Identifying pathways of change in mixed systems by linking regional land use and household models

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Introduction

The demand for livestock products in developing countries is projected to expand very rapidly as a result of urbanization, increased incomes and market access. (Delgado et al., 1999). These changes result in high and rapid land use dynamics and may lead to the evolution of production systems in the long term. These changes have consequences for the volumes of food produced, trade and farmers income and are therefore a primary concern for policy makers, researchers and other stakeholders supporting the livelihoods of rural communities, sustainability and the value chains of food production. This study forecasted crop-livestock systems evolution and the associated intensification technologies in the Kenyan highlands in the next 20 years under different development scenarios. Two complementary sets of models operating at different scales were used: regional spatially-explicit models estimated the spatial distribution of farming systems over time, and household and livestock models were used to validate the results of the spatial analysis at the local level, allowing for a more robust description of farming systems dynamics and a realistic identification of farm-level constraints and options at local level.

Methodology

Farming systems in the Kenyan highlands were characterized into 6 groups using survey data from 2866 households and using clustering techniques. The household data were obtained from three surveys conducted in central and western Kenya between 1996 and 2000, as part of collaborative efforts to design policies for the smallholder dairy sector (Baltenweck et al., 2003).
For the regional spatial modeling, location characteristics for the 2866 households were derived from a series of GIS layers. Logit models were used to predict the relative probability of finding the different farming systems at a certain location. They used the farming systems as dependent variable and the spatial variables of each location as explanatory variables. The fitted logit models were subsequently used to calculate the probabilities of finding the different farming systems across the study area based on the variability of the spatial data. The individual probability maps for the different farming systems were combined in an overall map indicating the spatial distribution of farming systems given the relative probabilities and the region-wide prevalence.

For the household modeling (HHM), three case studies were selected for each farming systems group, representing variation within each of the groups. The IMPACT tool (Herrero et al., 2005) was used in each case study to collect detailed household level information on land management, crop and livestock production, household composition and farm labour; inputs and outputs and others. Data from IMPACT were used to run a household model (HHM) for each of the 18 case studies to identify production alternatives as systems evolved. Key aspects determining production choices were prices of commodities and labour availability and price.

Both regional and household models were linked through the formulation of different development scenarios depicting different rates of population growth, market access, off-farm employment, export policies and others (van de Steeg et al 2005). The scenarios were developed in collaboration with policy makers and were based on past trends or trying to mimick proposed or currently implemented policy measures. The scenario analyses dictated how farming systems could evolve in the future, by translating projected growth trends into new spatial data layers for the drivers of the regional spatial analysis; and by the modification of some parameters and restrictions in the HHM analysis. We present the results for the equitable growth scenario as described by the Kenya Poverty Reduction Strategy. The overall methodology is presented in Figure 1.

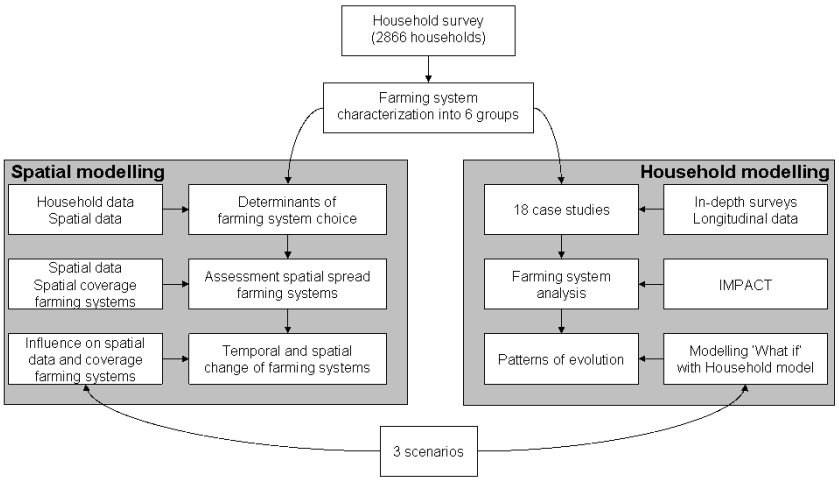

Figure 1: Methodology used for linking regional and farm level analyses

Results

The regional spatial model predicts that about 25% of the surface area in the region under study is likely to change from one system to another under equitable growth conditions. Of this change, more than 66% of the existing farming systems evolve towards export-oriented farming systems, with the most important trajectories of change from subsistence and intensive farmers with limited dairy activities to export cash-crop farming with limited dairy activities.

Results from the household model show that in small subsistence farms, there could be a shift towards more cultivation of cash crops, even export crops in some cases. Dairy activities could increase only if land can be dedicated to the cultivation of cut-and-carry forage crops. Hired labour requirements could increase, especially if export crops became an option. For households located in peri-urban areas, this scenario could mean a decrease in farm size and more expensive labour costs. The more expensive labour costs makes farmers invest in options that give the highest returns from the land: export crops. In case of farms already exporting crops and that have dairy, dairy can only be maintained if land can be devoted to forage crops, as crop residues do not support the level of production required. The cost of labour could also constraint the expansion of dairy, as its marginal productivity depends on the marginal revenue obtained, which depends on price of milk. In general terms, as these farming systems evolve, they will invest in activities where the productivity of labour is higher, as this input becomes more expensive.

Conclusions

Changes in population density and related factors like investment in infrastructure and market access are important factors explaining the spatial distribution of farming systems and their evolution in the Kenyan Highlands. Land fragmentation has major impacts on system change at household level. The opportunity costs of labour play a key role in determining the choice of enterprises in smallholder households in Kenya.

Integration of regional spatially explicit models and household models provides a suitable base for studying trajectories of change and enterprise choices in tropical production systems. Their main purpose is to stimulate interest of policymakers and decision makers, and to enhance the discussion about the effect of certain policy measures and the future of agriculture in Kenya in general.

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