Re-designing smallholder farming futures for reduced vulnerability to climate change in semi-arid southern Africa

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1 Introduction

Climate change will impact the productivity of maize-based crop-livestock systems and the food security of smallholders depending on them in semi-arid southern Africa. Earlier results from testing climate change adaptation options showed that incremental improvements in fertilizer application rates, use of adapted maize cultivars or introduction of forage production are insufficient for substantial improvement of smallholder livelihoods (Masikati et al., 2015). In this paper we therefore explored effects of more transformative system re-design on households' vulnerability to climate change, farm net returns and poverty rates. We tested the hypothesis that packages tailored to specific farm situations are more effective than blanket recommendations.

2 Materials and Methods

The study was carried out in the Nkayi district of semi-arid Zimbabwe, characterized by average annual rainfall of 650 mm with high interannual variability. Climate change projections agree on an increase in temperature of 2 to 3.5 °C, whereas future rainfall conditions are less certain. Apart from low and erratic rainfall, the poor soil fertility status and limited agricultural input use result in low productivity of the predominantly maize-cattle based systems, with average maize yields below 0.7 t ha^{-1}, high mortality rates up to 15%, and low milk yields. According to national statistics 76% of all rural households in Zimbabwe are poor and more than 22% are extremely poor (ZimVAC, 2013). Food self-sufficiency varies from 3 to 10 months depending on the annual rainfall, leaving rural households extremely vulnerable to the adverse effects of climate change. Heterogeneity in the farming community is high and three farm types are distinghuised, (1) extremely poor households with no cattle, cultivating 1.3 ha on average, (2) poor households with 0 to 8 cattle, cultivating 1.8 ha, (3) better-off households with more than 8 cattle, cultivating 2.5 ha.

We followed the AgMIP Regional Integrated Assessment procedure (Antle et al., 2015) using (i) a multi-modeling framework of climate, crop, livestock and economic simulation models, and (ii) representative agricultural pathways (RAPs) generated with stakeholders to define plausible future socio-economic conditions. System re-design for the three farm types (Table 1) followed the assumption that improved access to inputs, knowledge and markets encourages smallholders to intensify agricultural production, making full use of the cultivated land areas, diversifying production of crops (grain and forage legumes), enhancing mineral and organic fertilizer use and improving livestock management and marketing. Three transformative packages were designed and effects evaluated accros the entire farm population. Based on this, a set of tailored packages per farm type was developed to maximize net returns.

Table 1. Transformative packages (Tr) as compared to the current situation for three farm types in Nkayi

	0 cattle		0 – 8 cattle		> 8 cattle	
	Current	Tr 1	Current	Tr 2	Current	Tr 3
Maize (% of cropland)	75	25	70	25	70	20
Sorghum (% of cropland)	11	12.5	11	8	16	5
Groundnuts (% of cropland)	10	37.5	10	33	10	25
Common beans (% of cropland)		25				
Mucuna (% of cropland)				33		25
Banagrass (% of cropland)						25
Cereal fertilizer use (kg N / ha)	3	20	3	20	3	20
Offtake rate (%), cattle/small ruminants	0 / 17	0 / 50	4 / 12	10 / 50	7 / 10	20 / 50
Milk production (l/day/cow)	n.a.	n.a.	0.8	1.5	1.3	2

3 Results - Discussion

Stakeholders RAPs projected an optimistic future mid-term (2050s) scenario (called RAP1) towards positive economic development, Zimbabwe stepping out of the crisis and massive investments in market-oriented agriculture. Among key drivers they estimated productivity growth rates for maize (40%) and other crops (35%), cattle (30%) and other ruminants (25%). Producer price growth was expected to be limited to 5-20% for the various agricultural commodities. A step further, following improved availability of inputs and markets, farmers would be motivated to increase their cultivated land by 60%; poor farmers would at least double flocks of small ruminants (called RAP 2). Within that socio-economic context a dry climate change scenario would expose about 60% of the farming households to greater vulnerability. The very poor will loose up to 9% of their net returns, others will loose a smaller proportion.

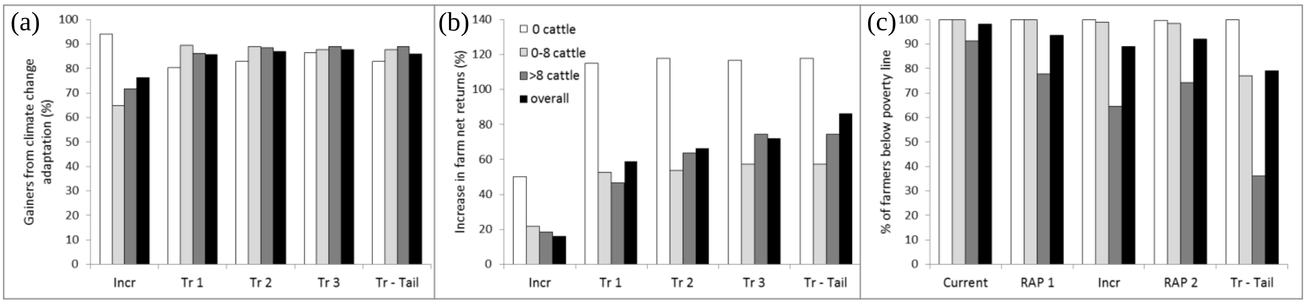

Fig. 1. Effects of incremental (Incr) and transformative (Tr) adaptations and RAPs on the percentage gainers from adapting (a), increase in net returns (b) and farmers below the poverty line (c) (packages 1, 2 and 3 are explained in Table 1 ; Tailored package (Tail) is a combination based on highest net returns).

The adaptation packages are likely to reduce vulnerability to climate change for most of the very poor farms. The incremental change will possibly benefit almost all very poor and more than 60% of the less poor (Figure 1a). It will increase their net returns by 50% as compared to < 20% for the less poor (Figure 1b). The magnitude of the benefits will however be small, less than 100 and 500 US$/farm for the very poor and less poor respectively. In comparison, drastic diversification of crop production along with greater participation in livestock markets will lift more than 85% of all farm types to a better economic situation (Figure 1a). The drastic adaptation packages will more than double the net returns of the very poor, and increase those of the poor and better off by 50 to 75% (Figure 1b). In absolute terms those with large cattle herds will benefit more, with on average 1300 US$ higher net returns, as compared to 500 US$ for the very poor, but they also face higher risk. Tailoring the technology packages to farm types increases the net returns for the entire community by 86%, as compared to 72% if technology packages are applied across the entire population as a blanket. Poverty levels might however remain high, even after drastic economic changes and tailored investments, (Figure 1c). Most substantial change in poverty rates will be for those with large cattle herds. The drastic adaptation package will reduce the proportion of these farms below the poverty line to around 35%, as compared to 65% under incremental change. It will reduce poverty levels among those with small cattle herds to 75%. Households without livestock, about 43% of the farm population, will have very little chances to move out of poverty.

4 Conclusions

This research illustrates that tailored systems diversification and market orientation can substantially increase farm production, food security and net returns from agriculture. Greater impact on poverty however requires further steps on multiple component innovations, better synchronizing of technologies, markets, policies, on-and off-farm investmens, triggering transformative system change (Geels and Schott, 2007). Incorporating the influence of socio-economic development and institutional and policy improvements defined in the RAPs enabled the comparison with purely climate change effects and is a first step to inform adaptation strategies at farm and larger scales. This approach should be taken further with policy and decision makers, to adjust socio-economic and institutional conditions that would make investments in farming more attractive while considering risk, essential to reduce vulnerability to climate change and enable sustainable futures for smallholders in semi-arid southern Africa.

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References

Antle, J.M., Valdivia, R.O., Boote, K.J., Janssen, S., Jones, J.W., Porter, C.H., Rosenzweig, C., Ruane, A.C. & Thorburn, P.J. (2015). AgMIP's Transdisciplinary Agricultural Systems Approach to Regional Integrated Assessment of Climate Impacts, Vulnerability, and Adaptation. In: Rosenzweig and Hillel (Eds), Handbook of Climate Change and Agroecosystems, The Agricultural Model Intercomparison and Improvement Project (AgMIP) Integrated Crop and Economic Assessments — Joint Publication with American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, pp. 27 – 44.

Geels, F. W., Schot, J. (2007). Typology of sociotechnical transition pathways Research Policy. 36: 3, 399–417

Masikati, P., Homann-Kee Tui, S., Descheemaeker, K., Crespo, O., Walker, S., Lennard, C.J., Claessens, L., Gama, A.C., Famba, S., van Rooyen, A.F. & Valdivia, R.O. (2015). Crop–Livestock Intensification in the Face of Climate Change: Exploring Opportunities to Reduce Risk and Increase Resilience in Southern Africa by Using an Integrated Multi-modeling Approach. In: Rosenzweig and Hillel (Eds), Handbook of Climate Change and Agroecosystems, The Agricultural Model Intercomparison and Improvement Project (AgMIP) Integrated Crop and Economic Assessments — Joint Publication with American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, pp. 159-200

ZimVAC (2013). Rural livelihoods assessment, Harare