Chapter 20
Climate Change Adaptation and Resilience on Small-Scale Farmers

Obert Jiri, Mutondwa M. Phophi, Paramu L. Mafongoya, and Blessing Mudaniso

Abstract Smallholder agricultural activities are susceptible to risks and uncertainties compounded and affected by climate change in intensity, frequency, and scope. Risks affecting crop yields and livestock survival are most important for smallholders, as they tend to consume a significant part of their own production. Local farmers have learned to live with the uncertainties of a changing climate, coping and adapting by building a memory of past events, accepting the reality of unstable systems, and increasing their ability to learn from shocks and crisis. Diversification of livelihoods is often used to reduce risks and increasing options in the face of increased climate hazard. Community-based monitoring and indigenous observations provide important impetus to close the gap between local impacts and adaptations and global science. Vulnerability of smallholder farmers is seen by their exposure to climate hazards, as they depend on climate-sensitive rainfed agriculture. However, the smallholder systems exhibit resilience to climate change, registered by their ability to deal with the shocks and hazards over time. Such resilience comes through development of various adaptive capacities, enabling the farmers to withstand the vagaries associated with uncertainties of a rapidly changing climate. Options to cope and adapt to change on smallholder farms often include climate-smart agriculture, off-farm livelihood options, and guided interventions by national governments, e.g., promotion of drought tolerant crop varieties.

Keywords Smallholder farmers · Adaptation · Adaptive capacity · Resilience · Climate change

O. Jiri (✉) · B. Mudaniso
Faculty of Agriculture, University of Zimbabwe, Harare, Zimbabwe

M. M. Phophi · P. L. Mafongoya
School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

S. Eslamian, F. Eslamian (eds.), *Disaster Risk Reduction for Resilience*,
https://doi.org/10.1007/978-3-030-99063-3_20

1 Introduction

Agriculture plays a huge role in ensuring the food security, job creation and generating income to farmers at local scale as well as globally. However, it can be affected by climate change. Human activities such as the burning of fuels, deforestation, and urbanization can contribute to greenhouse gas emissions, thus influencing climate change (Michalak, 2016). About 1.5 billion population in sub-Saharan Africa is expecting agriculture to play a huge role in feeding and enhancing food security by 2050 (FAO, 2007). However, due to climate change, achieving this goal will be a challenge. Crop yields are expected to drop by 2050 due to climate change and variability unless farmers adopt and use the mechanisms that will assist in adapting to climate change to enhance food security (Aggarwal et al., 2018). Smallholder farmers are more vulnerable to climate change because of the high poverty rate and high dependency on rainfall for sustainable agriculture.

2 Evidence of Climate Change and Its Impact on Smallholder Agriculture

Climate variables such as temperature, erratic rainfall, and extreme weather events affect the agricultural production severely. These factors affect pest population, pest distribution, pest behavior, and pest migration rate (Durak et al., 2016). Poikilothermic pests are the most affected by climate change and are more adaptable to increased temperatures than any other pests (Durak et al., 2016). Smallholder farmers are already vulnerable to such pests' damage and due to increased temperatures, they are expected to be more vulnerable to increased pest infestations. This has become a major problem in enhancing food security and sustainable agriculture due to lack of resources to manage these problematic pests.

As the vagaries of climate change and variability continue to unfold, it is the smallholder farmers who bear the brunt of nature's wrath (Parnell & Walawege, 2011). Smallholder farmers lack the necessary resource endowments to be able to effectively cope and adapt to rapid changes in the weather. Apart, from low resource endowment, these smallholder farmers also largely depend on climate-sensitive rainfed agriculture to sustain their livelihoods (Jiri et al., 2017). With increasing ambient average day temperatures, cooler night and winter temperatures, and poorly distributed rainfall, these small farmers have to drastically evolve and adopt new ways of farming and living. Such adaptation is not easy. It has to span from what the farmers are used to do but often venture into unchartered waters of adaptation beyond the individual and community levels. As usually reported, smallholder farmers have been coping and adapting to climate change since time immemorial (Ubisi et al., 2017). Such ways of coping, adaptation, and resilience need to be unpacked and documented. There are coping and adaptation strategies that are specific to a locality, but there are also some which are broad. Commonly, indigenous knowledge systems are believed to be specific, while scientific and meteorological models tend to be robust and need downscaling. However, some indigenous knowledge systems are robust, and there efforts to downscale the climate models to be effective at the local level (Nkomwa et al., 2014).

The impacts of climate change are often glaring at the local level, with loss of livelihoods being the eventual evidence. These impacts range from loss of agricultural productivity, for both crops and livestock, to loss of water and forest resources, due to temperature and rainfall variations (Muller, 2009). Crop yields have continued to decline, even with the "climate-smart crops" being developed and promoted in places. Droughts have become more frequent, particularly over southern Africa, causing devastating loss of life and livelihoods (Lobell et al., 2008). As a result of climate change, various biophysical risks are going to change, most of them in an uncertain way. Measuring these risks and impacts is often a complicated and difficult process as each component of the system will react differently, hence changing relationships within the system, at the local, national, and international levels.

3 Concept of Adaptation

Adaptation defines the processes of deliberate change in response to shocks and risks (in this case resulting from climate change) and other changes that affect the lives of people and communities (Below et al., 2010). The causes of these changes are usually very difficult to precisely identify. Successful adaptation is those actions that decrease the vulnerability of the smallholder farmers and increase resilience, in response to the shocks and risks. The vulnerability of the smallholder farmers depends on the degree of exposure to the climate risk or shock; and on the sensitivity of the system, their livelihoods are dependent such as rainfed agriculture; the already acquired adaptive capacity; and already acquired resilience (Berkes, 2007). For most smallholder farmers, whose lives depend on rainfed agriculture and the natural resource base, successful adaptations help to build resilience and decrease vulnerability to multiple threats. In relation to smallholder farming systems, it would be of interest to analyze the relationship between autonomous, locally driven adaptation and managed policy-driven adaptation. Local level coping and adaptation strategies are often seen as reactive, while policy-driven adaptations are seen as planned.

3.1 Local Forms of Adaptation

Smallholder farming communities, particularly in the global south, have been using a variety of strategies including indigenous knowledge systems and genetic diversity to adapt to climate change and variability (Padulosi et al., 2011). This has helped define types of effective and sustainable climate change adaptation. For example, smallholder farming communities have always protected wetlands which act as floodwater reservoirs. This brings to the fore what has been recently coined as "ecosystem-based adaptation." This approach tends to increase the local resilience and adaptive capacity when managed appropriately. There is also evidence that ecosystem-based approaches can be cost-effective and, concurrently, generate the social, economic, and environmental co-benefits (Valdivia et al., 2010).

The other approach has been termed "community-based adaptation," owing to it being a community lead process, based on community priorities, needs, knowledge, and capacities, which help the people to plan and cope with the impacts of climate change and variability. Community-based adaptation is often practiced reducing the impacts of vulnerability to farmers and also to assist farmers in becoming more resilient to climate change. It helps in boosting farmers adaptive capacity in order to improve the livelihoods and to enhance agricultural sustainability by implementing techniques and strategies to adapt to climate change (Gero et al., 2011). However, when implementing this approach would be inadequate to engage the community without adequate knowledge and understanding of the strategies to be used.

3.2 Why Adapt?

Climate change continues to impact the livelihoods at various levels of society. The smallholder farmers are hardest hit as, in most cases, they depend on climate-sensitive rainfed agriculture. Climate and weather extremes such as droughts, heat-waves, and flash floods already create widespread problems for smallholder farming communities (Stringer et al., 2009). In the absence of adaptation, these challenges will grow as the climate change increase the intensity, frequency, and duration of these extreme events. These impacts would be costly to attend to in the future. The impacts of climate change and variability are most acutely felt at the local level (Gbetibouo et al., 2010). This positions the smallholder farmers at the front line of having to deal with the climate change impacts. This creates the need and opportunity to reduce the vulnerability through adaptation planning at the local level. Action that is taken now to reduce vulnerability to current and future climate impacts may also lower the costs of those impacts by reducing financial losses and reducing the disruptions to livelihood processes. Furthermore, the range of coping and adaptation options may be more when preparing for, rather than reacting to, climate impacts (Rhodes et al., 2014).

3.3 Constraints to Adaptation

Climate change may happen rapidly or severely, that adaptation becomes difficult. Adaptation may be limited by the threshold of the climatic shock. These limits may be ecological, economic, physical, societal, or technological in nature. In order to reduce the adverse effects resulting from climate change, farmers need strategies to adapt to climate change impacts. However, this becomes more difficult due to lack of resources, lack of risk exposure awareness (Elum et al., 2017), poor service delivery from extension services and other organizations, poor technological facilities and norms and beliefs of farmers (Otitoju & Enete, 2016). Africa is expected to be exposed to increased water stress by 2020 and this will affect crop yields (Parry et al., 2007). Although smallholder farmers are battling to adapt to climate change impacts, in some African countries, farmers minimize climate impacts by changing crop planting dates, planting drought-resistant crops, and also irrigating their crops to improve yields (Bryan et al., 2009).

4 Resilience Building

In the context of smallholder agriculture, resilience entails the ability to survive and sustain livelihoods in the face of climate change and variability. Building resilience to climate change and variability should begin by building resilience through sustainable management of natural resources and ecosystem restoration (Gitz & Meybeck, 2012). Interventions, defined as building resilience, largely depends on the nature of the shock and risk. Some risks such as plant pests and livestock diseases resilience building would focus on early warning and action to prevent the spread of the risk (Fig. 20.1; Pasteur, 2011). However, this would need appropriate

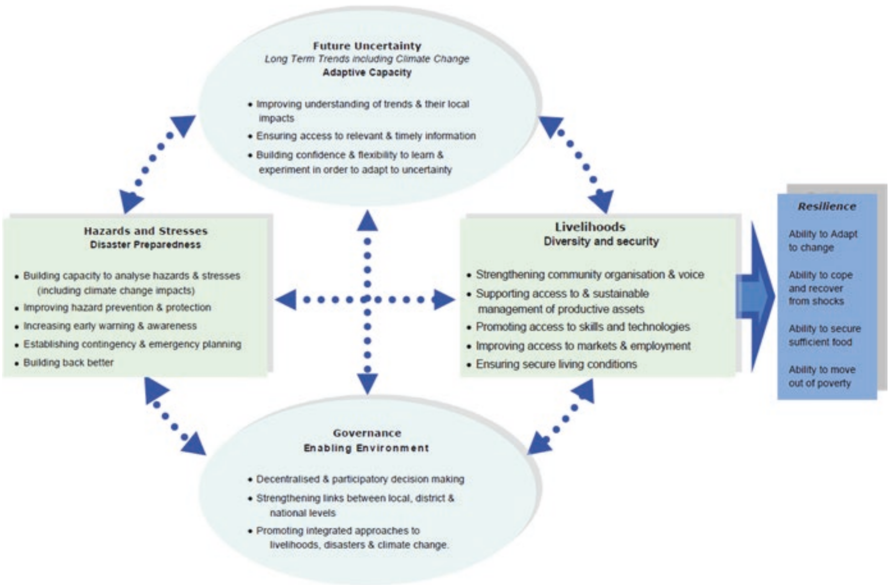

Fig. 20.1 Resilience framework (adapted from Pasteur, 2011)

equipment and tools, policies, and institutions to be in place. For crop seeds, for example, there would need to preserve genetic resources, and then making them accessible when needed. It should be noted that extreme climatic events significantly change the decision environment and a typical government response would be to institute implementation of robust policies, which may not be optimal in normal circumstances, but which avoids negative outcomes.

The Intergovernmental Panel on Climate Change defines resilience as "the ability of a system and its component parts to participate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and function" (Seipt et al., 2013). The continued upsets in temperatures and rainfall, negatively affecting the productivity of crops and livestock, affect food security. The uncertainty in the prediction of climate shocks and events increases the sensitivity of ecosystems and communities (Gitz & Meybeck, 2012). Climate change introduces the new uncertainties, modifies shocks and risks, vulnerabilities and the conditions that help the resilience of agricultural systems. Building resilience has to start with reducing vulnerabilities, as there is generally a negative correlation between the two (Gitz & Meybeck, 2012). The complication in this relationship is the problem of the time dimension, and the need to deal with uncertainties. This means that the resilience of agricultural systems cannot be an event but should happen over time, often with uncertain outcomes. This is what defines adaptive capacity. Adaptive capacity is a dynamic notion which denotes the capacity of a system to adapt in order to be less vulnerable (Aymone Gbetibouo & Ringler, 2009). This capacity is determined by the interaction of biophysical, economic, social, and economic factors that shape vulnerability though exposures and sensitivities. In essence, coping and adaptations are manifestations of adaptive capacity. It can be interpreted that increasing resilience can be achieved by reducing vulnerabilities (reducing exposure and reducing sensitivity) and increasing adaptive capacity. It is critical, therefore, to reduce the transmission of shocks between different types of risk, between scales and between domains and their interactions to negate cumulative effects so as to achieve better resilience.

The dynamic nature of agricultural systems poses the challenge of prescribing certain resilience building options. To ensure resilience, actions that build resilience in agricultural systems must be considered through time and taking into consideration future uncertainties (Table 20.1). Agricultural practices such as climate-smart agriculture (CSA) may help increase the resilience of smallholder agricultural systems (Stringer et al., 2012). CSA is multi-faceted but aims to increase agricultural productivity and incomes, as well as increasing resilience of ecosystems and livelihoods to the climate change and variability. In the longer term, CSA also helps to reduce greenhouse gas emissions. The effectiveness of CSA is driven by its consideration of context-specific and locally adapted actions and interventions, along the whole agricultural value chain. If promoted at the local level, this practice can strengthen the local knowledge base on sustainable strategies, and improve on financial and policy options to enable communities and countries to meet their food and nutritional security goals (FAO, 2010). Some of the key strategies that can be

Table 20.1 Suggestions on building smallholder farmer resilience at local level

Resilience building strategy	What can be measured as enabling information	Pathways for building resilience	Measurable outcomes
Access to localized, relevant, accurate data	Downscaled climate modelling and up-to-date climate change scenarios	Scientific and academic community and stakeholders consolidate and downscale research	Availability of data
Optimal activities in the face of climate change	Vulnerability and risk assessments Relevant downscaled climate modelling, weather and seasonal forecasts	Institutional social and safety nets, essential services, and emergency response services	Improved long-term stability against shocks and stressors Early warning systems operational at local level
Informed decision making	Downscaled climate modelling analytical tools to map impacts and weigh benefits and trade-offs	Engagement with climate information producers and knowledge brokers to discuss needs and availability of information	Useable and reliable climate change information available for use by policy makers and planners at the local and national level
Promotion of innovation and local research	Scenarios of future agroclimatic conditions Principles, practice, and case studies of resilient options available for farmers	Research programs specifically targeting climate resilient crops for expected conditions	Climate resilient crops developed and being trialled
Trained practitioners	Key skills required for climate resilient systems	In-service training to fill skills gaps in current agricultural practitioners	Courses that support climate resilience
Food security and farming	Principles, practice, and case studies of climate-smart options for different crops for different cropping systems	Promotion of climate-smart agriculture via extension, courses, and other information options Financial support and other incentives available for climate-smart agriculture	Farmers adopting climate-smart agriculture

used by smallholder farmers to develop the resilience and adaptive capacity are shown in Table 20.1. Success and continued adaptation are defined by these factors.

Building resilience around local woodlands, forests and trees in smallholder communities requires a basket of actions (Leeuwen et al., 2013). These may include the conservation, management, and use of the natural forest resources to reduce risk on the forest and people vulnerable to climate change. For example, the local folks in most indigenous communities use indigenous knowledge systems to predict seasons and forecast season quality through the use of tree phenology and animal behavior. Preserving these trees would ensure the perpetuation of use of indigenous knowledge in such communities (Njiraine & Ocholla, 2010). However, it also becomes a challenge when prolonged droughts, due to climate change, destroy the forest resources, often changing animal behavior and migration patterns, useful for indigenous predictions.

At the policy level, strategies to build resilience must combine a set of specific policies aimed at addressing certain categories of risks and vulnerabilities. Policies to help smallholder farmers should aim at building economic resilience at the farm level through increasing incomes and promoting diversification (Ifejika Speranza and Deutsches Institut für Entwicklungspolitik, 2010). Other measures could also include actions to prevent loss of productive assets, such as feedbanks for livestock during a drought or measures that help a quick recovery, such as ensuring availability of seed. The effectiveness and efficiency of risk management policies depend on other enablers such as favorable policies, support institutions, effective coordination and appropriate infrastructures, such as transport and markets (Pye-Smith, 2011).

4.1 Measuring Resilience

Resilience analysis is concerned with the ability of households or communities to adjust their livelihoods after disturbances (Osman-Elasha, 2006). To analyze resilience, therefore, both ex-ante actions that reduce continued risk and ex-post actions that help households and communities after a crisis occurs must be considered. This will lead to the most effective combination of short-term and long-term strategies for building the adaptive capacity and resilience, moving the families and communities out of the traps of food and nutritional insecurity. For smallholder farmers, four basic tenets determine their resilience to food security shocks as a result of climate change and variability (Solh & Van Ginkel, 2014):

1. access to water, healthcare, and energy
2. social safety nets, e.g., food assistance
3. assets, e.g., land, livestock
4. access to food (and income)

An analysis of these factors can give a quantitative score of resilience for each household. Further analysis of these pillars could also indicate which pillar needs to be strengthened to further build resilience. For example, analyzing how and why people in a certain location became food insecure may suggest ways of preventing this from happening in the future. Interventions that are made can then be tailored to enhance the people's ability to manage risk, climatic or otherwise, over time, leading to a reduction of the need for humanitarian assistance over time. Generally, vulnerability assessments and resilience assessments often compliment, rather than being seen as alternatives. However, the important difference is that vulnerability analysis tends to measure the susceptibility of farmers to damage when exposed to shocks, while resilience analysis pinpoints the specific factors that make households resilient, giving decision makers clear indications of where to intervene (Care

International, 2009). Policy interventions resulting from resilience analysis would lead to measures such as the promotion of climate-smart agriculture (CSA) and radical agricultural innovation systems. The main limitation to recommendations from a resilience analysis is usually financial, often addressed through private sector partnerships.

Policy measures that promote resilience in the smallholder farming sector often should go beyond the agriculture facet. Non-agricultural interventions are often important to enhance the effectiveness of these measures. Investments in infrastructure, developments of credit markets, enhancement of health facilities, and addressing other institutional constraints would support challenges in the face of climate change and variability. Safety nets for vulnerable smallholder farmers are a priority in the policy. Most of the smallholder farmers are not able to adapt and benefit, even when prospects are enhanced. For such smallholder farmers, safety nets to support production and consumption are required. Such decisions can be made based on the results of resilience analysis (Food and Agriculture Organization, 2013).

5 Conclusions

There are so many uncertainties in the way that climate change will, directly and indirectly, affect and impact the agricultural and food systems, as well as increasing related vulnerabilities. This makes building resilience of the individuals and communities central to risk-preparedness for future changes. Such resilience options need to be explored at the ecosystem (biophysical), economic, social and institutional levels, as well as at the various scales of operation and implementation. However, there can be an interaction between domains and scale of resilience implementation. For effective resilience building, it is important to identify and monitor potential shocks, risks, and vulnerabilities. This will allow early actions to be taken and avoid cumulative and long-term effects. There is also a need to increase the adaptive capacity of smallholder farmers and systems, to be able to recover from shocks and to prepare for future climate change. Disasters result from the impact of hazards on vulnerable communities, people with fragile livelihoods and who are inadequately prepared, not only from hazards themselves. Therefore, disasters are not inevitable and farmers do not have to be helpless. Action can be taken to build resilience to hazards and strengthen adaptive capacity to further climatic shocks. Farmers have traditionally adapted to the climate risk by diversifying across crops and risk management options. Farmers generally diversify their production systems by employing activities that are less sensitive to drought and/or temperature stresses and activities that take full advantage of beneficial climate conditions. For example, farmers time their planting and inputs based on their best estimates of the cropping season; and they reduce risk exposure by diversifying their livelihoods. Farmers diversify their cropping practices using a mix of crop species both in space and time (e.g., intercropping of different crops species, strip cropping and double cropping), growing different cultivars at different sowing dates and farm plots; combining less productive drought-resistant cultivars with high-yielding but water-sensitive crops. Nevertheless, managing droughts effectively in the vulnerable areas requires diversifying livelihood strategies and income generating options within and outside agriculture especially into income generating options through non-farm enterprises and employment opportunities. This will require the greater investments in infrastructure, road networks, electricity, communication, and market development. It is important that extension officers in African countries should be well informed about climate change and its impacts and also how to adapt to these changes to reduce vulnerability. There needs to be a strong link between research organizations and extension by the relevant institutions active at a country level. Workshops and formal meetings should be held to share information to extension officers so that they should give it with smallholder farmers. In order for the smallholder farmers to adapt to climate change, more experimental researches should be conducted on the farm, for farmers to see, look, and learn through experience.

References

Aggarwal, P., Vyas, S., Thornton, P., & Campbell, B. M. (2018). How much does climate change add to the challenge of feeding the planet this century? In *Environmental research letters*. IOP Publishing.

Aymone Gbetibouo, G., & Ringler, C. (2009). Mapping the South African farming sector's vulnerability to climate change and variability: A subnational assessment. *Food Policy*, 2. http://www.ifpri.org/publication/mapping-south-african-farming-sector-s-vulnerability-climate-change-and-variability

Below, T., Artner, A., Siebert, R., & Sieber, S. (2010). Micro-level practices to adapt to climate change for African small-scale farmers: A review of selected literature. *IFPRI Discussion Paper, 0953*, 28.

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. *Natural Hazards, 41*(2), 283–295. https://doi.org/10.1007/s11069-006-9036-7

Bryan, E., Deressa, T., Gbetibouo, G., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and constraints. *Environmental Science & Policy, 12*, 413–426. https://doi.org/10.1016/j.envsci.2008.11.002

Care International. (2009). *Climate vulnerability and capacity analysis handbook* (p. 52).

Durak, R., Węgrzyn, E., & Leniowski, K. (2016). Do all aphids benefit from climate warming? An effect of temperature increase on a native species of temperate climatic zone Cinara juniperi. *Ethology Ecology and Evolution., 28*(2), 188–201.

Elum, Z. A., Modise, D. M., & Marr, A. (2017). Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management, 16*, 246–257.

FAO. (2007). *Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities*. Food and Agriculturre Organization.

FAO. (2010). *"Climate-smart" agriculture: Policies, practices and financing for food security, adaptation and mitigation*. Food and Agriculture Organization.

Food and Agriculture Organization. (2013). *Climate-Smart Agriculture Sourcebook*. http://www.fao.org/docrep/018/i3325e/i3325e00.htm.

Gbetibouo, G. A., Ringler, C., & Hassan, R. (2010). Vulnerability of the south African farming sector to climate change and variability: An indicator approach. *Natural Resources Forum, 34*(3), 175–187. https://doi.org/10.1111/j.1477-8947.2010.01302.x

Gero, A., Méheux, K., & Dominey-Howes, D. (2011). Integrating community based disaster risk reduction and climate change adaptation: Examples from the Pacific. *Natural Hazards and Earth System Sciences, 11*(1), 101–113.

Gitz, V., & Meybeck, A. (2012). Risks, vulnerabilities and resilience in a context of climate change. In *Building resilience for adaptation to climate change in the agriculture sector* (pp. 19–36) http://www.fao.org/docrep/017/i3084e/i3084e00.htm

Ifejika Speranza, C., & Deutsches Institut für Entwicklungspolitik. (2010). *Resilient adaption to climate change in African agriculture*. DIE, Deutsches Institut für Entwicklungspolitik (Studies/Deutsches Institut für Entwicklungspolitik). https://www.die-gdi.de/uploads/media/Studies_54.pdf.

Jiri, O., Mafongoya, P. L., & Chivenge, P. (2017). Contextual vulnerability of rainfed crop-based farming communities in semi-arid Zimbabwe: A case of Chiredzi District. *International Journal of Climate Change Strategies and Management, 9*(6). https://doi.org/10.1108/IJCCSM-03-2017-0070

Leeuwen, M. V., Rense, M., Jiménez, A., Eijk, P. V., & Vervest, M. J. (2013). *Integrating ecosystems in resilience practice: Criteria for ecosystem-smart disaster risk reduction and climate change adaptation*. Wetlands International, Partners for Resilience.

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science, 319*(5863), 607–610. https://doi.org/10.1126/science.1152339

Michalak, D. (2016). A comparative analysis of initiatives and adaptation measures to climate change undertaken in Poland and Western Europe. *Comparative Economic Research, 19*(4), 107–122.

Muller, A. (2009). Benefits of organic agriculture as a climate change adaptation and mitigation strategy for developing countries. *IOP Conference Series: Earth and Environmental Science, 6*(343). https://doi.org/10.1088/1755-1307/6/37/372032

Njiraine, D., & Ocholla, D. N. (2010). Indigenous knowledge research in Kenya and South Africa: An informetric study. *INDILINGA – African Journal of Indigenous Knowledge Systems, 9*(2), 194–210.

Nkomwa, E. C., Joshua, M. K., Ngongondo, C., Monjerezi, M., & Chipungu, F. (2014). Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, Southern Malawi. *Physics and Chemistry of the Earth, Parts A/B/C, 67–69*, 164–172. https://doi.org/10.1016/j.pce.2013.10.002

Osman-Elasha, et al. (2006). *Adaptation strategies to increase human resilience against climate variability and change: Lessons from the arid regions of Sudan AIACC Working Papers*. www.aiaccproject.org

Otitoju, M. A., & Enete, A. A. (2016). Climate change adaptation: Uncovering constraints to the use of adaptation strategies among food crop farmers in South-west, Nigeria using principal component analysis (PCA). *Cogent Food and Agriculture, 2*(1), 1178692.

Padulosi, S., Heywood, V., Hunter, D., & Jarvis, A. (2011). Underutilized species and climate change: Current status and outlook. In *Crop adaptation to climate change* (pp. 507–521). https://doi.org/10.1002/9780470960929.ch35

Parnell, S., & Walawege, R. (2011). Sub-Saharan African urbanisation and global environmental change. *Global Environmental Change., 21*(Suppl. 1). https://doi.org/10.1016/j.gloenvcha.2011.09.014

Parry, M. et al. (2007). *Climate change 2007-impacts, adaptation and vulnerability* (Working group II contribution to the fourth assessment report of the IPCC). Cambridge University Press.

Pasteur, K. (2011). From vulnerability to resilience: A framework for analysis and action to build community resilience. *Vasa*. Practical Action Publishing, 128. http://practicalaction.org/media/preview/9654/lng:en

Pye-Smith, C. (2011). Farming's climate smart future: Placing agriculture at the heart of climate-change policy. *Farming's Climate-Smart Future*, 36. http://agris.fao.org/agris-search/search.do?recordID=GB2013201598.

Rhodes, E. R., Jalloh, A., & Diouf, A. (2014). Review of research and policies for climate change adaptation in the agriculture sector in West Africa. In *Coraf* (pp. 1–52). FARA. Retrieved November 15, 2015, from http://agris.fao.org/agris-search/search.do?recordID=XR2012209901

Seipt, C., et al. (2013). Capacity building for climate change risk management in Africa: Encouraging and enabling research for informed decision-making. *Environmental Development*. https://doi.org/10.1016/j.envdev.2012.11.006

Solh, M., & Van Ginkel, M. (2014). Drought preparedness and drought mitigation in the developing world's drylands. *Weather and Climate Extremes, 3*, 62–66. https://doi.org/10.1016/j.wace.2014.03.003

Stringer, L. C., Dougill, A. J., Thomas, A. D., Spracklen, D. V., Chesterman, S., Speranza, C. I., Rueff, H., Riddell, M., Williams, M., Beedy, T., Abson, D. J., Klintenberg, P., Syampungani, S., Powell, P., Palmer, A. R., Seely, M. K., Mkwambisi, D. D., Falcao, M., Sitoe, A., … Kopolo, G. (2012). Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands. *Environmental Science and Policy, 19–20*, 121–135. https://doi.org/10.1016/j.envsci.2012.02.004

Stringer, L. C., et al. (2009). Adaptations to climate change, drought and desertification: Local insights to enhance policy in southern Africa. *Environmental Science and Policy, 12*(7), 748–765. https://doi.org/10.1016/j.envsci.2009.04.002

Ubisi, N. R., Mafongoya, P. L., Kolanisi, U., & Jiri, O. (2017). Smallholder farmer's perceived effects of climate change on crop production and household livelihoods in rural Limpopo province, South Africa. *Change and Adaptation in Socio-Ecological Systems, 3*(1), 27. https://doi.org/10.1515/cass-2017-0003

Valdivia, C., et al. (2010). Adapting to climate change in Andean ecosystems: Landscapes, capitals, and perceptions shaping rural livelihood strategies and linking knowledge systems. *Annals of the Association of American Geographers, 100*(4), 818–834. https://doi.org/10.1080/00045608.2010.500198