Building Livelihoods Resilience in the Face of Climate Change: Case Study of Small-Holder Farmers in Tanzania

44

Saumu Ibrahim Mwasha and Zoe Robinson

Contents

Introduction	830
Background	830
Description of the Study Areas and Methodology	831
Study Area	831
Research Methods	831
Results and Discussion	835
Maximizing Existing Household Assets: Household Decision-Making and Female Empowerment	836
Building the Household Assets Base	837
Managing Natural and Physical Capital: Managing Slow Variables	839
Livelihood Diversification	843
The Role of Government in Building Small-Holder Farmer Resilience and Adaptation to Climate Change	843
Conclusion	844
References	845

Abstract

The impacts of climate change are already being felt on human and environmental systems, with the brunt of the impacts being felt by communities in the Global South, particularly small-holder farmers due to their poverty levels and greater direct dependency on natural resources for their livelihoods. Hence, there is a need to understand how to build small-holder farmers' resilience to climate change. Climate change adaptation strategies need to build livelihood resilience

This chapter was previously published non-open access with exclusive rights reserved by the Publisher. It has been changed retrospectively to open access under a CC BY 4.0 license and the copyright holder is "The Author(s)". For further details, please see the license information at the end of the chapter.

S. I. Mwasha (✉) · Z. Robinson

School of Geography, Geology and the Environment, Keele University, Staffordshire, UK

© The Author(s) 2021

W. Leal Filho et al. (eds.), *African Handbook of Climate Change Adaptation*,
https://doi.org/10.1007/978-3-030-45106-6_49

829

in the face of climate change as well as address the factors that contribute to farmers' vulnerability. This chapter draws from a mixed-method study conducted in three villages each in a different agro-ecological zone in the Kilimanjaro region, Tanzania, to explore how to build farmers' livelihood resilience through addressing factors that increase livelihood vulnerability to climate change. These farmers' livelihoods are vulnerable because of both the impacts of climate variability on the farmers' livelihood assets and certain social and environmental structures and characteristics. Building small-holder farmers' livelihood resilience that can ensure the desired levels of livelihood outcomes in the face of climate variability and change, requires integration of strategies across household resource management as well as farm-based livelihood assets, and a holistic rather than piecemeal approach to small-holder farmers' livelihoods.

Keywords

Climate change · Adaptation · Small-holder farmer · Livelihoods · Resilience

Introduction

Background

The impacts of climate change are expected to affect human and environmental systems across the globe but the more devastating impacts are projected to occur in developing countries particularly affecting small-holder farmers (Serdeczny et al. 2017). Many small-holder farmers especially in Sub-Saharan Africa farm and live in an extremely challenging environment. The production environment is characterized by reliance on rain-fed agriculture, a low level of economic diversification, and low livelihood productivity (Output per unit of input (Yu et al. 2002)) (Di Falco and Veronesi 2013). Climate change is expected to intensify existing challenges and thus there is an urgent need for adaptation of the livelihoods of small-holder farmers to enable them to thrive in the face of climate change.

Addressing how to build resilient small-holder farmers' livelihoods through adaptation to climate change is vital for food security as well as livelihood development (Afifi et al. 2014). To address these issues, considerable emphasis is placed by researchers on describing specific locally relevant agricultural or natural resource management practices or innovations that could potentially deal with impacts of extreme events at the farm/household level. However, it is important to note that the application of these strategies is context-specific and that several constraints exist that may limit farmers' capacity to optimize their benefits. Therefore, there is a need to develop adaptation tailored to the need of that community (Ebi and Burton 2008). The context-specific adaptations result from examining the vulnerability of the target community empirically, and utilizing community experience and knowledge to examine exposure and sensitivity of the community to climate change (Ebi and Burton 2008). The context-specific adaptation strategies or practices based on

examination of adaptation needs of the specific community will generate more practical measures (Ebi and Burton 2008). Adaptation based on this approach is less developed (Paavola 2008), and this research helps fill this gap by presenting potential adaptation strategies that small-holder farmers in the Kilimanjaro region of Tanzania can use to adapt to increasing climate variability. Further information about the exposure and sensitivity of these small-holder farmer communities can be found in Mwasha (2020).

Description of the Study Areas and Methodology

Study Area

The study was conducted in the Kilimanjaro region located in the North-eastern part of the Tanzania mainland. The region is divided into four agro-ecological zones; the forest reserve and Kilimanjaro mountain peak where no farming activities take place, and the highland, midland, and lowland zones where farmers are located (Fig. 1). Although all zones receive rainfall twice a year, the amount in each zone differs. Characteristics of the different zones are shown in Table 1.

Research Methods

Underpinning Theoretical Frameworks

Two lenses of analysis were used in this research; a livelihood approach drawing on the sustainable livelihood framework of the UK Department for International Development (DFID) (1999) and socio-ecological resilience drawing primarily on the work of Biggs et al. (2012, 2015). The sustainable livelihood framework is an analytical structure to facilitate understanding of broad factors that constrain or enhance livelihood opportunities, and puts people and their access to assets (financial, human, social, natural, and physical) at the center of this understanding (Reed et al. 2013). This framework also considers livelihood diversification as a risk management strategy and the role of institutions' structures and processes in shaping peoples' livelihoods (Ellis 2000). One of the main proponents of the use of a sustainable livelihood framework to studies of climate change resilience of poor communities is Tanner et al. (2015). They argued for resilience studies to incorporate a livelihood approach in order to pay attention to fundamental issues of human agency and empowerment, putting people at the center by focusing on capacities for human (rather than environmental) transformation.

Biggs et al. (2012, 2015) distinguish between resilience as a property of social-ecological systems (SES) and resilience as an approach and set of assumptions for analyzing, understanding, and managing change in SES. As a system property, they define resilience of SES as the capacity of an SES to sustain human well-being in the face of change, both through buffering shocks and also through adapting or transforming in response to change (Biggs et al. 2015). In order to analyze or build the

Fig. 1 Location of the Kilimanjaro region and different agro-ecological zones. (Source: Author 2020)

resilience of a system, Biggs et al. (2012, 2015) identify seven principles. The first principle refers to diversity and redundancy. Diversity involves the provision of different options for responding to change, achieved by ensuring variety (the number of different elements), balance (the number of representatives of each element), and

Table 1 Key characteristics of the three agro-ecological zones included in this study (information from Soini 2005; O'Brien et al. 2008; Regional socioeconomic profile, 2014)

Zone	Altitude (m above sea level)	Soil fertility	Rainfall (mm/a)	Temperature range (°C)	Population density (people/ km ²)	Major crops	Livestock and additional comments
Highland	1100– 1800	High	1250–2000	15–20	650	Wheat, beans, barley, coffee, banana, fruits, round potatoes	Majority of livestock are stall-fed. Some families own or rent plots of land in other zones particularly in the lowland zone.
Midland	900–1100	Moderate	800–1250		250	Coffee, banana, maize, beans	Dairy cattle, goats, pigs, rabbits, poultry farming
Lowland	<900		700–900	Average annual >30	50	Maize, cotton, rice, sorghum, cassava, pigeon peas	Beef cattle, goats, pigs, sheep. Provides fodder during the dry season for animals in all zones. Livestock mostly freely grazed because of the availability of open spaces especially after crops have been harvested

disparity (how different the elements are from one another). Redundancy describes the replication of elements within a system. The second principle is to manage connectivity, focusing on the way in which parts of an SES interact with each other. The third principle is to manage feedbacks and slow variables, such as long-term changes to environmental assets such as soil fertility. The fourth principle is to foster complex adaptive system thinking. The fifth principle is to encourage learning and experimentation. The sixth principle is to broaden participation and the seventh to promote polycentric governance systems. This chapter draws primarily on principles one to three, further analysis of the principles in the context of this study can be seen in Mwasha (2020).

Study Site Selection and Sampling Methods

The administrative structure in which the villages included in this study site is shown in Fig. 2. The district in which the study was conducted was selected in discussion with the regional environmental officer (who oversees activities related to the environment in the region) based on preset criteria: accessibility, evidence of climate change, and the presence of the three agro-ecological zones. The Kilimanjaro region has seven districts, but only some have three agro-ecological zones. Simple random sampling was used to select one ward from each agro-ecological zone in the selected district, and to pick one village in each ward. The district, ward, and villages are not named in order to maintain anonymity.

Data Sources, Collection Methods, and Analysis

Data were gathered from individual household surveys of household heads (who were all small-holder farmers) in the study villages, focus group discussions in each village, interviews with key informants, and researcher observations. Although the survey did not ask about the total household size because I wanted to understand the labor force, the regional socioeconomic profile (2014) shows that the Kilimanjaro

Fig. 2 Administrative structure in Tanzania

region had an average household size of 4.3 in 2012 which is the lowest in the country compared to a national average household size of 4.8 in the same year. The household surveys collected quantitative and qualitative data on the household heads' perceptions of the impact of climate change on the livelihood assets and farm production practices utilized by the household. The total numbers of interviewed households were 47, 35, and 24 in the highland, midland, and lowland zones, respectively. The total numbers of village for highland, midland, and lowland were 946, 702, and 483, respectively. Except in the lowland zone where the focus group was mixed gender, the midland and highland focus groups were gender-based. The focus group discussions explored trends in crop production, soil fertility, animal keeping, water availability, and management practices and their implication to climate change adaptation, as well as information about social factors that contribute to small-holder farmers' vulnerability to climate change. Interviews were held with five key informants (a community development officer; a representative from the Tanzania Coffee Research Institute; a district and village agriculture extension officer; and a network of farmers' groups in *Tanzania which is Nongovernmental Organization*) to understand their roles in helping farmers successfully adapt to climate change, factors that hinder farmers' adaptation ability, and potential solutions. Observations in the villages by the researcher were used to inform understanding of existing farm production practices. The data were collected in the Swahili language and translation was carried out by the researcher alongside data transcription. Details of the socioeconomic characteristics of the villages and measures contributing to livelihood vulnerability are found in Mwasha (2020) thesis.

The household survey data arises from closed-ended questions and open-ended questions with brief answers. The analysis of closed question data was carried out using SPSS descriptive statistics and qualitative data were manually coded using in vivo coding and descriptive coding, and grouped under the themes identified and entered into SPSS for analysis.

Data from the key informant interviews and focus groups were manually analyzed (Basit 2003). The transcription text was analyzed using evaluative coding based on the research questions (Smith and Firth 2011). The codes developed were categorized into different topics and then linked to form themes (Saldana 2009; Smith and Firth 2011).

Results and Discussion

This section is structured around four key areas of focus to support small-holder farmer adaptation to increase resilience to climate change. The first section focuses on the role of maximizing existing household assets, focusing specifically on human and social capital. The second section focuses on the management of physical and natural capital, also referred to as managing slow variables in reference to one of Biggs et al.'s (2015) resilience principles. The third section looks at the role of livelihood diversification, a key component of the sustainable livelihoods framework (DFID 1999), in building livelihood resilience to climate change, and Biggs et al.'s (2012, 2015) principles for

building resilience. The fourth section explores the role of government in supporting small-holder farmers' adaptation and resilience to climate change.

Maximizing Existing Household Assets: Household Decision-Making and Female Empowerment

The way in which a household's assets in terms of income and produce are utilized have a major role in building livelihood resilience. Both male and female focus group participants in the highland and midland zones gave examples of how division in household responsibilities (i.e., responsibility for keeping the family fed, sheltered, educated, clothed) and divided ownership of resources within households (i.e., certain cash crops typically belonging to male members of the household) could lead to resources being used without consideration of what is best for the whole household. Focus group participants in the highland and midland zones viewed it as preferable to have joint ownership of assets and shared household responsibilities, where what is produced in the household is considered to belong to the whole family; with couples planning together how those resources are used, creating more transparent and balanced decision-making in the household. In the lowland focus group discussion, division of ownership, and household obligation were said to have no impact on household resilience. However, as the lowland focus group was mixed gender, participants may not have been willing to discuss the issues arising from different gender roles within the household. The details of division of household obligations of gender roles are found in Mwashu (2020).

Achieving more balanced decision-making around resource use within households is supported by wider policies that promote the empowerment of women through increasing access to education and financial capital. The need to support female empowerment was supported in discussions within both gender focus groups in the highland and midland zones as there was no direct question asked about this matter but it came up during the discussion about household resource use and its impact on household resilience to climate variability and change. The empowerment of women is also reported in the literature as increasing household resilience to climate change (Almarino-Desolac 2014). However, not all women in the Kilimanjaro region, and Tanzania in general, have access to these opportunities (Kato and Kratzer 2013), and the slow pace of change requires other strategies to be adopted in some households to address problems of household resource utilization stemming from household inequities. In the highland and midland, there was discussion of how some women would hide some crop produce to be able to use this in times of adversity; showing how individual household strategies are used in helping build household resilience.

Another strategy farmers in all focus groups reported to use to build resilience relates to food storage systems especially after harvest to give food a longer life and protect it from damage. The focus group participants in all three zones mentioned the use of storage tanks which are tightly sealed after being filled with food, especially maize and beans (other crops were also mentioned by female

participants), as their main method of storing food, to provide reserve food stocks in times of limited harvests. Although there was no specific question asked about food storage systems, these discussions came about while exploring hunger periods in the study area.

Building the Household Assets Base

Small-holder farmer livelihoods depend on the quality of the assets (human, social, financial, and natural capitals) to which a household has access. The available assets form the foundation upon which livelihoods are built and define the ability of the people in question to execute different livelihoods strategies (Chambers and Conway 1992; DFID 1999; Ellis 2000; Scoones 2009). The discussion below explores ways to further build human and social capital (assets) which were perceived by respondents to be decreasing in the study area, and through this build resilience to climate change.

Building Human Capital

Human capital can be defined as the available labor force within a household to contribute to agricultural production, income generation, and household management. The household surveys identified that human capital was negatively affected as a result of malaria which has intensified by increasing temperatures allowing the geographic spread of mosquitoes particularly into the highland zone.

Adaptation strategies are needed to deal with an increase in malaria and its impact on human capital (Onwujekwe et al. 2000; Teklehaimanot and Mejia 2008; Asenso-Okyere et al. 2011). Teklehaimanot and Mejia (2008) summarized malaria control strategies as follows:

- Provision of early diagnosis and prompt treatment
- Selective and sustainable use of preventive measures, including vector control
- Prevention, early detection, and containment of epidemics
- Strengthening local abilities and applied research

These strategies require actions at both government and household level. Households are responsible for using preventive measures such as mosquito bed nets, managing the environment to reduce mosquito habitats, and going to the hospital when they get ill for diagnosis and treatment. The government is responsible for educating people about control measures, ensuring access to control measures and medical services, and investing in research on prevention and treatment of malaria diseases. Poverty also plays a crucial role in explaining why certain population groups are more vulnerable to malaria, because of the inability to pay for insecticide-treated bed nets and access to medical health (Teklehaimanot and Mejia 2008). In the study area, the household survey showed that most families were provided with free mosquito nets by the government to prevent malaria disease.

Building Social Capital

The household surveys in this study show a perceived decrease in social capital (described as support that households provide to each other) partly caused by climate variability reducing the amount of crop yield. Social capital is important as it can help households survive the impacts of poverty (Baiyegunhi 2014) through providing security in times of distress and access to resources (Grech 2012). There are different ways that households or individuals can build social capital. Baron et al. (2000) identified two different aspects of social relations that can build social capital for households and individuals: (i) obligations, expectations, and trustworthiness; and (ii) norms and effective sanctions.

One core element of social capital is where people are willing to help each other and do things for each other, relating to Baron et al.'s (2000) "obligations, expectations, and trust." For example, if an individual (named A) does something for B, and trusts B to reciprocate in the future, this establishes expectations in A and an obligation on the part of B. As A does the same to more people, and these people are trustworthy and responsible, this creates good safety nets for A in the event that something happens to A. This study revealed one practice based on these concepts of social capital, in the saving of food resources by one household for another, to be taken back in times of need. This area of social capital was the preserve of females in the communities who reported to support each other in this way.

Social capital can also be developed through the development of norms and sanctions (Baron et al. 2000). However, these can be fragile as some people can misuse them for personal interest. Norms and sanctions relevant to this study include the promotion of norms that encourage family members and neighbors to act selflessly in support of others, which may be reciprocated, providing positive motivations. For example, a household which does not support another household may not be supported if they need help themselves (negative motivation), while the household which supports another during difficult times may be positively motivated by the possibility of needing support themselves in the future.

These aspects that develop social capital for households and individuals are strengthened by social structures with high interconnectedness and interdependency between all actors (Fig. 3; Baron et al. 2000). This can be seen as another form of social capital; the connectivity of social structures that allow the proliferation of obligations and expectations. For example, in a less connected "open structure"

Fig. 3 Social networks without closure (a) and with closure within the social networks (b). (Source: Baron et al. 2000)

(Fig. 3a) individual A can carry out actions that negatively affect D and E who are not acquainted with each other, and therefore cannot unite to control the negative effects from A. In contrast, Fig. 3b shows that all actors are connected and therefore there will be stronger motivation for A to avoid negative effects on other actors.

The household survey and information from the community development officer shows that in the study area some households have developed structures that facilitate social capital. They support each other by forming groups based on similarities between members such as family relations, friends, or similar work space or type. The groups work as informal saving and credit institutions, and members get different services such as access to loans and social support in case they face shocks in their life. Based on information from key informants, there is some nongovernment organization capacity building of these groups by providing training into how groups select leaders and develop financial management and group policy. The government encourages group members to register through the community development office to increase accountability but most are reluctant to register because of registration fees. More government-subsidized training and waiving of registration fees could improve social capital in the area.

Drawing on the insights from Baron et al. (2000), households and individuals can improve their social capital by their own acts to support others and by developing trusted networks of individuals and households within their community, increasing their sources of support for times of adversity. Village-level initiatives based around these principles could also help develop social capital through promoting norms, trust, and responsibility and interconnectedness at the community level. Government-level initiatives can also help support more formalized social support networks such as credit unions.

Managing Natural and Physical Capital: Managing Slow Variables

This subsection adopts the concept of managing “slow variables” as used in Biggs et al.’s (2012; 2015) resilience framework. Slow variables are those variables that change slowly and can take time for changes in them to be noticed. The slow variables considered in this study focus on soil and water, two key areas of natural capital on which small-holder farmers depend, and which the results show have been affected negatively by management practices. Drawing on the study’s focus group discussions, household surveys, key informant interviews, and wider literature, this section describes strategies to ensure the adequate supply of water for agriculture, and strategies to improve soil fertility in the face of declines in these “slow variable” assets.

Managing Water Resources

Poor decisions and practices made by farmers, such as crop choice and inadequate water source management practices, can affect agricultural productivity particularly under weather-related stress (Bot and Benites 2005). This section looks at how farmers will need to adapt to climate change by choosing appropriate crops to

grow by considering plant traits with tolerance of water stress, conservation of water sources, and employing farming practices that encourage water infiltration and conserve soil moisture.

Planting Crops That Can Survive Climate Variability

Data collected in the study area demonstrated that in all three zones the types of agricultural produce grown by farmers threatens the capacity of the existing water resources to sustain agricultural production in the area, particularly as available water resources are perceived to have decreased. Cultivation of high value, high water demand crops, particularly horticultural produce such as tomatoes, cucumbers, onions, and carrots, has increased, increasing pressure on water resources. Although there are benefits to practicing horticulture as produce can be harvested in a relatively short time, the viability of these choices of crop is in question because of the capacity to sustain production in the long-term with trends of declining water availability. In contrast, traditional maize varieties are perceived to take a long time to mature (~6 months) which makes them vulnerable to the more variable rainfall patterns, potentially preventing the crops from reaching maturity. One solution is to replace traditional maize seeds with early maturing maize varieties which can survive the increased rainfall variability. In addition, planting drought-resistant crops such as millet is another strategy for managing the effects of decreasing rainfall amount and increasing variability. However, the results from this study show that the use of these crops is low in all three zones. As some farmers have negative attitudes toward crops like millet and cassava (another drought-resistant crop), there is the need for the government to encourage farmers to grow these crops through the development of an effective market for these crops. Government can also play a role in supporting further research into alternative drought-resistant crops but with a need to ensure that these will meet the needs and wants of small-holder farmers.

Conservation of Water Sources

Across all three zones, there are a number of different practices that were discussed as being important for the conservation of water resources, including encouraging on-farm tree planting and avoiding the cutting down of trees. The relationship between trees and water resources is complicated (Ellison et al. 2017). However, there is some indication that increasing tree planting on farms can help preserve water resources through the effect of shading to reduce evaporative loss from soils (Clement et al. 2016).

The use of farming techniques for increasing infiltration, reducing surface runoff and evaporation, and improving soil water availability is essential in dealing with weather-related shocks (Biazin et al. 2012). There was evidence of these practices in the study area. For example, in the highland zone the use of terraces was reported to help control soil erosion, as well as reducing surface runoff and increasing infiltration (Biazin et al. 2012). In the lowland zone, farmers reported using minimal tillage in order to protect soil moisture.

Rainwater Harvesting

Rainwater harvesting may also increase productivity from existing rainfall. The harvesting systems mentioned by focus group participants can be categorized into two types: earth dams and spate irrigation. Focus group participants in all three zones reported the need for earth dams especially in the lowland zone, to harvest available rainwater and use it for supplemental irrigation.

The use of spate irrigation was mentioned in the focus group in the lowland zone, where floodwaters from the highlands are channeled to nearby fields through gravity or water pumps to irrigate farms in the lowlands. This approach is used to cope with dry spells by taking advantage of the rain happening in upland areas even though it has ceased in lowland areas, as the rainy seasons last longer in the highland and midland zones relative to the lowland zone.

In addition to providing additional water sources, farmers with access to spate irrigation reported other benefits such as improved soil fertility, reducing the use of fertilizer on their farms because the spate water comes with eroded materials that are nutrient-rich. Although this strategy has many benefits it may come with other challenges because large flash floods can potentially cause damage to crops and prepared land (Komakech et al. 2012), although this was not mentioned by any focus group or household survey participant.

In addition to direct interventions such as water-conservation farming practices, wider systemic issues leading to poverty need to be addressed, because in some cases it is these systemic issues that push farmers in this area to inappropriately use water sources as a survival strategy. For example, as a result of reliable crop market, farmers chop down trees to sell timber as alternative source of income.

Managing Soil Fertility

Management of soil fertility particularly where weather-related shocks are experienced is vital for reducing the impact of climate change on soils as well as improving water productivity (Biazin et al. 2012). Soil fertility-related land management practices include appropriate use of fertilizer and soil conservation methods to reduce erosion and maintain organic matter (Clair and Lynch 2010; Kaczan et al. 2013). Farmers in the study area identified strategies to increase soil fertility and conserve soil moisture such as mulching by retaining crop residues in fields, intercropping, the use of organic fertilizers, minimal tillage, and agroforestry as potential adaptation strategies. However, comparison between zones shows that while retaining crop residues, intercropping and use of organic fertilizers were mentioned in all three zones, minimal tillage was not discussed as a strategy in the midland and highland zones. In addition, the role of agroforestry was debated in the lowland zone, with the majority of participants believing agroforestry to be appropriate in the midland and highland zones but not in the lowland zone because they perceive the crops grown in the lowland zone (see Table 1) do not require the shade provided by trees.

Focus group participants believed that given the increased nature of climate variability and projected climate change, the benefits from retaining crop residues in fields were more important than ever. However, although maintaining crop

residues in fields was seen as an important potential adaptation measure to build livelihood resilience to climate variability, it was also acknowledged that this is hindered by the free grazing of animals by livestock keepers residing in the lowland zone. This was particularly problematic for farmers in the highland zone who also held farmland in the lowland zone, and were not able to monitor their land in the lowland zone. In addition, the need for fodder for livestock kept in the midland and highland zones was partly met by the transport of crop residues from the lowland zone. Participants reported that the nature of the issues faced meant that farmers now needed to find the balance between livestock feed and improving agricultural soils through retaining crops residue.

In dealing with competing crop residue demands, agricultural intensification can help increase the amount of biomass produced which can be divided between livestock and that which can be retained in the soils. In addition, free-grazing animals in the lowland zone should be discouraged to motivate farmers to retain part of the residues in the farms. Livestock keepers should be encouraged to sell some of their livestock and retain only that which they can maintain using their own resources.

Agroforestry was also mentioned as a potential adaptation strategy to address issues of declining soil fertility in the study area in all focus group discussions. The household survey results showed that participants believed this strategy to have both socioeconomic and environmental benefits. Research literature has also reported several benefits of agroforestry, including an increase in soil organic matter, erosion control, reduced sensitivity to harsh weather, natural pest and disease control, and provision of an alternative source of income (Reyes et al. 2005; Nair 2007; Nguyen et al. 2013; Pumariño et al. 2015; Sepúlveda and Carrillo 2015; Schwab et al. 2015). It is important to acknowledge that, in the survey results, there were a small number of respondents who disagreed about the benefits of agroforestry (particularly in the lowland zone) when combined with cereal crops like maize. However, studies do suggest that there is potential for agroforestry within maize production (e.g., Garrity et al. 2010), which offers opportunity to explore further types of trees that could be relevant in the study area to be integrated with maize, but the acceptance of farmers would need to be developed.

The use of organic fertilizer from livestock is another potential strategy to enhance agricultural productivity (Clair and Lynch 2010) and was reported by focus group participants and key informants. However, farmers reported that the main challenge of using organic fertilizer was the inconvenience for some associated with transferring manure from the homestead where cattle are kept to the farm fields which could be up to 5 km from households. There are several potential ways to address these issues, including farmers cooperating with neighboring farm owners to hire transport and share the transportation costs. This shows the importance of social capital (in terms of a strong supportive community willing to work collectively) to address a range of issues. However, it should be acknowledged that any additional costs may be prohibitive for the poorest farmers highlighting that mechanisms to address financial capital and systemic issues leading to poverty underpin many different solutions.

Livelihood Diversification

Small-holder farmers in the study area have access to three different areas of livelihood contribution: (i) crop production for subsistence, (ii) livestock keeping for subsistence, and (iii) off-farm income activities, including small business such as small shops, street vending, and sale of agricultural products for income. The results from this study show that not all households diversify their livelihoods even though in the focus group discussions in all three agro-ecological zones it was reported that households should ensure they have more than one livelihood option as a risk management strategy, particularly important in the face of increased climate change variability. Given the types of livelihood options practiced in the study area, there are some similar dependencies in almost all livelihood options. For example, crop production and livestock keeping are all dependent on natural capital such as soil fertility and water resource availability. This suggests that if the flow and stock of these resources are affected by climate change or climate variability, the main livelihood contributions will be affected even where there is some diversity in income. Drawing on Biggs et al.'s (2012, 2015) resilience principles, it is clear that greater resilience can be achieved with greater disparity in the diversification options, and therefore having different livelihood options based around agriculture may provide less resilience than including diversification away from agriculture.

The Role of Government in Building Small-Holder Farmer Resilience and Adaptation to Climate Change

This subsection looks at the role of government in helping farmers to adapt to climate change in the Kilimanjaro region of Tanzania. The discussion is divided into two areas: (i) the role of government officials (e.g., agriculture extension officers and community development officers); (ii) government policies and directives. Nongovernmental Organizations also often play an important role in tackling livelihood adaptations in the Global South (e.g., Kajimbwa 2006; Oshewolo 2011). However, the role of NGOs was not a focus of this study and only one NGO was included as a key informant interview, nor were NGOs brought up by study participants in the discussions of livelihood resilience and adaptation to climate change. Government officials provide small-holder farmers with access to different services. For example, connections between farmers and agriculture extension services are an important way of providing farmers with timely and relevant knowledge on agricultural aspects of livelihood management (Fosu-Mensah et al. 2012) especially where traditional knowledge systems do not work in responding to climate change (Shackleton et al. 2015). The need to improve access to agriculture extension officers was mentioned by some respondents in the household survey as well as in key informant interviews. Access to extension officers by small-holder farmers could be improved by allocating more extension service providers to farmers as well as providing the service providers with improved means of transport to facilitate their transport to the small-holder farmer villages. The community

development officers differ to agriculture extension officers in that they work with farmers to provide financial capital. However, the existing financial support given to women and youth group projects was reported to be inadequate compared to the demand. Therefore, the government needs to provide other sources of support such as credit, which farmers can exploit as access to financial capital is essential to facilitate adaptation (Deressa et al. 2011; Ndamani and Watanabe 2015; Belay et al. 2017).

There are a number of policy areas that were identified in the study where government could make adjustments to create more favorable conditions to support farmers' adaptation to climate change. These include: the 2007 Warehouse Receipt System (WRS) introduced to help farmers take advantage of price fluctuations by enabling farmers to store crops in warehouses and sell them when prices are high (MAFAP 2013). There was low use of WRS, especially for cereal crops. The government needs to increase the capacity of cooperatives unions, farmers' organizations, and savings and credit cooperatives to be able to implement the WRS for the variety of crops that are produced in the study area.

There are several areas of regulations where there is weak implementation causing availability of fake agricultural inputs in the market. Examples include, the Seeds Act (2003) which regulates the production and trade of all varieties of agricultural seeds including the mandatory provision of seeds for quality assurance; the Fertilizer Act (2009) regulates and controls the quality of fertilizer, either domestically produced or imported; and the Tropical Pesticides Research Institute Act (1979) which regulates research on pesticides for the purpose of ensuring their quality. The study participants reported poor implementation of these regulations with negative effects on the farmers. This shows a need for the government to ensure existing laws and policies are implemented more effectively to achieve the intended results. There were also government actions which small-holder farmers directly referred to as having a negative effect on their livelihoods. These included an export ban on crops preventing farmers from maximizing income in times of food scarcity in other countries (but supporting food security within Tanzania); government appropriation of resources (particularly water) for urban areas; and the lack of implementation of a requirement for using scales for measurement of agricultural produce meaning that farmers often ended up being short-changed by unscrupulous buyers.

Conclusion

This chapter discusses areas of focus to build the livelihood resilience to climate change of small-holder farmers in the Kilimanjaro region of Tanzania, drawing on results from a study of three villages in the region and key informant interviews. Building small-holder farmers' livelihood resilience needs to be tackled at different spatial and temporal scales; from individual farmer decisions to government interventions, from short-term to long-term strategies, and in different spheres from household management practices, agricultural practices, livelihood diversification,

to the building of community and social capital, and the development of wider regulatory and economic systems.

These results highlight the importance of scale and context. Even a single region, such as the Kilimanjaro region studied here, is not a homogenous block. Although there were some similarities across the three agro-ecological zones such as the importance of measures to build social capital, control malaria disease, and the overall management of slow variables, there were some distinctions in the actual practices for management of slow variables as well as the existing social structures affecting resilience within the household. For example, the use of terraces and agroforestry was perceived as relevant in the highland and midland zones while leaving crop residues, minimal tillage, and drought-resistant crops were articulated more in the lowland zone. However, it should also be remembered that these zones do not exist in isolation, for example, some small-holder farmers own land in a different zone to the one in which they live, water resources from the highland zone travel through the midland and lowland zone, and forage for livestock may be sourced from a different zone. Therefore, changes implemented in one zone also have the potential to impact other zones, requiring adaptation measures to both respond to the specific context of an area and understand the interconnections between areas.

Combining a socioecological resilience framework and sustainable livelihood framework provides an important approach to understand small-holder farmers' assets bases as well as their vulnerability and sensitivity to climate change (Mwasha 2020). This combined framework also helps to understand the barriers to climate change adaptation strategies as well as strategies to build resilience to climate change across different temporal and spatial scales and spheres. Building resilience principles into sustainable livelihoods thinking clearly has a role to play in addressing the resilience to climate change of small-holder farmer livelihoods in the study region and likely throughout the Global South.

References

- Affi T, Liwenga E, Kwezi L (2014) Rainfall-induced crop failure, food insecurity and out-migration in same-Kilimanjaro, Tanzania. *Clim Dev* 6(1):53–60. <https://doi.org/10.1080/17565529.2013.826128>
- Almario-Desolac MS (2014) Women empowerment and climate change adaptation in northern Quezon. *Asia Pac J Multidiscip Res* 2(4):14–21
- Asenso-Okyere K, Asante FA, Tarekegn J, Andam KS (2011) A review of the economic impact of malaria in agricultural development. *Agricultural economics* 42(3):293–304
- Baiyegunhi LJS (2014) Social capital effects on rural household poverty in Msinga, KwaZulu-Natal, South Africa. *Agrekon. Taylor & Francis* 53(2):47–64
- Baron S, Field J, Schuller T (2000) *Social capital: critical perspectives*. Oxford University Press, Oxford
- Basit T (2003) Manual or electronic? The role of coding in qualitative data analysis. *Educ Res. Taylor & Francis* 45(2):143–154
- Belay A et al. (2017) Smallholder farmers adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agriculture and Food Security. BioMed Central* 6(1):1–13. <https://doi.org/10.1186/s40066-017-0100-1>

- Biazin B, et al. (2012) Rainwater harvesting and management in rainfed agricultural systems in sub-Saharan Africa – a review. *Phys Chem Earth*. Elsevier Ltd, 47–48:139–151. <https://doi.org/10.1016/j.pce.2011.08.015>
- Biggs R et al (2012) Toward principles for enhancing the resilience of ecosystem services. *Annu Rev Environ Resour* 37:421–448
- Biggs R, Schlüter M, Schoon ML (2015) Principles for building resilience: sustaining ecosystem services in social-ecological systems. Cambridge University Press, Cambridge, MA
- Bot A, Benites J (2005) The importance of soil organic matter: key to drought-resistant soil and sustained food production. Food & Agriculture Organization of the United Nations, Rome
- Chambers R, Conway G (1992) Sustainable rural livelihoods: practical concepts for the 21st century. Institute of Development Studies (UK)
- Clair SBS, Lynch JP (2010) The opening of Pandora's Box: climate change impacts on soil fertility and crop nutrition in developing countries. *Plant and Soil* 335(1–2):101–115
- Clement M, Mwakilila S, Norbert J (2016) Implications of land use and climate change on water balance components in the Sigi Catchment, Tanzania. *J Geograph Assoc Tanzania* 39(1)
- Dereassa TT, Hassan RM, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J Agric Sci*. Cambridge University Press 149(1):23–31
- DfID UK (1999) Sustainable livelihoods guidance sheets. London: DFID, 445
- Di Falco S, Veronesi M (2013) How can African agriculture adapt to climate change? A counterfactual analysis from Ethiopia. *Land Econ* 89(4):743–766. <https://doi.org/10.3368/le.89.4.743>
- Ebi KL, Burton I (2008) Identifying practical adaptation options: an approach to address climate change-related health risks. *Environ Sci Policy*. Elsevier 11(4):359–369
- Ellis F (2000) Rural livelihoods and diversity in developing countries. Oxford university press, Oxford
- Ellison D, et al. (2017) Trees, forests and water: cool insights for a hot world. *Glob Environ Change*. Elsevier 43:51–61
- Fosu-Mensah BY, Vlek PLG, MacCarthy DS (2012) 'Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. *Environ Dev Sustain*. Springer 14(4):495–505
- Garrity DP, et al. (2010) Evergreen agriculture: a robust approach to sustainable food security in Africa. *Food Secur*. Springer 2(3):197–214
- Grech S (2012) Disability, communities of poverty and the global south: debating through social capital. In: *Inclusive communities*. Brill Sense, Boston, pp 69–84
- Kaczan D, Arslan A, Lipper L (2013) Climate-smart agriculture: A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia. Rome: United Nations Food and Agriculture Organization
- Kajimbwa M (2006) NGOs and their role in the global south. *Int J Not-for-Profit L* 9:58
- Kato MP, Kratzer J (2013) Empowering women through microfinance: evidence from Tanzania. *ACRN J Entrepreneurship Perspect* 2(1):31–59
- Komakech HC, Van der Zaag P, Van Koppen B (2012) The Last Will Be First: Water Transfers from Agriculture to Cities in the Pangani River Basin, Tanzania. *Water Alternatives* 5(3)
- MAFAP (2013) Review of food and agricultural policies in the United Republic of Tanzania. MAFAP Country Report Series, FAO, Rome, Italy
- Mwashia SI (2020) Livelihoods, vulnerability, and adaptation to climate change of small-holder farmers in Kilimanjaro, Tanzania. Unpublished PhD thesis, University of Keele, UK
- Nair PR (2007) The coming of age of agroforestry. *Journal of the Science of Food and Agriculture* 87(9):1613–1619

- Ndaman F, Watanabe T (2015) Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: A micro-level study in Ghana. *Water* 7(9):4593–4604
- Nguyen Q, Hoang MH, Öborn I, van Noordwijk M (2013) Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. *Climatic change* 117(1–2):241–257
- O'Brien G, et al. (2008) Climate adaptation from a poverty perspective. *Clim Policy*. Taylor & Francis 8(2):194–201
- Onwujekwe O, Chima R, Okonkwo P (2000) Economic burden of malaria illness on households versus that of all other illness episodes: a study in five malaria holoendemic Nigerian communities. *Health policy* 54(2):143–159
- Oshewolo S (2011) Limited policy engagement of non-governmental organizations: a guilt trip on the Nigerian state. *J Sustain Dev Africa* 13(1):142–152
- Paavola J (2008) Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. *Environ Sci Policy*. Elsevier 11(7):642–654
- Pumariño L, Silesi GW, Gripenberg S, Kaartinen R, Barrios E, Muchane MN, Midega C, Jonsson M (2015) Effects of agroforestry on pest, disease and weed control: a meta-analysis. *Basic and Applied Ecology* 16(7):573–582
- Reed MS, et al. (2013) Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. *Ecol Econ*. Elsevier 94:66–77
- Reyes T, Quiroz R, Msikula S (2005) Socio-economic comparison between traditional and improved cultivation methods in agroforestry systems, East Usambara Mountains, Tanzania. *Environ Manag*. Springer, 36(5):682–690
- Saldana J (2009) Chapter 1: An introduction to codes and coding. In J Saldaña (Ed.) *The coding manual for qualitative researchers* (pp. 3–21). Thousand Oaks, CA: Sage
- Schwab N, Schickhoff U, Fischer E (2015) Transition to agroforestry significantly improves soil quality: A case study in the central mid-hills of Nepal. *Agriculture Ecosystems & Environment* 205:57–69
- Scoones I (2009) Livelihoods perspectives and rural development. *J Peasant Stud*. Taylor & Francis 36(1):171–196
- Sepúlveda RB, Carrillo AA (2015) Soil erosion and erosion thresholds in an agroforestry system of coffee (*Coffea arabica*) and mixed shade trees (*Inga* spp and *Musa* spp) in Northern Nicaragua. *Agriculture Ecosystems & Environment* 210:25–35
- Serdeczny O et al. (2017) Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change* 17(6):1585–1600. <https://doi.org/10.1007/s10113-015-0910-2>.
- Shackleton S, et al. (2015) Why is socially-just climate change adaptation in sub-Saharan Africa so challenging? A review of barriers identified from empirical cases. *Wiley Interdiscip Rev Clim Chang*. Wiley Online Library, 6(3), pp. 321–344
- Smith J, Firth J (2011) Qualitative data analysis: the framework approach. *Nurse researcher*. RCN Publishing Company 18(2):52–62
- Soini E (2005) Land use change patterns and livelihood dynamics on the slopes of Mt. Kilimanjaro, Tanzania. *Agric Syst*. Elsevier 85(3):306–323
- Tanner T, et al. (2015) Livelihood resilience in the face of climate change. *Nat Clim Change*. Nature Publishing Group 5(1):23
- Teklehaimanot A, Meja P (2008) Malaria and poverty. *A N Y Acad Sci*. Wiley/Blackwell (10.1111), 1136(1):32–37
- Yu B, Fulginiti LE, Perrin RK (2002) Agriculture productivity in Sub-Saharan Africa. *Annual Meetings of the American Agricultural Economics Association*. California

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.