Climate change and adaptation impacts in mixed crop-livestock systems in south west Zimbabwe

Policy Brief 39
November 2021

Drought and disease tolerant fodder legume mucuna pruriens enriches the soil in nitrogen and provides valuable protein-rich fodder resources for the farmer.

AgMIP projections show that poverty will reduce significantly if climate smart technologies are adopted. Yet many, especially those without livestock, will remain poor.

Key messages

1. Science-based evidence should play a key role for guiding Zimbabwe's national agricultural and climate change related policies and adaptation options.
2. In south west Zimbabwe where soil fertility is low, crop and livestock productivity, poverty, and food insecurity can only be reduced with transformation of the agri-food system.
3. A sustainable agricultural development pathway (SD) that diversifies crop production and enhances the livestock sector may provide effective and equitable solutions, enabling farmers to increase farm incomes and food security in a future that includes climate change.
4. Raising the economic importance of livestock involves increasing livestock offtake levels and milk production through better integration with crops, and ensuring that the resource poor participate in and benefit from interventions and improved markets.
5. Vulnerability to climate change is high with increased productivity, as the risk to lose also increases. Investment in SD offsets the negative impacts of climate change more effectively. Climate change adaptation strategies are thus needed to support the transformation of agri-food systems while minimizing risk of losses.
6. Improved livestock feeding (crop residues, forage, supplements) and switching from cattle to goats are some of the profitable ways to adapt to climate change, which increases the likely return on farm system improvement as well.
7. However, in order to address inherent trade -offs with environmental benefits and reducing GHG emissions, more drastic mitigation efforts are required. Improved feed production and livestock feed conversion are critical to enhance individual animal productivity and resource use efficiency.

About AgMIP CLARE

Given the need for more effort to enhance climate action, the AgMIP (Agricultural Model Intercomparison and Improvement Project) CLARE (Climate Change Adaptation and Resilience) project provides tools, and information to better understand vulnerabilities of agriculture to climate change, and its performance under plausible future pathways, towards enhanced climate change adaptation and resilience. The collaboration with multi-scale and multidisciplinary experts and stakeholders to undertake and validate forward-looking research is set to guide actionable agriculture and climate change policy decisions.

ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

AgMIP The Agricultural Model Intercomparison and Improvement Project

Introduction

There is increased urgency in Zimbabwe toward climate change adaptation planning in agriculture, and towards building a shared national vision for agriculture and food systems transformation. However, there remain knowledge gaps in national level climate change adaptation planning for agriculture, including in terms of science but also policy making, as well as how best to create linkages across scale for implementation at a sub-national level.

The particular conditions of agricultural systems in semi-arid areas are not adequately addressed by agricultural and climate change related policies, strategies and action plans to allow for meaningful participation by this community in the country's vision 2030 and business paradigm shift. Challenges to adaptation in high risk areas, including in the southwest of Zimbabwe, are not yet sufficiently captured, so do not adequately inform planning and decision making at national level. Without scientific evidence and bottom-up interaction, national policy and practice are not sufficiently sensitized to the locally specific requirements.

Therefore, forward looking research is required to inform national agricultural and climate change adaptation policy planning through improved feedback from implementation in particular agricultural systems. This brief illustrates of what would happen in different farming systems, should the country continue along one agricultural pathway or another.

About AgMIP CLARE Regional Integrated Assessment (RIA)

The AgMIP CLARE project uses a Regional Integrated Assessment (RIA) and stakeholder engagement approach to explore impacts of climate change and adaptation decisions on particular farming systems, allowing decision-makers to identify which adaptation package would best improve outcomes under future conditions.

Key features include (Figure 1):

- **Stakeholder driven approach**: Scientists work in collaboration with experts and stakeholders throughout the research process, to characterize farming systems, set priorities, identify indicators and co-design pathways and adaptation/mitigation packages, review and validate research results and identify ways to disseminate the information to users.
- **Multi-model and multi-scale framework**: Multiple climate scenarios, crops and livestock economic models allow more holistic analyses, while they also provide information on uncertainty in projections. Linking sub-national farming system simulations with the national level vision for agricultural development, we can examine the extent to which national policies can be implemented at the regional scale.
- **Whole farm approach**: A range of economic, food security and emission indicators can be projected by capturing the important household, on-farm and off-farm activities and characteristics, including biophysical conditions like soil fertility, crop and livestock management, crop production, herd sizes and off-takes, cultivated land, herd, and farm size. The distribution of likely impacts of climate change and adaptation uptake can be projected for particular farming communities and households.
- **Plausible future conditions**: Representative Agricultural Pathways (RAPs) are co-developed in an iterative process with experts and stakeholders. Sub-national RAPs characterize future plausible socio-economic and biophysical conditions under which climate change might impact future agriculture. National RAPs capture agricultural development policies and climate specific policies of the agricultural sector (e.g. vision 2030 for sustainable development).
- **Adaptation and mitigation packages**: Climate change adaptation options are co-designed in a way that captures local context and suitable for specific farming systems. They incorporate economic aspects, policy interventions, improvements of infrastructure and markets in response to climate change. Trade-offs with mitigation options are being considered.

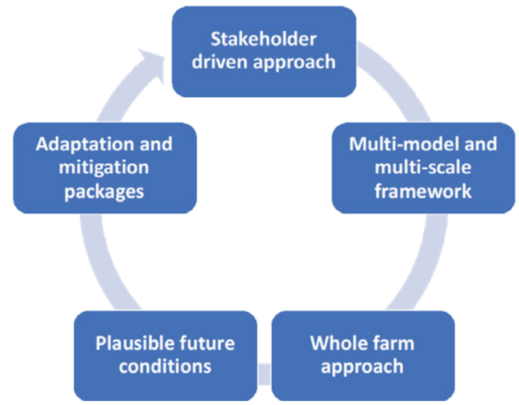


Figure 1. Key features of the AgMIP CLARE approach, part of an iterative science policy engagement approach.

Unpacking impacts of climate change

AgMIP CLARE aims at better understanding the impacts of climate change to devise climate change adaptation and mitigation strategies. We chose a typical mixed crop livestock agricultural system, here in the case of Nkayi District in agro-ecological zone IV. First, we looked at current agricultural systems in Nkayi District, with extremely low agricultural productivity. Then, we developed different agricultural pathways to characterize future conditions and to understand what needs to be improved for agricultural development and climate change adaptation that could guide Zimbabwe towards meeting the goals of its agricultural vision 2030, and its commitments towards the Sustainable Development Goals.

We investigate the range of climate and adaptation impacts for hotter and wetter conditions as well as hotter and drier conditions, the latter of which is considered the most likely. Impacts were analyzed for the three types of farm households found in Nkayi District. 42% of households are without cattle and termed *'extremely resource poor'*; 36% of households have with 1-8 cattle and are termed *'resource poor'*, and 12% of households have 8 or more cattle and termed *'non-resource poor'*.

Current agricultural systems and impacts of climate change

Current national policies

Current polices and socio-economic conditions influence the extent of the impacts of climate change in Zimbabwe and guide the response interventions. Zimbabwe aims to transform its agricultural sector, towards enhancing agriculture's contribution to the national GDP, and combatting the impacts of climate change, reducing its devastating impacts on poverty and malnutrition. The National Development Strategy 1 (NDS1) prioritizes commercializing the agricultural sector and building resilience to climatic shocks, while stabilizing the macro-economic environment. The Agriculture and Food Systems Transformation Strategy targets 7.8% annual growth rates by 2025, with efforts to climate proof the agricultural sector. The Food and Nutrition Security Policy (FNSP) exhibits the commitment to reduce poverty, food and nutrition insecurity. The National Climate Policy (NCP) is being mainstreamed across all sectors through multi-stakeholder approaches.

The case of Nkayi district

Agricultural activities are predominately maize production, with limited small grains and legumes. Cattle and small ruminants provide farm inputs and income. Agricultural productivity is extremely low, with most soils of poor fertility, with limited investment in livestock feed, and pest and disease pressure.

Given the already low agricultural productivity in Nkayi district, the relative magnitude of the climate change impact was small, though it did vary by farming activities and farm types.

Climate: Increasing temperatures across the season by 1 to 3ºC, along with low and erratic rainfall (<650mm annual average) and a likely decrease in rainfall by up to 23%, result in overall drier climate. Higher temperatures accelerate phenological development, shortening the time for biomass accumulation, reduced yields and changing rangeland plant diversity. Less rain implies water stress.

Crops: Crops showed a range of responses to climate change, depending on climate scenarios and soil fertility (Figure 2). Soil fertility influences crop sensitivity to climate impacts. Poor soil fertility locks farmers into a low level of crop productivity. In Nkayi, about 78% of the farmers plant maize in very poor soils, and as such, there is little response by maize to climate change in these locations. Groundnuts tend to benefit from climate change, as higher CO_2 concentrations offset the impact of increased temperature. Only the 12% *non-resource* poor farmers, on soils with better fertility, had higher crop yields. However, the impacts of climate change were also found to be larger for this group.

Livestock: Feed deficits affected the few farmers with larger cattle herd sizes more negatively. Hot dry conditions on rangelands and crop residue biomass reduced feed intake of livestock, further reduced livestock productivity. Under hot wet conditions, the impacts of climate change were small.

Economic impacts: Poverty levels and food insecurity were extreme in Nkayi District. The majority of household were below the poverty line (83%) and struggling to produce maize on poor soils while keeping some livestock. Climate change worsened the conditions for these farmers, even though the impacts on poverty levels were mostly small (<5%). Farmers with larger cattle herds experienced greater economic losses due to feed shortages. They were likely to have alternative means to compensate for these losses, as compared to the poor, and were less likely to experience complete losses of assets than the poorer farms.

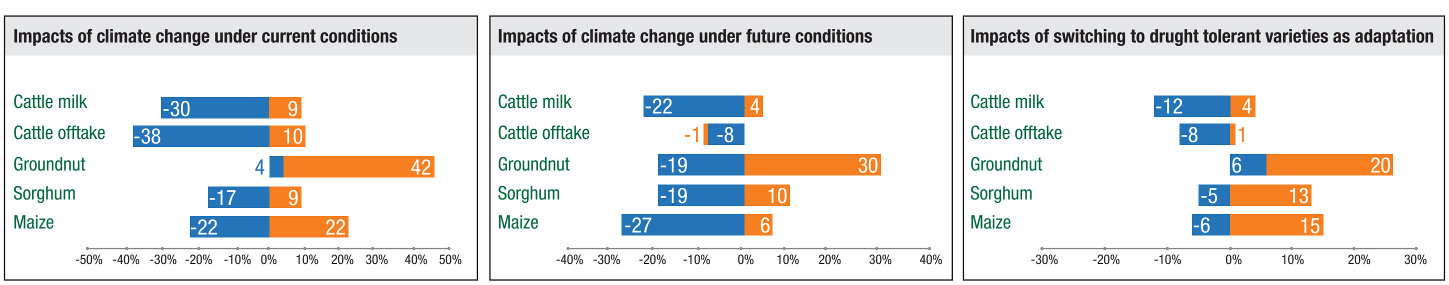


Figure 2. Relative change in yields (%) for crop and livestock outputs, Nkayi District.

Hot dry Hot wet

Vulnerability to climate change was explored using contrasting climate scenarios, and found to be high (38-72%). Up to three quarters of households lost from hotter and drier climate. Farmers with more cattle exhibited larger feed gaps and that made them more vulnerable to the adverse effects of climate change. Vulnerability under hotter and wetter climate was lower, but still affected about a third of the households.

Future impacts of climate change

National Representative Pathways

Three Representative Agricultural Pathways (RAPs) were co-designed with experts and stakeholders. One represents a Business As Usual (BAU) scenario, one Sustainable Development (SD) and one Unsustainable Development (UD).

The RAPs help to understand the behavior of agricultural systems from the current situation of extremely low agricultural productivity, alarming poverty and food insecurity moving into a future dependant on agricultural policies and other drivers that shape the conditions for responses to climate change and other shocks.

Depending on the RAP chosen, different importance was attributed to climate change adaptation and mitigation supporting agricultural development and different extent of coherence in implementation strategies (Figure 3).

Linking national policies with regional RAPs shows to what extent national policies are being implemented to improve agricultural systems in response to regional conditions (Figure 4).

The case of Nkayi district

The simulation results suggest that following the RAPs the conditions for agriculture can be improved, production increased and poverty reduced by 2030. The magnitude of impact, especially for the extremely poor, however, depends on the RAP chosen.

At higher productivity levels, the losses from climate change were higher and the magnitude of impacts was therefore larger. The RAPs differently offset the losses from climate change.

Crops: Crop productivity levels were higher in future, and the range of climate change impacts on crop productivity was large. The SD pathway increased crop yields more as compared to UD and BAU pathway through cultivation of climate-resilient high-yielding dryland legumes (groundnut and forages). Cereal yields were increased on smaller land through organic soil fertility amendment. Improving soil quality exhibited higher yields. The resource-poor benefited more from improved crop production.

Livestock: Supplementary feeding was key to reduce losses to climate change. SD raised the economic importance of livestock addressing strategic bottlenecks through the inclusion of (i) supplementary feed (crop residues, forage, supplements) to improve livestock productivity (ii) mechanized crop cultivation to release cattle from draft power (iii) improved market access to raise off-take levels. Negative effects of higher temperature and CO_2 levels on rangelands resulted in higher supplementary feeding of commercial feeds. A national restocking strategy in response to the increasing

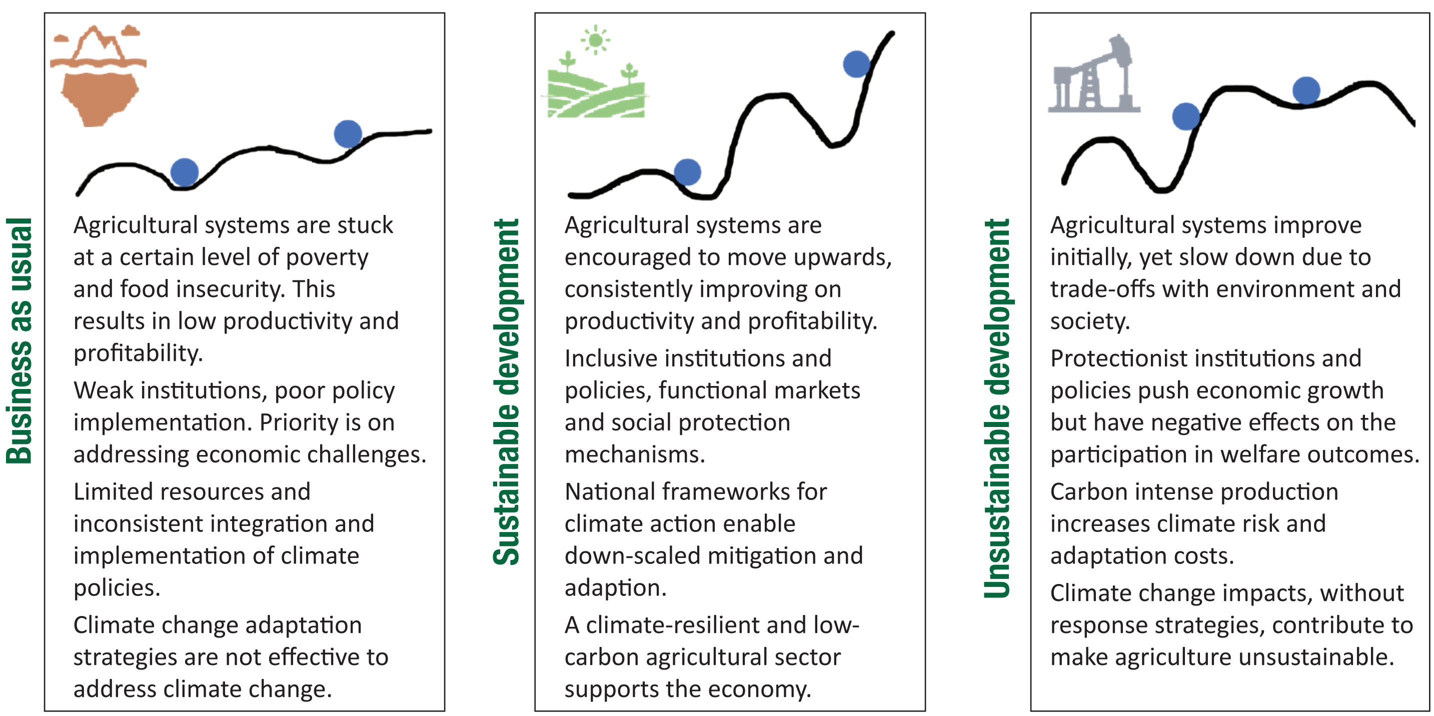


Figure 3. National Representative Agricultural Pathways (RAPs) in Zimbabwe, systems behavior, drivers and outcomes (2030).

Business as usual

Continuous crisis coping

Inconsistency between national agricultural policies and regional implementation.

With national food security as a priority, investment in dryland agriculture remains low.

Implementation challenges with diversifying agriculture, including small grains, legumes and livestock.

Protracted crisis limits opportunities for women and youth.

Adaptation package: Not tailored to context

Switch to drought-tolerant crop varieties, residual feed increase

Sustainable development

Win-win situation

Synergies from the agricultural systems' comparative advantages.

Investment in small grain, legume and livestock value chains stimulate on-farm diversification and integration.

Farmers at different levels of resource endowments participate in market opportunities.

Women and youth are change makers and gain competence, income and nutrition benefits.

Adaptation package: tailored to regions and farm contexts

Switch to drought-tolerant crop varieties, residual feed increase

Crop diversification, for soil and feed benefits

Switch cattle to goats, with market incentives, mitigation

Unsustainable development

Short-term fast economic growth

Dual structure, commercial push in livestock business.

The better-off expand agriculture on prime land using carbon intensive production methods.

The majority is resource poor and live on marginal land, from low-paid off-farm employment and subsistence agriculture.

Growing inequality aggravates inefficient resource use, and degradation

Adaptation package: not tailored to context

Switch to drought-tolerant crop varieties, residual feed increase

Figure 4. Regional implementation and respective adaptation packages (2030).

demand for livestock provided every household with at least five cattle. Under the UD pathway resource-poor farmers were excluded from keeping cattle.

Economic impacts: The main issue for mixed farming systems in Zimbabwe, regardless of climate change, was to look at improvements that would reduce poverty and inequality (Figure 5). Following Sustainable Development was more effective as agricultural incomes increased for all households and poverty rates reduced to 34%. Unsustainable Development and Business As Usual increased inequality, agricultural incomes improved for the better off, however, the majority of resource-poor households did not benefit from agricultural policies under these two RAPs and poverty rates remained high at 65 and 80%, respectively.

With improved economic development the impact of climate change on poverty levels was small (<5%). However, a large proportion of households was still vulnerable to climate change (47-60%). Under the SD pathway the resource poor were more vulnerable to climate change, yet higher and more profitable agricultural production offset the impacts of climate change.

Future impacts of climate change adaption in Nkayi Districts

Advising adequate climate change adaptation and mitigation strategies is critically important to ensuring that the benefits from economic investments are not lost. This needs to support reducing poverty and improving farms resilience to climate change.

The SD pathway adaptations (with 3 options) provided larger benefits to farmers, accomplishing the goals of improving farmers livelihoods and making the system more resilient to climate change, moving the system towards meeting the SDGs (Figure 6). The adaptation strategies under BAU and UD pathways provided small benefits for farmers with cattle. Those resource-poor farmers without cattle remained with very low income, which demonstrates that following those pathways would make it difficult (or worse) to improve the livelihoods for resource-poor farmers.

Adaptation package 1 (A1): Switching to drought-tolerant varieties is one important strategy to adapt to increasing temperatures. Adoption rates were between 51 and 55% across the three RAPs. The impact on farm incomes was,

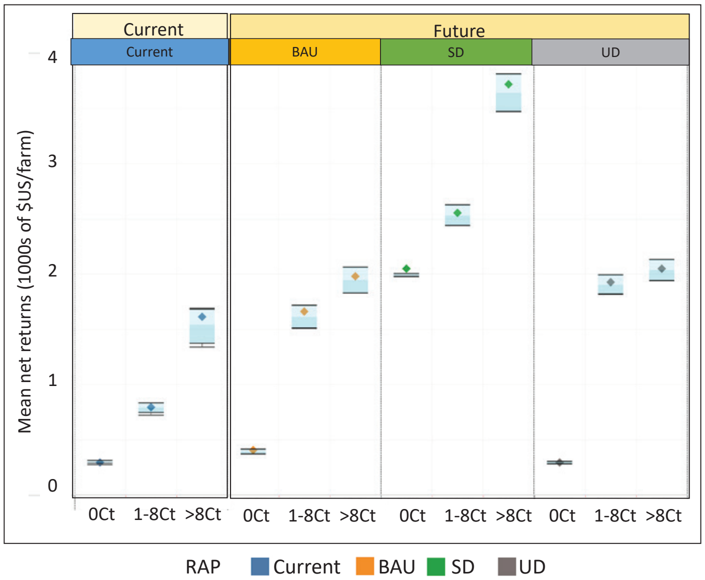
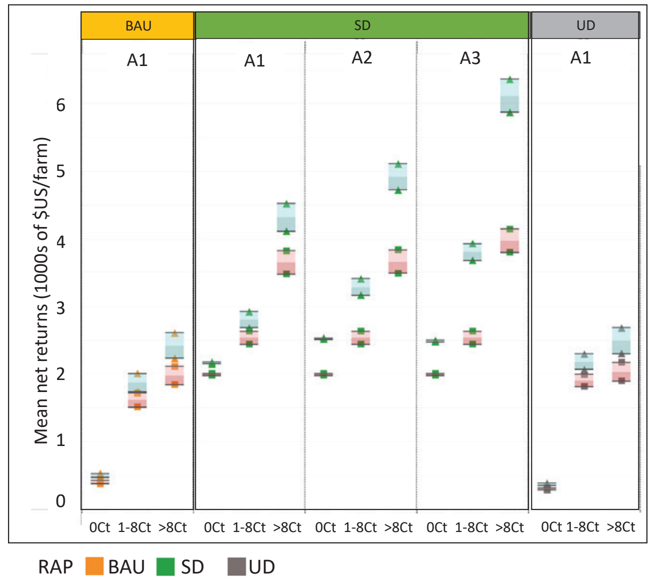


Figure 5. *Impact of agricultural development and climate change for RAPs [Business as Usual (BAU), Sustainable Development (SD) and Unsustainable Development (UD)] and climate scenarios (Hot-Dry, Hot-Wet), and farm types in Nkayi, Zimbabwe, using APSIM and DSSAT results as input.*



Pink blocks = Mean Net Returns (NR) with Climate Change (CC)
Blue blocks = NR with CC and adaptation

Figure 6. *Impact of adaptation to climate change for RAPs (BAU, SD, UD) and climate scenarios (Hot/Dry, Hot/Wet), and farm types in Nkayi, Zimbabwe, using APSIM and DSSAT results as input.*

however, relatively small with increased farm net returns of 8 to 20%. The adaptation package alone is therefore not sufficient.

Adaptation package 2 (A2): In addition to the components of A1 in this adaptation, deliberate efforts were made to further increase the feed supply for livestock, converting land into high-yielding *leucaena.* The majority of farmers (84 to 86%) adopted this package, farm incomes increased by 28 to 32%.

Adaptation package 3 (A3): In addition to the components of A2, switching from cattle to goats was tested as an adaptation strategy, as the smaller and more resilient livestock are easier to handle, especially for women. In a next step a price incentive of 15% price increase was offered to stimulate the conversion. This package was attractive for most farmers, with a projected adoption rate of 88-90%. This increased farm incomes by 41-43%. It illustrates that financing a shift from cattle to goats can provide important adaptation benefits.

Mitigation impacts: Switching cattle to goats had however limited impacts on reducing greenhouse gas emissions. Hence more drastic mitigation efforts are required in terms of feed improvement and improving individual animal productivity.

Policy recommendations/actions

Supporting agricultural transformation

Agricultural policies and future conditions in Zimbabwe will shape the structure of farming systems in the country, with varying consequences of climate change and adaptation measures under different pathways.

The country can explore contrasting agricultural pathways (RAPs) established among policy experts and AgMIP scientists in the region. Features of RAPs, designed specifically for dryland systems in Zimbabwe, illustrate that addressing poverty, food insecurity and inequality are most critical issues, which can further deteriorate under climate change. Not investing in SD can deepen poverty and food insecurity for the majority of the population and increase inequality. Given that under BAU and UD the majority of farmers still operate on soils of poor fertility, it will be more difficult to get those out of the 'locked' state in future. These are very strong arguments for inclusive policies, interventions and tools to support the transformation of the agri-food system.

Transforming agri-food systems in semi-arid areas starts with recognizing that climate change is not the main problem. The problem is that the majority of farmers are trapped on poor soils with low input access and use, and low levels of resource endowments. With high levels of labor migration this takes a toll, especially on women.

To reduce poverty and increase farm household food security, a shift in focus is needed from narrow or time limited food security strategies (BAU), towards pathways that enable ongoing policy-supported solutions appropriate for local condition, with a focus on improved farmer well-being (SD). Climate change adaptation and mitigation needs to support poverty reduction through measures that are well-tailored, gender sensitive and integrate farmers at varying levels of resource endowments.

This would involve:

Crop diversification: Part of transformation in technical investments is to cultivate maize on smaller land and thereby release land to increase the contribution by other crops, notably legumes and other underutilized species, with strong climate resilience and nutrition-density.

Soil fertility and health: Soils play an important role and can act as buffer to reduce impacts of climate change on crop production. Strategies that also improve the soils are important for possible future modified crop genetics for increased resilience to climate factors such as rainfall and CO_2; this is especially true for legumes, which improve soil fertility and provide nutritious food and feed for livestock.

Crop improvement: The contribution of genetic crop improvement can be more effective if combined with (i) improved soil fertility for higher yield response and (ii) market improvements as incentives for farmers to budget these varieties. Synergies with other management components are thus critical to increase the returns on crop improvement.

Market oriented investments: Enhancing market participation is critical for all farmers to increase off-take and farm reinvestment as well as to increase productivity, farm incomes and resilience. Policy support is required to enable the shift to more profitable agriculture, while reducing the risk to lose from climate change.

Social protection: Vulnerability was found to be high in future, and there were households 'locked' in poverty. Social protection mechanisms are thus critical, as are adaptation packages that minimize the likelihood of future losses from climate change, especially in resource poor households.

Adaptation strategies in response to climate change

Given the variable impact of climate change on the different farm groups, policy makers who understand the dynamics of climate change may better formulate effective climate policies for the future that consider, and address this dynamic, so as to ensure the impacts of climate change on poverty do not increase while farm groups improve their well-being.

Switch to high-yielding biomass crops pays off through improved soil fertility and livestock feed, better adapted cultivars for the poor soils typical in these areas, improved access to nutrient-dense diets, and learning about climate change factors.

Shifting from cattle to small livestock such as goats will promote the resilience of the livestock sector because small livestock demands less water and can better withstand stressful climatic conditions.

The success of adaptation packages is however not possible if there is not adequate investments in markets, infrastructure, and knowledge to enable the adaptation.

Mitigation

For drylands, integrated and diversified crop-livestock system is a recommended strategy to generate income and livelihoods. To reduce livestock greenhouse gas emissions, strategies to address co-benefits from adaptation and mitigation are important. An assessment of the trade-offs of policy and technology interventions between environmental, social and economic outcomes can inform policies that enable such strategies.

For example, the impacts of shifting cattle to goats for reducing the emission of methane, as demonstrated in the example of Nkayi District, were limited. Hence more drastic mitigation efforts are required in terms of improving local feed production and individual animal productivity. More research is needed on improving livestock feed conversion, while not losing the adaptiveness of local breeds.

Conclusions

The results of simulation assessments can guide decision processes for Zimbabwe as policy makers and scientists work together to understand the complexity of likely outcomes, as well as the consequences on policy decisions. The efforts should lessen the gap, and increase informed action and investment toward farming systems with pathways to address shortfalls beyond just climate change, that make for effective adaptation to climate change. These sorts of analyses are also important to the exploration of mitigation co-benefits that further farm household well-being while maintaining local biodiversity.

This supports coordination between national and localized adaptation and mitigation planning in agriculture, aiming at raising the food basket while mainstreaming climate change adaptation, and understanding trade-offs with mitigation. An improved understanding of the effectiveness of adaptation strategies at the local level, gaps in national policies can be identified, with regards to technical implementation and the level of granularity required.

Reading material

Descheemaeker K, Zijlstra M, Masikati P, Crespo O and **Homann-Kee Tui S.** (2018). Effects of climate change and adaptation on the livestock component of mixed farming systems: a modelling study from semi-arid Zimbabwe. Agricultural Systems. 159. pp. 282-295

FAO. 2019. *Five practical actions towards low-carbon livestock.* Rome. https://www.fao.org/3/ca7089en/ca7089en.pdf

Homann-Kee Tui S, Descheemaeker K, Masikati P, Sisito G, Valdivia R, Crespo O and **Claessens L.** (2021). Climate Change Impacts and Adaptation for Dryland Farming Systems in Zimbabwe: A Stakeholder-Driven Integrated Multi-Model Assessment. Climatic Change. Climatic Change. 168:10. https://doi.org/10.1007/s10584-021-03151-8

Homann-Kee Tui S, Masikati P, Descheemaeker K, Sisito G, Francis B, Senda T, Crespo O, Moyo EN and **Valdivia R.** (2021). Transforming Smallholder Crop–Livestock Systems in the Face of Climate Change: Stakeholder-Driven Multi-Model Research in Semi-Arid Zimbabwe. In: Handbook of Climate Change and Agroecosystems: Climate Change and Farming System Planning in Africa and South Asia: AgMIP Stakeholder-driven Research (In 2 Parts). Vol. 5, 217-276. World Scientific Publishing Company. World Scientific Publishing. [Rosenzweig C, CZ Mutter and E Mencos Contreras (eds.)].

Masikati P, Descheemaeker K and **Crespo O.** (2019). Understanding the role of soils and management on crops in the face of climate uncertainty in Zimbabwe: a sensitivity analysis. Chapter 5. In: Rosenstock TS, Nowak A, Girvetz E (eds) The Climate-Smart Agriculture Papers. Investigating the Business of a Productive, Resilient and Low Emission Future. Springer Open, Berlin, pp 49–64

Moyo EN, Mugabe FT, Ndebele-Murisa MR and **Makarau A.** (2018). CMIP5 GCM Selection for future climate simulations over Zvishavane, Zimbabwe In Petrik D, Ashburner L (Eds) 2018. Conference Proceedings of Adaptation Futures 2018. Adaptation Futures 2018. University of Cape Town, Cape Town. https://openbooks.uct.ac.za/uct/catalog/download/AF18/27/935-1?inline=1. Doi. https://doi.org/10.15641/0-7992-2543-3

Valdivia R, Homann-Kee Tui S, Antle J, Subash N, Singh H, Nedumaram S, Hathie I, Geethalakshmi V, Claessens L and **Dickson C.** (2021). Representative Agricultural Pathways: A Multi-Scale Foresight Process to Support Transformation and Resilience of Farming Systems. In: Handbook of Climate Change and Agroecosystems: Climate Change and Farming System Planning in Africa and South Asia: AgMIP Stakeholder-driven Research (In 2 Parts) (Vol. 5). World Scientific Publishing. [Rosenzweig C, CZ Mutter and E Mencos Contreras (eds.)].

Von Braun J, Afsana K, Fresco LO and **Hassan M.** (2021). Science for Transformation of Food Systems: Opportunities for the UN Food Systems Summit. Scientific Group for the United Nations Food Systems Summit 2021. https://sc-fss2021.org/

Accronyms

AgMIP CLARE	Agricultural Modeling Intercomparison and Improvement Project Climate and Resilience
BAU	Business as Usual RAP
RAP	Representative Agricultural Pathway
SD	Sustainable Development RAP
UD	Unsustainable Development RAP

Coauthors

Dr Sabine Homann-Kee Tui (ICRISAT),
Mr Gevious Sisito (Matopos Research Institute),
Dr Roberto Valdivia (Oregon State University), Dr Katrien Descheemaeker (Wageningen University), Dr Elisha Moyo (Climate Change Management Department),
Dr Thulani Dube (Lupane State University),
Dr Carolyn Mutter (Columbia University).

Acknowledgements: "This work was carried out with financial support from the UK Government's Department for International Development and Foreign, Commonwealth & Development Office, as well as the International Development Research Centre, Ottawa, Canada Climate and Resilience (CLARE) Program; via the Agricultural Model Intercomparison and Improvement (AgMIP) 'A-Teams' project award #109204-001 to Columbia University, including support of seven additional AgMIP partners."

Thanks to Mr Kudzai Ndidzano, Climate Change Management Department for the review and Strategic Marketing and Communication, ICRISAT, for design and editing.

Donors:

IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international
Canada

Foreign, Commonwealth & Development Office

Research partners:

Lupane State University
Oregon State University
WAGENINGEN UNIVERSITY & RESEARCH
COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK
NASA