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Transitions in agro-pastoralist systems of East Africa: Impacts on food security and poverty☆

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ABSTRACT

Climate-induced livelihood transitions in the agricultural systems of Africa are increasingly likely. There is limited evidence on what such transitions might look like. We carried out fieldwork in 12 sites in Kenya, Tanzania and Uganda to understand changes in farming systems in the recent past, and to test the hypothesis that sedentary farmers in zones that may become warmer and drier in the future may be forced to increase their reliance on livestock *vis-à-vis* cropping in the future. We estimated the contribution of crop and livestock activities to incomes, food security and poverty. Householders were asked how to adapt farming in the future. We found no direct evidence for the hypothesised extensification of production across study sites. Human diets have changed considerably in the last 40 years, as cropping has been taken up by increasing numbers of pastoral households, even in marginal places. Maize and legumes predominate, but some householders are increasing their crop and diet diversity, particularly in locations with annual rainfall higher than 800 mm. At all sites people want more livestock. Food insecurity is common at all sites with an annual rainfall of 800 mm or less, and critical levels are seen at sites with <700 mm. Households are self-sufficient in securing adequate dietary energy from food production in 7 of the 12 sites, all with rainfall higher than 800 mm. Although many householders have some knowledge about drought-tolerant crops, few cultivate millet, sorghum and cassava. Policies aimed at increasing the consumption of cassava, sorghum, millet and pigeon pea could be highly beneficial for future food security in the region. Vulnerability in the drier locations is already high, and policies should support safety nets and market and infrastructural development. Households in the wetter areas need to manage risk and to increase crop productivity. A critical requirement is knowledge transfer concerning the growing and utilisation of unfamiliar and untraditional crops.

1. Introduction

The increases in food production necessary to feed the growing global human population have to occur in conjunction with climate change. Climate change may affect the regional distribution of hungry people, and particularly large negative effects are expected in many parts of sub-Saharan Africa (SSA) because of the projected declines in agricultural production that affect both food availability and access (IPCC, 2007). The linkages between climate change and future food security in East Africa, as in other regions, are uncertain, partly because climate and impact models themselves are incomplete and subject to considerable uncertainty. While progress is being made, there is considerable work still to do to reduce these uncertainties to reasonable levels (Ramirez-Villegas et al., 2013). Nevertheless, there is evidence that climate change will have serious impacts on crop and livestock production in many parts of SSA (Challinor et al., 2009; Thornton et al., 2011).

The effects of climate change on agricultural systems in developing countries will depend on location and people's adaptive capacity. But adapting to and coping with a changing climate are not infinitely plastic, and it may be envisaged that in some places climate change may push agro-ecological conditions beyond the 'coping range', such that current adaptation measures may not be longer be viable. In such places, livelihood options may have to change. In the mixed crop-livestock rainfed arid and semiarid

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systems of Africa, cropping will become increasingly risky, and this could lead to increased dependence on livestock keeping or increasing diversification into non-agricultural activities and migration to urban areas (Jones and Thornton, 2009). Such livelihood changes could be seen as antithetical to an evolutionary process of agricultural intensification, in which increasing human population pressure on relatively fixed land resources is seen as the driving force of agricultural intensification (Boserup, 1965). Nevertheless, this reversal of an evolutionary process is entirely plausible; the ability of householders in regions of high climatic risk to adapt, using blends of old and new techniques as well as a host of methods to extensify and/or diversify the production system has long been the subject of study (Matlon and Kristjanson, 1988; Tache and Oba, 2010).

If climate change in the coming decades in SSA does induce an extensive reversal to agriculture dominated by mobility of the means of production and of residence, the social implications would be profound. As for many other types of widespread livelihood transition, there would be social, environmental, economic and political effects at local, national and even regional levels, and these effects would need to be appropriately managed and facilitated.

Livelihood transitions mediated via changes in climate *vis-à-vis* changes caused by other drivers (e.g. immigration, conflicts for natural resources, and changing economies) need to be elucidated to disentangle the impacts of climate change on African rural households. In this study we tested the hypothesis that sedentary farmers who currently keep livestock in transition zones that are becoming warmer and possibly drier in the future may ultimately be forced to increase their reliance on livestock *vis-à-vis* cropping in the future, despite other potential driving forces shaping their livelihoods. We analyse past and current responses of farming households to climate variability and regional change in marginal cropping areas of East Africa, and assess impacts on household income, food security, and food self-sufficiency, while at the same time providing evidence on future coping and adaptation mechanisms.

2. Methods

This work builds on Jones and Thornton (2009) using high-resolution methods to identify, analyse and characterise hotspots where climate change might induce system extensification in the future. The site selection process identified case studies for in-depth analysis working across contexts sufficiently heterogeneous to ensure that outputs and recommendations would have wider application and relevance at other sites.

For the target countries, Kenya, Tanzania, Uganda, we refined the original hotspot analysis of identifying transition zones, using up-to-date data layers (Jones and Thornton, 2009). We developed a sampling framework using cluster analysis, sampled the transition zones, and identified a small number of locations in each country, giving a total of 12 study sites in all. From each site we collected on-the-ground information on what are the prevalent crop and livestock systems, together with information on cropping calendars, input use, production levels and local prices via key-informant interviews and household survey.

2.1. Sampling frame design

We generated a sampling frame for the window from longitudes 29° E to 42° E and latitudes 12° S to 5° N, masking out the countries bordering Tanzania, Kenya and Uganda. The following variables were used in subsequent analysis, standardised to a resolution of 5 arc-min:

- Season failure rates for current conditions and for a future world with +4 °C of warming; details of the methods used are given in Jones and Thornton (2013).
- pH, cation exchange capacity (CEC), base saturation, silt and clay contents of the topsoil, and soil water holding capacity were taken from the digital version of the FAO soils map of the world (FAO, 1998, 2009) and collated with soil profile information following Gijsman et al. (2007).
- Elevation and slope data were compiled from the datasets of Jarvis et al. (2008).
- Human population was derived from GPWv3 (CIESIN/CIAT, 2005) and ILRI (2006) for the year 2000.
- Livestock densities for cattle, sheep and goats were derived from Robinson et al. (2007).
- Images of the extent of land cropped in maize, sorghum, beans, cassava, cowpea and pigeon pea were from Monfreda et al. (2008). The proportions of each pixel under cultivation and in pasture were obtained from Ramankutty et al. (2008).

All pixels in the window with current crop failure rates of fewer than 1 year in 10 and >4 years in 5 were excluded; all remaining pixels were taken to represent areas where cropping was possible but risky. Of these, pixels with <3% cropland were omitted, thus eliminating all pixels with less dense cropland. Pixels with a human population density in excess of 800 persons per square km were excluded as urban. Twenty variables (Appendix Table 1) for the remaining pixels were analysed in a principal components analysis. A cluster analysis was then carried out using the first eight eigenvalue scores (accounting for 77% of the variance) to minimise the sums of squares within clusters. Twelve distinctive clusters were produced from the data (Table 1). These are mapped in Fig. 1. The 12 clusters vary in size because the clustering was designed to maximise the between-cluster distances and minimise the within-cluster variances. We sampled one point from each cluster to spread the samples as widely as possible. In an attempt to minimise logistical problems, we chose a sample pixel from each cluster that was relatively close to the main road network. The selected sample pixels are also mapped in Fig. 1.

2.2. Selection of households

Using the coordinates of the sample pixels, a working map for each site was developed to identify province, district, division, location and sub-location where each of the pixels was situated. The maps, drawn to scale, served as a source of secondary information for each site to identify main trading centres, health facilities, schools, rivers, boreholes and the dominant type of vegetation. The coordinates were uploaded into global positioning system (GPS). The GPS and working area map were used as a guide to the specific location of the site.

At each site, the administrative officer of the location was identified, and the objective of the study explained. The key person was then asked to help organise the households for a focus group discussion (FGD). All households in each site falling within the area in the pixel were eligible to participate. During the FGDs, we explained the objective of the visit and discussed climate change and variability and opportunities for dealing with climatic uncertainty. Key persons were mainly government appointed administration officers for each location and traditional authorities. They included Chiefs in Kenya, Village Executive Officers in Tanzania and Local Councillors in Uganda. In some sites, the agricultural Extension Officers were also interviewed.