Rattan Lal · Bal Ram Singh
Dismas L. Mwaseba · David Kraybill
David O. Hansen · Lars Olav Eik *Editors*

# Sustainable Intensification to Advance Food Security and Enhance Climate Resilience in Africa

Springer

*Editors*
Rattan Lal
Carbon Management and Sequestration Center
Ohio State University OARDC
Columbus, OH, USA

Bal Ram Singh
Department of Environmental Sciences
Norwegian University of Life Sciences
Ås, Norway

Dismas L. Mwaseba
Sokoine University of Agriculture
Morogoro, Tanzania

David Kraybill
AEDE/CFAES
The Ohio State University
Columbus, OH, USA

David O. Hansen
IPA/CFAES
The Ohio State University
Columbus, OH, USA

Lars Olav Eik
Department of International Environment and Development Studies/Noragric
Norwegian University of Life Sciences (NMBU)
Ås, Norway

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# Preface

The Green Revolution of the 1960s and 1970s in South Asia and elsewhere did not happen in Sub-Saharan Africa (SSA). Indeed, agriculture in SSA either stagnated or regressed during the second half of the twentieth century and has lagged behind that of Asia and other parts of the developing world. Yet, a large part of the population of SSA is dependent on agriculture. It underpins the livelihoods of ~70 % of Africa's poor and under-privileged population. Agriculture in SSA is characterized by small farms of less than two 2 ha and subsistence farming which is typically characterized by the use of hand tools and manual labor and the absence of other inputs, including agrochemicals and irrigation.

That said, several regions of SSA have experienced substantial improvements in crop yields and growth in agricultural production since the beginning of the twenty-first century. Yet, no drastic increase in per capita food grain production has occurred, primarily because of rapid rates of population growth. And per capita food production has decreased in East Africa, Southern Africa and Central Africa. Thus, hunger, malnutrition and poverty remain endemic throughout SSA. Agriculture in SSA is vulnerable to harsh and uncertain climate variations. Resource-poor and small landholders are particularly susceptible to their negative impacts. SSA is one of the global hotspots for adverse effects of climate change on agricultural production and the environment. These include severe problems of soil degradation, nutrient and organic matter depletion, water contamination and eutrophication, and loss of biodiversity, especially the below-ground's diversity.

Despite encouraging signs of agronomic yield increases since 2000, major challenges remain in bringing about substantial agricultural improvements throughout SSA. Therefore, the strategy is to improve agricultural production while minimizing negative externalities and improving the environment.

It is in this context that sustainable intensification (SI) can play an important role in enhancing agricultural production while restoring degraded/desertified soils, mitigating global warming by sequestering atmospheric $CO_2$ in soils and vegetation (forests), adapting to climate change by using recommended management practices of the so-called climate-resilient or climate-strategic agriculture, improving farm income, and empowering women and other under-privileged populations. SI is defined as the process of producing more from less while reducing negative externalities and restoring quality of soil and water resources.

An international conference that addressed SI as it relates to climate change and increased food security was held at the Sokoine University of Agriculture (SUA), Morogoro, Tanzania, from 13 to 15 November 2013. Major objectives of the conference were to describe the importance of SI in restoring soil quality and its organic carbon pool as a tool to off-set anthropogenic emissions; to deliberate the role of economic, social (gender), policy and cultural factors in adoption of RMPs by small landholders of SSA; and to identify priority research, development and training priorities that will facilitate SI in SSA.

This 32-chapter volume represents the core of several oral and poster presentations made at the conference. In addition to Introduction and Conclusion sections, the book is thematically divided into seven sections, namely, (1) Land Use and Farming Systems, (2) Effects of Climate Change on Crop Yield, (3) Soil Nutrient and Water Management for Carbon Sequestration, (4) Rehabilitation of Degraded Lands Through Forestry and Agroforestry, (5) Management of Animal Production for Greenhouse Gas Emissions, (6) Smallholder Adaptation to Climate Change, and (7) Economic, Social and Policy Issues.

The conference was attended by more than 100 participants from SSA countries as well as the USA and Norway. It was organized by a Steering Committee with representatives from SUA, the Ohio State University, and the Norwegian University of Animal and Life Sciences. The conference was funded by NORAD, USAID and SUA. Primary funding for the conference was channeled through several programs at SUA, namely the USAID-funded International Agricultural Research Initiative (iAGRI), the Climate Change Impacts, Adaptation and Mitigation (CCIAM) project, and the Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-Chains (EPINAV) project. In addition, the conference benefitted from contributions from Africa Rising, the International Food Policy Research Institute (IFPRI), the World Agroforestry Center (ICRAF), and the Carbon Management and Sequestration Center (C-MASC).

The editors thank all authors for their outstanding contributions to this volume. Thanks are also due to staff at Springer for their timely efforts in publishing this volume. Our special thanks are due to Laura Alexander (iAGRI), Samantha Alvis (Leland Congressional Fellow), Jennifer Donovan (C-MASC), Anthony Sangeda (iAGRI) and Ambonisye Haule (iAGRI).

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# Chapter 9
# Factors in Smallholder Farmers' Vulnerability to Climate Change Impacts in the Uluguru Mountains, Morogoro, Tanzania

**Amon Z. Mattee, K.R. Mussa, Dismas L. Mwaseba, C.P. Mahonge, and J.V. Nsenga**

**Abstract** This study assessed factors in smallholder farmers' vulnerability to climate change impacts in the Uluguru Mountains in the Morogoro Region, Tanzania. To this end, the study first determined the smallholder farmers' awareness and perception of climate change and identified adaptation options preferred by the farmers. A combination of methods, including focus group discussions, key informants interviews, participant observations, and household surveys, were used for data collection. The results indicate that smallholder farmers had a poor understanding of climate change issues, but their knowledge was enhanced by a project that was implemented collaboratively by Sokoine University of Agriculture (SUA) and Professionals for Fair Development (GRET), a French non-governmental organization (NGO). The adaptation strategies preferred by smallholder farmers included terracing, planting fruit trees, the rehabilitation of micro-irrigation canals, and fish farming. However, a noticeable disparity in preference between men and women was observed. The results further revealed that smallholder farmers were vulnerable to climate change and variation due to their limited knowledge of climate change risks, low level of literacy, limited access to climate information, and absence of farmer-based organizations to facilitate better access to credit and market services. The study concludes that crucial factors for smallholder farmers' vulnerability to climate change in the Uluguru Mountains are access to information and resources, road and market infrastructure, and smallholder farmers' organization.

A.Z. Mattee (✉) • D.L. Mwaseba
Department of Agricultural Education and Extension, Sokoine University of Agriculture, Morogoro, Tanzania
e-mail: mattee@iagri.org

K.R. Mussa
Department of Physical Sciences, Sokoine University of Agriculture, Morogoro, Tanzania

C.P. Mahonge • J.V. Nsenga
SUA Centre for Sustainable Rural Development, Sokoine University of Agriculture, Morogoro, Tanzania



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**Keywords** Vulnerability • Smallholder farmers • Climate change impacts

## 9.1 Introduction

### *9.1.1 Background Information*

Climate change has a significant impact on rural inhabitants in developing countries, particularly among smallholder farmers, who have limited adaptive capacity. Smallholder farmers in many developing countries are predominantly dependent on rain-fed agriculture for their farming activities. They tend to have comparatively high exposure to extreme events, suffer from widespread poverty, and are highly marginalized. Studies (Harley et al. 2008; Gbetibouo and Ringler 2009; Lasco et al. 2011) indicate that smallholder farmers in sub-Saharan Africa, especially those in semi-arid areas, are particularly vulnerable to the effects of climate change. Based on knowledge generated from studies on the impact of and vulnerability to climate change and variability, the most vulnerable societies are usually those deprived of mechanisms and resources, including information to prepare for and adapt to climate change (Wongbusarakum and Loper 2011). Equally important, smallholder farmers are vulnerable to climate change because they face various socio-economic, demographic, and policy trends that limit their capacity to cope with climate change (Lasco et al. 2011). These farmers are characterized by complex, diverse, and risk prone environments and most have small farms and produce primarily for subsistence.

It is well documented (Mongi et al. 2010) that smallholder farmers in Tanzania are among the most vulnerable people to the projected changes in the climate system. Predictions show that areas with unimodal rainfall patterns will experience a 5–15 % decrease in rainfall while those with bimodal rainfall patterns will experience increased rainfall of 5–45 % (United Republic of Tanzania – URT 2005, 2007). Overall observations show that rains are increasingly declining in most parts of the country and cycles are detrimentally changing (Yanda et al. 2006; Mwandosya 2007; Mongi et al. 2010). Such changes in climatic variables are expected to alter the characteristics of the agro-ecological zones, leading to reduced yields of some crops, such as maize by 33 % nationally (URT 2007). This projection in crop yield reduction is in line with the prediction of the Global Climate Adaptation Partnership (GCAP) (2011) for maize, which showed that it will decrease by between 16 and 35 % by 2050.

Similarly, a study by the International Institute for Environment and Development (IIED) (2009) on the effects of climate change on agriculture in Tanzania found that rainfall patterns will become highly variable across the country, with an increase in the northern parts of 5–45 % and decreases of 5–15 % elsewhere. Wetter regions are at risk of more frequent and severe flooding. Accordingly, IIED (2009) suggested that the overall impact of climate change in Tanzania could be enormous, possibly shrinking the country's GDP by 0.6–1.0 % by 2030. Thus, it concluded that smallholder farmers will need to adapt to climate change impacts over the next 20 years to avoid catastrophic future costs. However, in order to do so, they will also need policy backing.

The effects of climate change and variability have been experienced in Tanzania. For example, it is reported that the severe droughts of 1994–1996 and 2005/2006, which hit most parts of Tanzania, led to acute food shortages, water scarcity, hunger, and acute shortage of hydropower (URT 2007). In economic terms, the 2005/2006 droughts are estimated to have cost the country at least 1 % of GDP (GCAP 2011).

In addition, the International Food Policy Research Institute (IFPRI 2007) estimated that by the 2080s, the world agricultural productivity could decline by 3–16 %, with the loss in Africa projected to be 17–28 %. Thus, it is apparent that the future of agricultural productivity in Tanzania is intertwined with climate change; hence, immediate adaptation measures are necessary.

### *9.1.2 Factors Aggravating Vulnerability of Smallholder Farmers to Climate Change in Tanzania*

As with many other sub-Saharan African countries, the vulnerability of Tanzanian smallholder farmers to climate change is aggravated by several factors. The traditional farming systems used by about 90 % of smallholder farmers leave them highly vulnerable to climate change. As smallholder farmers, they are usually not well organized and not very well informed (URT 2003). In addition, smallholder farmers make little use of irrigation, improved seeds, or basic mechanization. Soil and water conservation techniques are not often applied, and these farmers have very limited market options.

URT (2003) and IFPRI (2007) reported that the choice of crops grown by smallholder farmers is influenced more by dietary preferences than by the suitability of the crop to particular agro-ecological conditions. Other vulnerability factors include (i) limited access to technology and delivery channels, with 60–75 % of households estimated to have no contact with research and extension services; (ii) limited access to financing for the uptake of technologies; (iii) high transaction costs due to the poor state or lack of infrastructure; (iv) under-investment in productivity enhancing technologies; and (v) unmanaged risks with significant exposure to variability in weather patterns and periodic droughts. The impact of these events is amplified by smallholder farmers' dependency on rain-fed agriculture and their limited capacity to manage land and water resources efficiently. In addition, weak capacity and coordination in the formulation and implementation of policy interventions among the various actors in the agricultural sector exacerbate smallholder farmers' vulnerability to climate change impacts (URT 2003; IFPRI 2007).

Although smallholder farmers have developed several adaptation options to climate change and variability, such adaptations are not sufficient for projected climate changes. Therefore, ensuring food security in a changing climate is one of the major development challenges facing Tanzania and many other developing countries (Kangalawe 2012). Consequently, if strong, more focused adaptation measures are not implemented, climate change may severely impact crop production and livelihoods in Tanzania.

Thus, enhancing smallholder farmers' adaptive capacity to the impacts of climate change will require concerted and long-term efforts by various stakeholders. However, a starting point is to understand their level of awareness and perception of climate change, its impact on their livelihood activities, and how they are adapting to it. Enhancing their adaptive capacity is thus a necessity. It includes understanding their vulnerability factors, and key barriers to adaptation. Furthermore, enhancing the adaptive capacities of smallholder farmers in Tanzania also includes support for their actual efforts to deal with the effects of climate change through innovation and complementarity.

In this paper, vulnerability factors and potential adaptation options available to smallholder farmers in the Uluguru Mountains are reviewed. Observations are based on activities that are being implemented to strengthen the resilience of the communities living on the slopes of the Uluguru Mountains. More specifically, the objectives of this paper are to: (a) assess smallholder farmers' levels of awareness and perception of climate change and variability; (b) analyze key challenges faced in adapting to climate change impacts in the Uluguru Mountains; (c) assess the vulnerability of smallholder farmers to climate change impacts; and (d) assess smallholder farmers' preferences with regard to adaptation practices introduced in the study area.

In the next section, the methodology adopted for the study is described. This is followed by a presentation and discussion of the study findings. The last section presents conclusions from the study.

## 9.2 Methodology

### *9.2.1 Description of the Study Area*

The Uluguru Mountains lie immediately south of the town of Morogoro between latitudes 7° and 8° south and between longitudes 37° and 38° east and about 200 km from Dar es Salaam, the commercial city of Tanzania (Fig. 9.1). This study was carried out on the western slopes of the Uluguru Mountains. It covered three villages in the Luale Ward, namely, Luale, Londo, and Masalawe, in the Mvomero District, which is part of Morogoro Region.

Climatically, the eastern side of the Uluguru Mountains captures moisture moving inland from the Indian Ocean and is, therefore, wetter than the western side, with rainfall estimated at over 3,000 mm per year. Some rains fall in a sporadic fashion. According to Jens and Hansen (1993), the mean annual temperature in the Uluguru Mountains used to be 19.5 °C (with a maximum of 22 °C in December and a minimum of 17 °C in July). However, there has been a significant temperature increase and decline of rainfall and cloud cover (Mussa et al. 2012; Orlhac 2013). By using the principal component analysis technique on rainfall and temperature data, Orlhac (2013) found that the years 2003 and 2005 and 1978 and 1979 were highly correlated in terms of monthly maximum temperature average. Temperatures were low in 1978 and 1979 as compared to 2003 and 2005. Maximum temperatures were higher in the 2000s compared to the 1970s. In addition, Orlhac

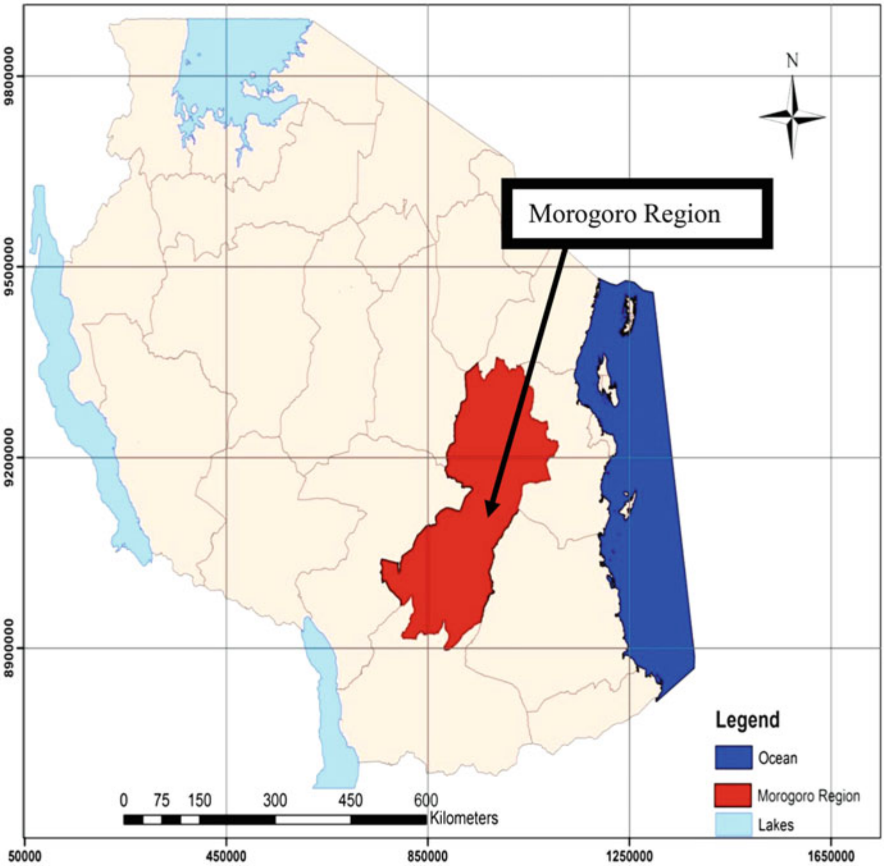


**Fig. 9.1** Map of Tanzania showing the location of the Uluguru Mountains

(2013) found that rainfall amounts were higher in the 1970s than in the 2000s. This confirms the perception that there has been a significant change in the trends in key climatic variables (e.g. temperature and rainfall) in the Uluguru Mountains.

### *9.2.2 Data Collection Methodology*

This study employed a combination of methods to collect relevant data, namely focus group discussions (FGDs), key informant interviews (KIIs), participant observation, a household survey, and a review of the literature. Three FGDs were held with smallholder farmers, women, and primary and secondary school pupils. Five KIIs were conducted involving agricultural extension and natural resources officers, primary and secondary school teachers, and village government officials.

FGDs and KIIs had two major objectives. First, they were designed to provide opportunities to clarify and supplement information collected from the literature and household survey regarding the vulnerability of smallholder farmers in Tanzania and in the Uluguru Mountains in particular. Second, they were designed to seek feedback from the aforementioned stakeholder groups regarding the potential of some of the proposed adaptation activities to build the resilience of local communities to climate change impacts.

The process of selecting individuals for interview (household survey) involved purposive and random sampling techniques. A purposive sampling technique was used to identify smallholder farmers who have been actively involved in project activities, with the specific consideration of having implemented at least one of the introduced climate change adaptation strategies. Thereafter, a simple random sampling technique was used to select 46 smallholder framers for interview. A one-to-one interview method was used to administer the household questionnaire in the study area. Therefore, the sample size used in this study was more deterministic than probabilistic.

Adaptation challenges faced by smallholder farmers were assessed in terms of the following criteria:

- Access to climate information,
- Access to market,
- Attainment of formal education,
- Knowledge of climate risks,
- Presence of farmer-based organizations,
- Access to credit services,
- Condition of road infrastructure, and
- Conservation agriculture skills.

The impacts of climate change were assessed in terms of their effects on different human and natural systems linked to the livelihoods of smallholder farmers in the Uluguru Mountains. This involved using the concept of "vulnerability," which was defined by Chambers (2009) as the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. Chambers (2009) added that vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Vulnerability was assessed based on resilience, marginality, susceptibility, adaptability, fragility, risk, and exposure of key livelihood resources to climate change impacts. The framework was used to describe socio-economic groups at risk, as well as those with insecure livelihoods on the margins of society because of climate change and variability in the Uluguru Mountains.

The vulnerability assessment framework developed for this study contains seven criteria to identify current and potential smallholder farmer vulnerabilities to climate change impacts. It points out how climate change impacts the resource base on which smallholder farmers draw their livelihoods. The first step in the vulnerability assessment was to identify key livelihood resources. Second, each resource was analyzed based on the seven key vulnerability criteria shown in Table 9.1.

**Table 9.1** Vulnerability assessment framework

| S/N | Vulnerability criteria | Definition |
|---|---|---|
| 1 | Magnitude of impacts | If the expected impacts are substantial, they are evaluated as key vulnerabilities in contrast with impacts with more limited effects. The magnitude of an impact is determined by: |
| | | Its scale, |
| | | The area affected, |
| | | The number of people affected, |
| | | The intensity, which implies the degree of damage caused |
| 2 | Timing of impacts | A harmful impact is more likely to be considered key if it is expected to happen sooner rather than in the distant future |
| 3 | Persistence and reversibility of impacts | A harmful impact is more likely to be considered key if it is persistent and/or irreversible |
| 4 | Likelihood (estimates of uncertainty) of impacts and vulnerabilities | An impact characterized by high likelihood is more apt to be seen as key than the same impact with a lower likelihood of occurrence |
| 5 | Potential for adaptation | To assess vulnerability to climate change, the ability of individuals, groups, and communities to adapt to or ameliorate adverse impacts of climate change must be considered. The lower the availability and feasibility of effective adaptations, the more likely such impacts would be characterized as key vulnerabilities |
| 6 | Distributional aspects of impacts and vulnerabilities | Impacts that have significant distributional consequences are likely to have higher salience and therefore a greater chance of being considered key |
| 7 | Importance of the system(s) at risk | A salient though subjective criterion for the identification of key vulnerabilities is the importance of the vulnerable system or system property |
| | | If the livelihoods of many people depend on the functioning of a system, this system may be regarded as more important than a similar system in an isolated area |

Adapted from the Inter-governmental Panel on Climate Change (IPCC) (2007)

In order to analyze the preference of smallholder farmers to various adaptation strategies, farmers were asked to rank climate change adaptation activities that were being promoted by the project supported by the European Union and implemented in the Uluguru Mountains by Sokoine University of Agriculture in collaboration with GRET, a French non-governmental organization (NGO). A weighted ranking method was employed in which interviewees were asked to rank adaptation activities on a scale from one to four, with the most favored activity assigned a weight of four points, the second most favored a score of three points, and the third and fourth activities being assigned scores of two and one point, respectively. Scores were then summed across all respondents, and total scores for each adaptation activity were used to define the most preferred adaptation activities by smallholder farmers in the Uluguru Mountains.

## 9.3 Study Findings

### *9.3.1 Smallholder Farmers' Awareness and Perception of Climate Change*

The SUA-GRET climate change project that has been in effect for the last 2.5 years has boosted the understanding of climate change issues of smallholder farmers in the Uluguru Mountains. This study found that before the project, 65 % of the 46 interviewed smallholder farmers had a poor understanding of climate change issues. Only 5 % reported that they had a good knowledge of climate change issues. None reported having had very good knowledge of climate change and variability (Fig. 9.2).

However, 2 years after the intervention by the climate change adaptation project, nearly 42 % of smallholder farmers in the Uluguru Mountains reported that they now have a very good understanding of climate change issues, and 39 % reported

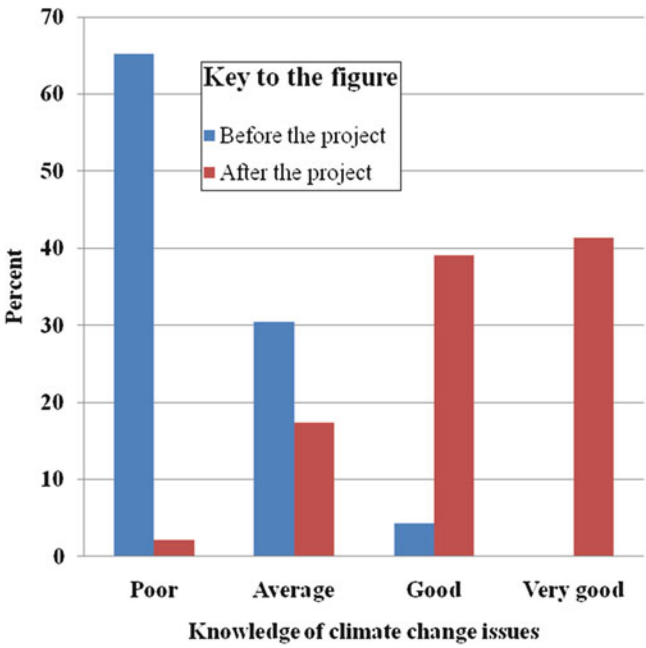


**Fig. 9.2** Knowledge of climate change issues before and after the SUA-GRET climate change project in the Uluguru Mountains

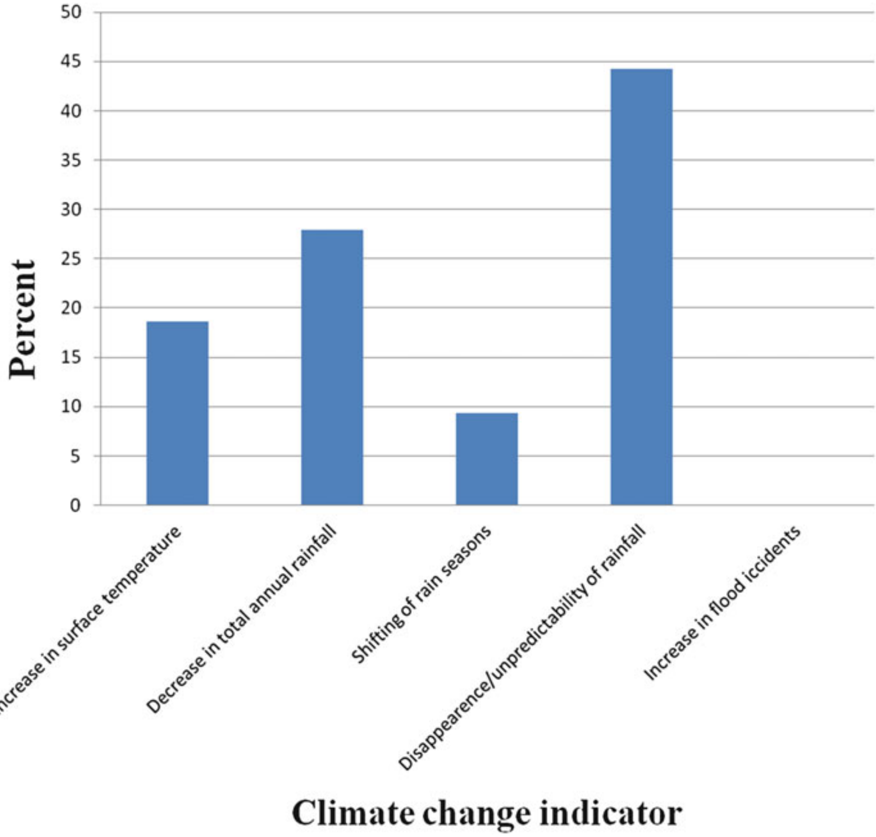


**Fig. 9.3** Main indicators of climate change reported by smallholder farmers

having a good knowledge of those issues. The only source of this knowledge cited by respondents was the SUA-GRET climate change project.

When asked about the variable "rainfall" which they most commonly associate with climate change in their area, almost half (44.2 %) of smallholder farmers pointed to the unpredictable nature of seasonal rainfall. This was the principal indicator of the changing climate in the western slopes of the Uluguru Mountains. However, a decrease in the amount of rainfall received annually and an increase in surface air temperature were also cited as indicators of climate change in the area (see Figs. 9.3, 9.4 and 9.5).

### *9.3.2 Adaptation Challenges and Vulnerability of Smallholder Farmers in the Uluguru Mountains*

Although access to and control over the resources necessary for adaptation varies within communities and even within households, it is hugely influenced by external

**Fig. 9.4** A terraced land in the study area

**Fig. 9.5** One of the fishponds in the study area

factors, such as policies, institutions, and power structures (Chambers 2009). Notwithstanding, adaptive capacities vary over time based on changing conditions and may differ in relation to the prevailing climatic hazards. Nevertheless, Chambers (2009) has documented that the world's poorest people are the most vulnerable to climate change. This is often because they have limited access to the resources that would facilitate adaptation.

The vulnerability of smallholder farmers in the Uluguru Mountains was largely found to be a result of inadequate knowledge of climate risks and low literacy levels, as discussed elsewhere by Nkombe (2003), and most of the inhabitants of the Uluguru Mountains lack adequate formal education. They also lack conservation education. Since education raises awareness of the need for environmental conservation, most people in the Uluguru Mountains are unaware of the existing link between the surrounding forests and climate change.

Other factors that exacerbate vulnerability were identified using KIIs, FGDs, and participant observation. They include limited access to climate information and the absence of farmer-based producer organizations, which would facilitate better access to credit and marketing services. Another major factor is limited access to knowledge of climate change issues and climate information in general.

Nonetheless, the data indicate that the least-vulnerable villages in this study are Londo and Luale, and the most vulnerable village is Masalawe. It was further established that a common feature of the less vulnerable villages is that they have a higher percentage of inhabitants with primary level education and a relatively higher level of knowledge of climate risks. These villages have more organized farmer-based producer organizations, better access to credit services, and a better road infrastructure. Thus, it is easier for them to access health and marketing services. The most vulnerable village has less access to these services, since it is located in a more remote and inaccessible area.

The vulnerability assessment framework and household surveys were used to assess the vulnerability of smallholder farmers. These methods were used to estimate exposure to and the sensitivity of key livelihood resources. Based on this analysis, the discrepancy between knowledge of key conservation agricultural practices and the adoption of such practices was determined.

Key livelihood resources for smallholder farmers in the study area were found to be land and water for irrigation. Both land and water resources were found to be susceptible to destruction by extreme climate events, evinced by severe erosion and landslides, destruction of irrigation infrastructure, drying up of water sources, and irrigation water shortages. All of these events represent exposure of smallholder farmers to current and potential climate change impacts. Conway (1997) reported that mountainous areas are ecologically vulnerable and exacerbate the vulnerability of communities whose livelihoods largely depend on resources located in these fragile ecosystems. The ecological vulnerability reported by Conway (1997) extends to climatic vulnerability since, with limited rainfall, ecosystem goods and services, such as water, become highly limited, thus putting the livelihoods of mountainous communities at risk.

The magnitude of the impact on smallholder farmers was determined by assessing its scale; the area affected; the number of people already affected, i.e., those who disproportionately depend on land and water resources; and impact intensity, which refers to the level of damage inflicted on livelihood niches of smallholder farmers in the Uluguru Mountains. The magnitude of impact on both cropland and water resources and the ensuing consequences for smallholder farmers in the Uluguru Mountains are relatively high, as the two resources form the livelihood backbone of about 95 % of the communities in the study area.

**Table 9.2** Knowledge on conservation/climate-smart agriculture practices by smallholder farmers

| Practice | Percentage aware | Percentage actually practicing |
|---|---|---|
| Agroforestry | 33.3 | 20.0 |
| Green manure residue or compost incorporation | 66.7 | 46.7 |
| Zero or minimum tillage | 33.3 | 20.0 |

The timing of climate change impacts, their adaptation potential, and the likelihood of occurrence of these impacts were found to be key determinants of vulnerability of smallholder farmers to climate change impacts in the Uluguru Mountains. Impacts are already observed, and the capacity to adapt to both current and potential impacts is relatively limited.

Most smallholder farmers interviewed were found to be generally unaware of adaptation practices, and thus few had actually adopted them. For instance, only 33 % of the smallholder farmers reported awareness of agroforestry practices, and only 20 % of them actually practice agroforestry (Table 9.2). Lack of familiarity with the practices and not having sufficient resources to implement them were the key reasons for low adoption of these adaptation practices.

Climate change vulnerability is a function of system sensitivity to climate hazards and low adaptive capacity (Chambers 2009; IPCC 2007; Gbetibouo and Ringler 2009). Smallholder farmers in the Uluguru Mountains remain vulnerable to climate change impacts because of the sensitivity of the water sources and the cropland to climate changes.

However, the vulnerability of smallholder farmers in the Uluguru Mountains is not an isolated case. Conway (1997) reported that the majority of the world's poor live in areas that are resource poor, highly heterogeneous, and risk-prone. This scholar added that after semi-arid and arid zones, poverty is prevalent in mountainous areas that are ecologically vulnerable. The inhabitants of the Uluguru Mountains are a case in point.

### 9.3.3 Adaptation Options and Preferences of Smallholder Farmers to Various Adaptation Activities in the Uluguru Mountains

The ranking of alternative strategies are found in Table 9.3. Scores represent the number of individuals identifying the practice as first, second, third, or fourth preference multiplied by the relative weight for the preference from four (highest preference) to one (lowest preference).

Smallholder farmers in the western slopes of the Uluguru Mountains prefer terracing over other options as an adaptation strategy. This is followed by the planting of fruit trees, the rehabilitation of micro-irrigation canals, and fish farming.

**Table 9.3** Preferences for different adaptation options

| Adaptation activity | Preference score | | | | Total score | Overall rank |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | | |
| Terracing | 72 | 42 | 14 | 7 | 135 | 1st |
| Planting of fruit trees | 36 | 45 | 40 | 2 | 123 | 2nd |
| Rehabilitation of micro-irrigation canals | 60 | 33 | 20 | 9 | 122 | 3rd |
| Fish farming | 16 | 18 | 18 | 27 | 79 | 4th |

**Table 9.4** Preference of adaptation activities by gender

| | Terracing | | Fruit trees | | Irrigation canals | | Fish farming | |
|---|---|---|---|---|---|---|---|---|
| | Percentage response by gender | | | | | | | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| 1st option | 26 | 58 | 15 | 26 | 48 | 11 | 11 | 5 |
| 2nd option | 37 | 21 | 30 | 37 | 22 | 28 | 11 | 17 |
| 3rd option | 19 | 11 | 48 | 37 | 11 | 39 | 22 | 17 |
| 4th option | 18 | 10 | 7 | 0 | 19 | 22 | 56 | 61 |

Among these, 15 farmers indicated that canal rehabilitation was preferred as opposed to only nine who indicated the planting of fruit trees as preferred. Fish farming was viewed as the least favorable option. However, overall score shows that terracing is the preferred, while fish farming is the least preferred adaptation strategy (Table 9.3).

However, the data in Table 9.4 suggest men prefer fish farming and the rehabilitation of micro-irrigation canals to terracing and fruit trees. The laborious nature of fishpond construction and the rehabilitation of irrigation canals (as shown in Fig. 9.6) are possible reasons why women do not prefer these activities. Yet women rank terracing activity as the most preferred adaptation strategy despite it being a relatively labor-intensive undertaking. This is perhaps explained by the fact that terracing is usually associated with household food production (Fig. 9.7).

These results confirm a growing recognition of gender-based vulnerability to climate change and the need for gender-conscious interventions to climate change adaptation that is informed by the differences in needs, responsibilities, and unique contributions of both women and men in any social setting. As reported in Table 9.4, men and women indicated different preferences for adaptation strategies, with men preferring irrigation infrastructure and fish farming while more women preferred fruit trees and terracing.

## 9.4 Conclusion

Farmers in the Uluguru Mountains are aware of changes that have taken place with regard to the ability of the ecosystem to support their livelihoods. However, they have less understanding of the concept of climate change. Changes in rainfall patterns and

**Fig. 9.6** Irrigation canal work in the study area is mainly attended by men

**Fig. 9.7** One of the fruit tree nurseries in the study area

increases in temperature levels are the most perceptible indicators that things are not the same. Likewise, farmers have noted changes in the land and water, the two key livelihood resources, in terms of decreasing quality of the land due to increased soil erosion and landslides and decreased amounts of irrigation water. The level of smallholder farmers' awareness seems to have increased as a result of an intervention, which has enhanced awareness of the concept of climate change and promoted various adaptation measures in the form of climate-smart agricultural practices.

This study has also revealed that local communities in the Uluguru Mountains are generally vulnerable to climate change. Limited access to information about climate change issues and climate in general, poor road and market infrastructure, and the absence of effective local institutions are associated with the relatively high level of vulnerability of these communities. As such, there is a need to promote adaptive measures to reduce this vulnerability. Nonetheless, while promoting specific adaptation measures, it is crucial to consider gender differences in terms of the preferences for the various adaptation measures among different socio-cultural groups. Thus, climate change adaptation measures should be informed by differences in needs, responsibilities, and the unique contributions made by different gender groups in any social setting.

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