers, herbicides, pesticides, irrigation, compost, etc.)?	_____ Tsh 88 DK 99 REF	ESTIMATES ARE ACCEPTABLE
D34	In the last year, how much money did you spend purchasing seeds?	_____ Tsh 88 DK 99 REF	ESTIMATES ARE ACCEPTABLE
D35	In the last year, how much grain (bags and weight) were you able to store, and how much did you sell (and at what price)?	_____ (type) Grain Stored: _____ kg/bag _____ number bags _____ (type) Grain Sold: _____ kg/bag _____ number bags _____ Tsh _____ (type) Grain Stored: _____ kg/bag _____ number bags _____ (type) Grain Sold: _____ kg/bag _____ number bags _____ Tsh _____ (type) Grain Stored: _____ kg/bag _____ number bags _____ (type) Grain Sold: _____ kg/bag _____ number bags _____ Tsh 88 DK 99 REF	ESTIMATES ARE ACCEPTABLE; PLEASE SPECIFY GRAIN TYPE
D36	How does last years' yields compare (kg and bags) to the	_____Last Year	ESTIMATES ARE ACCEPTABLE

	last good year of yields in your memory in the Kilombero Valley?	_____Last "Good" Year (YEAR: _____) 88 DK 99 REF	
SECTION E. Migration and Climate Change			
#	**Question**	**Response**	**Notes/Skips**
READ: Now I am going to ask you some questions about your opinions, or perceptions. There are no right or wrong answers. I am only interested in your experience.			
E1	In your view, should immigration to the Kilombero Valley change? If so, how?	1 Increase 2 Decrease 3 Stay the same 4 Other, specify: 88 DK 99 REF	
E2	In your opinion, why are most migrants from other places moving to the Kilombero Valley?	1 Work/financial opportunity 2 Family 3 Education 4 Environment 5 Escape bad conditions 6 Health/medical/illness 7 Climate (rainfall and temperature) 8 Fertile agricultural land 9 Other, specify: 95 Not aware of any migrants 88 DK 99 REF	RANK ORDER **UP TO 3 REASONS** (MOST RESPONSIBLE=1)
E3	What is your opinion of migrants to the Kilombero Valley?	1 Positive to the community 2 Negative to the community 3 Other, specify: 95 Not aware of any migrants 88 DK 99 REF	
E4	During the time you have lived in the Kilombero Valley, has the number of migrants moving to the Kilombero Valley for fertile agricultural land changed? If so, how?	1 Increased 2 Decreased 3 Constant 4 Other, specify: 95 Not aware of any migrants 88 DK 99 REF	
E5	During the time you have lived in the Kilombero Valley, has the number of migrants moving to the Kilombero Valley due to climatic issues (temperature and rainfall) changed? If so, how?	1 Increased 2 Decreased 3 Constant 4 Other, specifiy: 95 Not aware of any migrants	

		88 DK 99 REF	
SECTION F. Completion			
INTERVIEW END TIME _____:_____			
READ: Thank you for your time. Do you have any questions or concerns? **IF NOT**: Proceed with close-out.			
INTERVIEWER COMMENTS:			

Appendix D. Household survey (Swahili)

Uhamiaji, Maoni ya Tabia Nchi & Shughuli za Kilimo Katika Bonde la Kilombero, TZ: 2017
Siri: Data Kwa Ajili Ya Utafiti Tu.
CHUO KIKUU CHA PENNSYLVANIA

Taarifa za Usaili

Tarehe ya Usaili:
Jina la Msaili: Muda wa Kuanza Usaili:
Kifupi Cha Majina ya Mkaguaji : Tarehe iliyoingizwa kwenye kompyuta :

Utangulizi na Ridhaa

Habari, jina langu ni _____. Ninafanya kazi naChuo Kikuu Cha Pennsylvania kilichopo Marekani. Tunafanya utafiti kuhusu uhamiaji, maoni ya tabia nchi, na shughuli za kilimo katika Bonde la Kilombero, kuongeza data zilizokusanywa kiindi cha nyuma kuhusu matumizi ya katika ngazi ya kaya. Taarifa tutakazokusanya zitatumika katika uelewa kuhusu uhamiaji, tabia nchi, na kilimo hapa Tanzania. Majibu yote yatakuwa ni siri na siri kabisa. Kaya yako imechaguliwa katika utafiti. Ungependa kusikia Zaidi kuhusu utafiti huu?

[TOA FOMU YA RIDHAA]

MDODOSWAJI AMEKUBALI **[ENDELEA NA DODOSO]**	MDODOSWAJI AMEKATAA **[ACHA]**

Msaili: Hakikisha kwamba usaili unafanyika katika eneo ambalo ni la faragha sehemu ambayo watu wengine hawataweza kusikia maswali na majibu. Kama hii haitawezekana, ACHA dodoso. Pia, tafadhali andika pembeni kutu chochote ambacho kitakuwa kinavutia ambacho mdodoswaji anakisema na kijumuishe kwenye sehemu karibu na swali la muda, au mwisho wa dodoso.

SEHEMU A. Utangulizi

#	Swali	Majibu	Noti/ Ondoka
A1	**USISOME**: Mdodoswaji ni mwanamke au mwanaume?	Mwanaume Mwanamke	
A2	Una umri gani?		
A3	Ni mwezi gani na mwaka gani uliozaliwa?	_____MM 88 DK / 99 REF _____YYYY 8888 DK / 9999 REF	
A4	Nini hali yako ya Ndoa?	1 Kamwe sijaoa au olewa 2 Tunaishi amoja 3 Ndoa ya mke na mume mmoja tu 4 Ndoa ya mume na wake wengi 5 Tumepeana talaka 6 Tumeachana 7 Ni mjane 88 DK 99 REF	
A5	Watoto wangapi umeshawahi kuwa		

	nao?	_____ Idadi 88 DK 99 REF	
A6	Ulishwawahi kusoma shule?	1 Ndio 2 Hapana 88 DK 99 REF	KAMA HAPANA, NENDA A8
A7	Una elimu gani?	1 Shule ya Msingi 2 Sekondari 3 Elimu ya Juu 88 DK 99 REF	
A8	Wewe ni dini gani?	1 Katoliki 2 Anglikana 3 Methodist 4 Presbyterian 5 Pentecoste/Charismatic 6 Msabato 7 Zehebu lengine la kikristo 8 Muislam 9 Unaamini utamaduni 10 Hauna dini 11 Dini nyengine, elezea: 88 DK 99 REF	
A9	Unatokea kabila gani?	_____ 88 DK 99 REF	
A10	Lugha gani wewe au watu wengine kwenye kaya hii mnaongea, na katika ngazi gani ya uelewa wa lugha hiyo?	1 _____ 2 _____ 3 _____ 4 _____ 88 DK 99 REF	1 = hapana hatujui sana 2 = tunajua kidogo 3 =tunajua tu kwa mazungumzo 4 = ni lugha ya asili yangu au naongea lugha mbili
A11	Ukiachilia mbali Kiswahili, wewe au mtu mwengine kwenye kaya anaongea lugha ya kabila lenu nyumbani au sehemu nyengine? Kama **NDIO**, wapi, kwanini, na mara ngapi?	1 Ndio 2Hapana Wapi? _____ Kwanini? _____ Mara ngapi? _____ 88 DK 99 REF	
A12	Watoto wadogo kwenye kaya yako	1 Ndio	KAMA HAPANA,

	(ndugu wadogo, watoto wako, watu vijana ambao unaishi nao) wanaongea lugha ya kabila lako?	2 Hapana 88 DK 99 REF	NENDA **A16**
A13	Umejifunzaje?	1 Mama/Baba 2 Mababu na Mabibi 3 Marafiki 4 Majirani 5 Shule 6 Nyegine, eleza: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZO SAHIHI ***WEKA ALAMA HII KUONESHA UMUHIMU SANA**
A14	Nini uwezo wako wakuongea lugha yako ya kabila?	1 Hapana sio sana 2 Naongea tu kidogo 3 Kwaajili tu yamaongezi 4 Ni lugha ya asili au naongea lugha mbili 88 DK 99 REF	
A15	Ni levo ipi ya kuongea lugha ya kikabila kwa wanakaya wengine (mchumba, watu wazima wengine, n.k.?	1 Hapana hakuna uwezo sana 2 Naongea tu kidogo 3 Kwaajili tu ya maongezi 4 Ni lugha ya asili au naongea lugha mbili. 88 DK 99 REF	NENDA **B1**
A16	Kwanini unafikiri hawaongei lugha yao ya asili?	_____ _____ 88 DK 99 REF	
SEHEMU B. Uhamiaji na Kuhama hama			
#	**Swali**	**Majibu**	**Noti/Ondoka**
SOMA: Sasa nataka nikuulize maswali kuhusu sehemu ambazo ulishaishi na muda ambao ulihama au kusafiri.			
B1	Mkoa gani ulizaliwa?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya 14 Morogoro 15 Mtwara 16 Mwanza	

		17 Njombe 18 Pemba N 19 Pemba S 20 Pwani 21 Rukwa 22 Ruvuma 23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar Ksakazini 30 Zanzibar Kusini na Katikati 31 Zanzibar Magharibi 32 Nyengine, elezea: 88 DK 99 REF	
B2	Nini jina la sehemu, jiji, au mji uliozaliwa?	_____ 88 DK 99 REF	
B3	Sehemu uliyozaliwa ni (kijijini au nje ya mji) au mjini (mjini au jiji)?	1 Kijijini 2 Mjini 88 DK 99 REF	
B4	Ni Muda gani sasa umeishi katika bonde hili la Kilombero?	_____ Miaka _____ Miezi 98 Miaka yote 88 DK 99 REF	KAMA NI MIAKA YOTE NENDA **B9**
B5	Sehemu gani, jiji au mjini uliishi kabla ya Bonde la Kilombero?	_____ 88 DK 99 REF	
B6	Ni mkoa gani uliishi kabla haujakuja kwenye Bonde la Kilombero?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya 14 Morogoro 15 Mtwara 16 Mwanza	

		17 Njombe 18 Pemba Kaskazini 19 Pemba Kusini 20 Pwani 21 Rukwa 22 Ruvuma 23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar Kaskazini 30 Zanzibar Kusini na Katikati 31 Zanzibar Magharibi 32 Nyengine, elezea: 88 DK 99 REF	
B7	Ulihamia na nani kwenye Bonde hili la Kilombero?	1 Mke/Mume/Mchumba 2 Mama/Baba 3 Watoto 4 Familia 5 Hapana mtu (nilikuja mwenyewe) 88 DK 99 REF	
B8	Kipi kilisababisha wewe uhamie katika Bonde la Kilombero?	1 Kazi/fursa za kifedha 2 Familia 3 Elimu 4 Mazingira 5 Kukimbia hali mbaya 6 Afya/Matibabu/Magonjwa 7 Tabia nchi (mvua na joto) 8 Rutuba na ardhi ya kilimo 9 Mengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE AMBAZO ZINAHUSIKA
B9	Ni mkoa gani ambao mke/mume/mchumba alishi kabla ya Bonde la Kilombero?	1 Arusha 2 Dar es Salaam 3 Dodoma 4 Geita 5 Iringa 6 Kagera 7 Katavi 8 Kigoma 9 Kilimanjaro 10 Lindi 11 Manyara 12 Mara 13 Mbeya	KAMA SIO MHAMAJI ONDOKA KWENDA **B11** KAMA HAKUNA MCHUMBA ONDOKA NENDA TO **B11**

		14 Morogoro 15 Mtwara 16 Mwanza 17 Njombe 18 Pemba Ksakazini 19 Pemba Kusini 20 Pwani 21 Rukwa 22 Ruvuma 23 Shinyanga 24 Simiyu 25 Singida 26 Songwe 27 Tabora 28 Tanga 29 Zanzibar Kaskazini 30 Zanzibar Kusini and Katikati 31 Zanzibar Magharibi 32 Mengine, elezea: 96 Hakuna mchumba 97 Kamwe sio mhamiaji 88 DK 99 REF	
B10	Nini ilikua sababu ya mkeo/mumeo/ mchumba wako kuhamia katika Bonde la Kilombero?	1 Tulihamia kama familia katika Bonde la Kilombero 2 Kazi/fursa za kifedha 3 Familia 4 Elimu 5 Mazingira 6 Kukimbia hali mbaya 7 Afya/matibabu/ugonjwa 8 Tabia nchi (mvua na joto) 9 Rutuba na ardhi ya kilimo 10 Mengineyo, elezea: 97 Kamwe sio mhamaji 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI
B11	Vijiji vingapi umeishi katika Bonde la Kilombero?	_____ (idadi ya vijiji) 88 DK 99 REF	KAMA HAPANA NENDA **B14**
B12	Taja majina ya maeneo ambayo uliwahi kuishi katika Bonde la Kilombero?	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____	

		88 DK 99 REF	
B13	Umeishi kwa muda gani mfululizo katika nyumba /jengo hili?	_____ Miaka _____ Miezi 98 Maisha Yote 88 DK 99 REF	
SOMA: Sasa nataka nikuulize maswali kuhusu uzoefu wako wa mwaka jana, ikijumuisha maswali kuhusu kazi na kipato chako.			
B14	Kazi yako kubwa ni ipi?	_____ 88 DK 99 REF	
B15	Mikakati gani mengine unayoitumia kuongezea kwenye kazi yako kuu?	1 _____ 2 _____ 3 _____ 4 _____ 88 DK 99 REF	
B16	Je unapokea na/au kutuma pesa kwenda na/au kutoka kwa familia? Kama **NDIO**, kiasi gani cha pesa ulituma na/au kupokea kwa wastani wa kila mwezi?	1 Ndio 2 Hapana _____Tsh imetumwa _____ Tsh imepokelewa 88 DK 99 REF	Kama **HAPANA**, soma B17A; Kama **NDIO**, soma B17B.
B17	A. Kipi kilikuwa kipato chako mwaka jana? B. Kipi kilikuwa kipato chako mwaka jana kabla ya kutuma na/au kupokea pesa?	_____ Tsh 88 DK 99 REF	
SEHEMU C. Joto na Maoni ya Mvua			
#	**Swali**	**Majibu**	**Noti/Ondoka**
SOMA: Sasa nataka nikulize maswali kuhusu maoni yako, au mtazamo wako. Hakuna jibu sahihi au siosahihi. NIngependa tu kujua uzoefu wako.			
C1	Lini mvua za **vuli zinanyesha?**	1 Januari 2 Februari 3 Machi 4 Aprili 5 Mei 6 Juni 7 Julai 8 Agosti 9 Septemba 10 Oktoba	ZUNGUSHIA MIEZI YOTE ILIYOSAHIHI

		11 Novemba 12 Disemba 88 DK 99 REF	
C2	Lini mvua **za masika zinanyesha**?	1 Januari 2 Februari 3 Machi 4 Aprili 5 Mei 6 Juni 7 Julai 8 Agosti 9 Septemba 10 Oktoba 11 Novemba 12 Disemba 88 DK 99 REF	ZUNGUSHIA MIEZI YOTE AMBAYO NI SAHIHI
Msaili USISOME KWA NGUVU: Yaulize maswali mawili ya mwanzo kwa namna moja. Soma maswali. Kama mdodoswaji atajibu **HAPANA**, zungushia “Hakuna Mabadiliko” na **ONDOKA** nenda swali linalofuata. Kama mdodoswaji atajibu NDIO, **SOMA** “Kama ni hivyo, kivipi?” na rekodi majibu yao.			
C3	Katika kipindi ulichoishi katika Bonde la Kilombero, wingi wa mvua umebadilika katika kipindi cha **mvua za vuli**? Kama ni hivyo, kivipi?	1 Umeongezeka kiwango 2 Umepungua kiwango 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C4	Katika kipindi ulichoishi katika Bonde la Kilombero, wingi wa mvua umebadilika katika kipindi cha **mvua za masika**? Kama ni hivyo, kivipi?	1 Umeongezeka kiwango 2 Umeungua kiwango 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C5	Katika kipindi ulichoishi katika Bonde la Kilombero, muda wa kunyesha mvua umebdalika katika kipindi cha **mvua za vuli**? Kama ni hivyo, kivipi?	1 Zinawahi kunyesha mapema 2 Zinachelewa kunyesha 3 Zinaaisha mapema 4 Zinachelewa kuisha 5 Kuna mabadiliko makubwa 6 Kuna mabadiliko madogo 7 Zinatabirika sana 8 Zinatabirika kidogo 9 Hakuna mabadiliko 10 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE AMBAZO NI SAHIHI ***ALAMA HII INAELEZEA MABIDILIKO MAKUBWA KABISA**
C6	Katika kipindi ulichoishi katika Bonde la Kilombero, muda wa kunyesha mvua umebdalika katika kipindi cha **mvua za masika**?	1 Zinawahi kunyesha mapema 2 Zinachelewa kunyesha 3 Zinaisha mapema 4 Zinachelewa kuisha	ZUNGUSHIA ZOTE AMBAZO NI SAHIHI ***ALAMA HII**

	Kama ndivyo, kivipi?	5 Kuna mabadiliko makubwa 6 Kuna mabadiliko madogo 7 Zinatabirika sana 8 Zinatabirika kidogo 9 Hakuna mabadiliko 10 Nyengine, elezea: 88 DK 99 REF	**INAELEZEA MABIDILIKO MAKUBWA KABISA**
C7	Katika ki**p**indi ulichoishi katika Bonde la Kilombero, hali ya jotoridi imebadilika **kipindi cha asubuhi**? Kama ndivyo, kivipi?	1 Imeongezeka/joto 2 Imepungua/baridi 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C8	Katika kipindi ulichoishi katika Bonde la Kilombero, hali ya jotoridi imebadilika **katika ki**p**indi cha mchana**? Kama ndivyo, kivipi?	1 Imeongezeka/joto 2 Imepungua/baridi 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C9	Katika ki**p**indi ulichoishi katika Bonde la Kilombero, hali ya jotoridi **imebadilika katika kipindi cha usiku**? Kama ndivyo, kivipi?	1 Imeongezeka/joto 2 Imepungua/baridi 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C10	Katika ki**p**indi ulichoishi katika Bonde la Kilombero, joto la jua limebadilika katika ki**p**indi cha mchana? Kama ndivyo, kivipi?	1 Imeongezeka/joto 2 Ime**p**ungua/baridi 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C11	Katika ki**p**indi ulichoishi katika Bonde la Kilombero, hali ya kutokea kwa ukame imebadilika? Kama ndivyo, kivipi?	1 Imeongeza kutokea 2 Ime**p**ungua kutokea 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C12	Katika kipindi ulichoishi katika Bonde la Kilombero, **hali ya kukauka kwa mito imebadilika**? Kama ndivyo, kivipi?	1 Imeongezeka kutokea 2 Imepungua kutokea 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
C13	Katika ki**p**indi ulichoishi katika Bonde la Kilombero, **matukio ya magonjwa ya mazao yamebadilika**? Kama ndivyo, kivi**p**i?	1 Yameongezeka 2 Yame**p**ungua 3 Hakuna mabadiliko 4 Nyengine, elezea:	

		88 DK 99 REF	
C14	Katika kipindi ulichoishi katika Bonde la Kilombero, matukio ya magonjwa ya mifugo imebadilika? Kama ndivyo, kivipi?	1 Imeongezeka 2 Imeungua 3 Hakuna mabadiliko 4 Nyengine, elezea: 88 DK 99 REF	
SOMA: Sasa nataka nikuulize maswali kuhusu misimu ya mvua katika kiindi cha mwaka mmoja uliopita. Kama unakumbuka tarehe kamili, tafadhali iseme.			
C15	Lini **mvua za vuli** zilianza mwaka huu?	1 Mapema 2 Zilichelewa 3 Kawaida _____SIKU/MWEZI 88 DK 99 REF	
C16	Lini **mvua za vuli** ziliisha mwaka huu?	1 Mapema 2 Zilichelewa 3 Kawaida _____SIKU/MWEZI 88 DK 99 REF	
C17	Kwa kiasi gani ilinyesha katika kiindi cha **mvua za vuli** katika msimu huu?	1 Nyingi kuliko kawaida 2 Chache kuliko kawaida 3 Kawaida 88 DK 99 REF	
C18	Lini **mvua za masika** zilianza kunyesha mwaka huu?	1 Mapema 2 Zilichelewa 3 Kawaida _____SIKU/MWEZI 88 DK 99 REF	
C19	Lini **mvua za masika** ziliisha mwaka huu?	1 Mapema 2 Zilichelewa 3 Kawaida _____SIKU/MWEZI 88 DK 99 REF	
C20	Kwa kiasi gani ilinyesha katika kipindi cha **mvua za masika** mwaka huu?	1 Nyingi kuliko kawaida 2 Chache kuliko kawaida 3 Kawaida 88 DK 99 REF	
SEHEMU D. Shuguli za Kilimo			
#	**Maswali**	**Majibu**	**Noti/Ondoka**

SOMA: Sasa nataka nikuulize maswali kuhusu shughuli zako wewe za kilimo.			
D1	Unamiliki/kukodi/ardhi nyengine za kilimo?	1 Miliki 2 Kodisha 3 Nyengine, elezea: _____ekari/__ MILIKI _____ekari/__ KODISHA _____ekari/__ NYENGINE 88 DK 99 REF	TAFADHALI ZUNGUSHIA ZOTE ZILIZOSAHIHI NA ENEO LINALOMILIKIWA na KUKODISHWA na NYENGINE ZUNGUSHIA EKARI AU ANDIKA KIPIMO KINGINE
D2	Nini ukubwa wa ardhi yote ya eneo lako la kilimo unalolima?	_____(/ekari/___) 88 DK 99 REF	ZUNGUSHIA EKARI AU ANDIKA KIPIMO KINGINE
D3	Wapi unapata **mbegu** ya mazao unayolima?	1 Afisa Ugani 2 Rafiki/Jirani 3 Sokoni 4 HIfadhi yangu binafsi/mbegu zilizohifadhiwa 5 Familia 6 Nyengine, elezea: 88 DK 99 REF	**P**ANGA KWA ODA HADI NJIA 3 ZA KU ZUNGUSHIA ZOTE ZILIZOSAHIHI **ZA KUPATA MBEGU** (INAYOTUMIKA SANA=1))
D4	Unapataje mbegu kwa mazao unayolima ?	1 Nunua 2 Biashara 3 Imehifadhiwa tangu mwaka jana 4 Nyengine, elezea: 88 DK 99 REF	**P**ANGA KWA ODA HADI NJIA 3 ZA KU ZUNGUSHIA ZOTE ZILIZOSAHIHI **ZA KUPATA MBEGU** (INAYOTUMIKA SANA=1)
D5	Je, unamiliki kuku au mfugo mwengine wowote? Kama **NDIO**, Wangapi na ni wanyama gani?	1 Ndio 2 Hapana ___ Kuku ____ Ng'ombe ___ Kondoo ___ Mbuzi _ ___ Nyengine, elezea: 88 DK 99 REF	
D6	Nini ukubwa wa eneo la sehemu ndogo (bustani) unalolima?	_____(ekari/___) 88 DK 99 REF	ZUNGUSHIA EKARI au ANDIKA KIPIMO KINGINE **KAMA 0, TAFADHALI NENDA SWALI D15**

D7	Nani katika nyumba hii anajukumu la kulima kwenye eneo dogo (bustani)?	1 Mke 2 Mume 3 Watoto (wakiume/wakike) 4 Mama 5 Baba 6 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INATUMIKA ZAIDI**
D8	Wapi eneo dogo hilo (bustani) linapatikana?	_____ 88 DK 99 REF	
D9	Kipi kinacholimwa katika sehemu ndogo (bustani))? Tafadhali elezea yai kati ya mazao yafuatayo ni kwaajili ya Keshi (C), Matumizi ya Kaya (S) na matumizi mchanganyiko wa keshi na kaya (M).	1 Mahindi C S M 2 Nyaya C S M 3 Mbaazi C S M 4 Vitunguu C S M 5 Karoti C S M 6 Muhogo C S M 7 Magimbi C S M 8 Viazi vitamu C S M 9 Kunde C S M 10 Spinchi C S M 11 Boga C S M 12 Nyengine, elezea: C S M C S M C S M C S M 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI
D10	Mikakati gani unaitumia kupanda katika eneo dogo (bustani)?	1 Kilimo cha zao moja 2 Kilimo cha mazao mchanganyiko 3 Kilimo mseto 4 Kuchimbua ardhi 5 Hapana kuchimbua ardhi 6 Nyengine, elezea: 88 DK 99 REF	ANGA KW AODA **HADI MIKAKATI 3** (UNAOTUMIKA SANA=1))
D11	Je, mara ngapi unaacha shamba lako dogo (**bustani)** bila ya kupanda?	1 Kila baada ya mwaka mmoja 2 Kila miaka 2 3 Kila miaka 3 4 Kamwe 5 Nyengine, elezea: 88 DK 99 REF	
D12	Kwanini unatumia mfumo huu wa kuacha eneo bila ya kupandwa kwa eneo dogo (bustani)?	_____ _____	

		88 DK 99 REF	
D13	Mara ngapi unafanya kilimo cha kuhama hama katika eneo lako dogo unalolima (bustani)?	1 Kila mwaka 2 Kila baada ya mwaka mmoja 3 Kila baada ya miaka 2 4 Kila baada ya miaka 3 5 Kamwe 6 Nyengine, elezea: 88 DK 99 REF	
D14	Ni pembejeo gani unazotumia katika eneo lako dogo (bustani)?	1 Mbolea ya viwandani 2 Mbolea ya asili (mboji) 3 Madawa yakuua wadudu 4 Madawa wa kuua majani 5 Umwagiliaji 6 Umwagiliaji wa dripu 7 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAZO ZINATUMIA DAIMA**
D15	Je, umepanda miti yoyote ile ya matunda? Kama **ndio**, ni ya aina gani na wapi?	1 Ndizi 2 Embe 3 Papai 4 Limau 5 Pera 6 Nyengine, elezea 7 Hakuna 8 Karibu na nyumbani 9 Mbali na nyumbani/ shambani 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA MITI UNAYOIPANDA DAIMA**
D16	Nini ukubwa wa eneo la shamba unalolima?	_____(ekari/___) 88 DK 99 REF	ZUNGUSHIA EKARI AU ANDIKA KIPIMO KINGINE
D17	Nani katika kaya anajukumu la kulima katika shamba lenye eneo kubwa?	1 Mke 2 Mume 3 Watoto (wakiume/wakike) 4 Mama 5 Baba 6 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA MUHUSIKA MKUU**
D18	Wapi shamba hilo linapatikana?	_____ 88 DK 99 REF	
D19	Nini kinalimwa katika shamba hili?	1 Mahindi 2 Muwa	ANGA KWA ODA (ENEO

		3 Mpunga 4 Nyengine, elezea: 88 DK 99 REF	KUBWA=1); KAMA NI "MLIMAJI WA NJE", TAFADHALI ONEHA ENEO UTAKALOFANYIA KILIMO CHA NJE &KWA NANI ZAO LAKO UTALIUZA
D20	Mikakati gani unayotumia wakati unapolima katika shamba kubwa?	1 Kilimo cha Zao Moja 2 Kilimo cha mazao tofauti 3 Kilimo mseto 4 Kuchimbua ardhi 5 Hapana kuchimbua ardhi 6 Nyengine, elezea: 88 DK 99 REF	ANGA KW AODA **HADI MIKAKATI 3** (UNAOTUMIKA SANA=1)
D21	Ni mara ngai katika shamba lako kubwa linakaa bila ya kupandwa?	1 Kila baada ya mwaka mmoja 2 Kila miaka 2 3 Kila miaka 3 4 Kamwe 5 Nyengine, elezea: 88 DK 99 REF	
D22	Kwanini unatumia aina hii ya utaratibu wa kuacha kupanda?	_____ _____ 88 DK 99 REF	
D23	NI mara ngai unapanda mazao ya kutambaa kwenye shamba lako katikati ya misimu ya kilimo?	1 Daima 2 Kamwe 3 Nyengine, elezea: 88 DK 99 REF	
D24	Ni vipi unapanda shamba lako kubwa?	1 Kwa mkono peke yake 2 Kwa mkono na njia nyengine 3 Kwakutumia mashine pekee 4 Kwa mashine na njia nyengine 5 Kwa wanyama peke yake 6 Kwa wanyama na njia nyengine 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INATUMIKA SANA**
D25	Je unatumia pembejeo gani katika shamba lako kubwa?	1 Mbolea ya dukani 2 Mbolea ya asili 3 Madawa ya kuua wadudu 4 Madawa ta kuua majani 5 Umwagiliaji 6 Umwagiliaji wa dripu 7 Nyengine, elezea:	ZUNGUSHIA ZOTE AMBAZO NI SAHIHI ***INAELEZEA ZOTE AMBAZO UNATUMIA DAIMA**

		88 DK 99 REF	
D26	Nini wastani wa mazao kwa ekari katika eneo la shamab lako kubwa?	zao…….. mavuno/ekari _____ /ekari _____ /ekari _____ /ekari _____ /ekari _____ /ekari 88 DK 99 REF	KAMA IKITAJWA KWA GUNIA, PLEASE HAVE MDODOSWAJI AELEZE UZITO; ZUNGUSHIA EKARI AU TAJA KIIMO KINGINE KILICHOTUMIKA
D27	Katika kipindi ulichoishi Bonde la Kilombero, mavuno ya mazao ya nafaka yanayoliwa sana (mpunga, mahindi, etc.) yamebadilika? Kama ndivyo, kivipi?	Mchele 1 Umeongezeka 2 Umeungua 3 Uko vile Mahindi 1 Umeongezeka 2 Umeungua 3 Uko vile Nyengine, elezea: 1 Umeongezeka 2 Umepungua 3 Uko vile 88 DK 99 REF	KAMA IMEONGEZEKA SOMA **D28** IKAMA IMEUNGUA SOMA **D29** KAMA HAPANA, ZUNGUSHIA VILE VILE, ONDOKA NENDA **D30**
D28	Kwa maoni yako, kwanini mavuno yameongezeka?	**Mchele:** 1 Hali nzuri ya tabia nchi (mvua na joto) 2 Afya ya ardhi iliyoboreshwa 3 Mbegu bora 4 Matumizi ya pembejeo 5 Nyengine, elezea: **Mahindi** 1 Hali nzuri ya tabia nchi (mvua na joto) 2 Afya ya ardhi iliyoboreshwa 3 Mbegu bora 4 Matumizi ya pembejeo 5 Nyengine, elezea 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INAJUKUMU KUBWA**
D29	Kwa maoni yako, kwanini mavuno yamepungua?	**Rice** 1 Hali mbaya ya tabia nchi (mvua na joto) 2 Afya ya udongo iliyoharibiwa 3 Mbegu mbaya 4 Hakuna matumizi ya embejeo 5 Nyengine, elezea: **Mahindi**	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INATUIMIKA SANA**

		1 Hali nzuri ya tabia nchi (mvua na joto) 2 Afya ya ardhi iliyoboreshwa 3 Mbegu bora 4 Matumizi ya pembejeo 5 Nyengine, elezea 88 DK 99 REF	
D30	Katika kipindi ulichoishi katika Bonde la Kilombero, kuna mabadiliko yoyote ya njaa ya kaya? Kama ndivyo, kivipi?	1 Imeongezeka 2 Imepungua 3 Vile vile 88 DK 99 REF	KAMA IMEONGEZEKA SOMA **D31** KAMA IMEUNGUA SOMA **D32** KAMA HAPANA , ZUNGUSHIA VILE VILE, ONDOKA NENDA **D33**
D31	Kwa maoni yako, kwanini njaa imeongezeka?	1 Hali mbaya ya tabia nchi (mvua na joto) 2 Afya ya ardhi iliyoharibiwa 3 Mbegu mbaya 4 Hali mbaya ya masoko 5 Kuharibika kwa masoko 6 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INATUMIKA SANA**
D32	Kwa maoni yako, kwanini njaa imepungua?	1 Hali nzuri ya tabia nchi (mvua na joto) 2 Afya bora ya udongo 3 Mbegu bora 4 Hali nzuri ya masoko 5 Hali nzuri ya mahali a kuhifadhia mbegu 6 Nyengine, elezea: 88 DK 99 REF	ZUNGUSHIA ZOTE ZILIZOSAHIHI ***INAELEZEA AMBAYO INATUMIA SANA**
SOMA: Sasa nataka nikuulize maswali kuhusu shughuli za kilimo katika kiindi cha mwaka mmoja uliopita na ukilinganisha na miaka iliyopita.			
D33	Katika kipindi cha mwaka jana, how kiasi gani cha esa ulitumia katika manunuzi ya pembejeo (mbolea za dukani, madawa ya kuua majani, madawa yakuua wadudu, umwagiliaji, mbolea ya asili, nk.)?	_____ Tsh 88 DK 99 REF	MAKADIRIO YANAKUBALIKA
D34	Katika kipindi cha mwaka jana, ni kiasi gani ha pesa ulitumia katika kununua mbegu?	_____ Tsh 88 DK 99 REF	MAKADIRIO YANAKUBALIKA
D35	Katika kipindi cha mwaka jana kiasi cha nafaka (gunia na uzito)	_____ (aina) Nafaka iliyohifadhiwa:	MAKADIRIO YANAKUBALIKA;

	uliweza kuhifadhi, na kiasi gani uliuza (na kwa bei gani)?	_____ kg/gunia _____ idadi ya gunia _____ (aina) Nafaka Iliyouzwa: _____ kg/gunia _____ idadi ya gunia _____ Tsh _____ (aina) Nafaka iliyohifadhiwa: _____ kg/gunia _____ idadi ya gunia _____ (aina) Nafaka iliyouzwa: _____ kg/gunia _____ idadi ya magunia _____ Tsh _____ (aina) Nafaka iliyohifadhiwa: _____ kg/gunia _____ idadi ya gunia _____ (aina) Nafaka iliyouzwa: _____ kg/gunia _____ idadi ya magunia _____ Tsh 88 DK 99 REF	TAFADHALI ELEZEA AINA YA NAFAKA
D36	Vipi mavuno yam waka jana (kg and magunia) ukilinganisha na miaka ya nyuma katika kumbukumbu zako za mavuno katika Bonde la Kilombero?	_____Mwaka Jana _____Mwaka 'Jana Mzuri' (MWAKA: _____) 88 DK 99 REF	MAKADIRIO YANAKUBALIKA
SEHEMU E. Uhamiaji na mabadiliko ya Tabia Nchi			
#	**Maswali**	**Majibu**	**Noti/Ondoka**
SOMA: Sasa nataka nikuulize maswali kuhusu maoni yako, au mtazamo wako. Hakuna JIbu sahihi au sisahihi. Nataka tu kujua uzoefu wako.			
E1	Kwa maoni yako, hali ya uhamiaji katika Bonde la Kilombero umebadilika? Kama ndivyo, kivipi?	1 Imeongezeka 2 Imepungua 3 Vile 4 Nyengine, elezea: 88 DK 99 REF	
E2	Kwa maoni yako, kwanini wahamiaji kutoka maeneo mengine wanakuja Bonde la Kilombero?	1 Kazi/fursa za kifedha 2 Familia 3 Elimu 4 Mazingira 5 Kukimbia hali mbaya 6 Afya/matibabu/magonjwa 7 Tabia nchi (mvua na joto)	PANGA KWA ODA MPAKA 3 (SABABU KUBWA=1)

		8 Ardhi ta Kilimo yenye rutuba 9 Nyengine, elezea: 95 Sijui chochote kuhusu uhamiaji 88 DK 99 REF	
E3	Nini maoni yako kwa uhamiaji katika Bonde la Kilombero?	1 Chanya katika Jamii 2 Hasi katika Jamii 3 Nyengine, elezea: 95 Sijui chochote kuhusu uhamiaji 88 DK 99 REF	
E4	Katika kiindi ulichoishi katika Bonde la Kilombero, idadi ya watu wanaohamia katika Bonde la Kilombero kwa ajili ya ardhi yenye rutuba imebadilika? Kama ndivyo, kivipi?	1 Umeongezeka 2 Umeungua 3 Vile 4 Nyengine, elezea: 95 Sijui chochote kuhusu uhamiaji 88 DK 99 REF	
E5	Katika kipindi ulichoishi katika Bonde la Kilombero, idadi ya watu wanaohamia katika Bonde la Kilombero kwa ajili ya mambo ya tabia nchi (joto na mvua) umebadilika? Kama ndivyo, kivipi?	1 Umeongezeka 2 Umeungua 3 Vile 4 Nyengine, elezea: 95 Sijui chochote kuhusu uhamiaji 88 DK 99 REF	
SEHEMU F. Hitimisho			
MWISHO WA MUDA WA USAILI _____:_____			
SOMA: Asante sana kwa muda wako. Je una maoni au hofu yoyote? **KAMA SIVYO**: Endelea kufunga.			
MAONI YA MSAILI: