Preface

Around 2.6 billion people in the developing world are estimated to have to make a living on less than $2 a day and of these, about 1.4 billion are 'extremely' poor; surviving on less than $1.25 a day. Nearly three quarters of the extremely poor – that is around 1 billion people – live in rural areas and, despite growing urbanization, more than half of the 'dollar-poor' will reside in rural areas until about 2035. Most rural households depend on agriculture as part of their livelihood and livestock commonly form an integral part of their production system. On the other hand, to a large extent driven by increasing per capita incomes, the livestock sector has become one of the fastest developing agricultural sub-sectors, exerting substantial pressure on natural resources as well as on traditional production (and marketing) practices.

In the face of these opposing forces, guiding livestock sector development on a pathway that balances the interests of low and high income households and regions as well as the interest of current and future generations poses a tremendous challenge to policymakers and development practioners. Furthermore, technologies are rapidly changing while at the same time countries are engaging in institutional 'experiments' through planned and un-planned restructuring of their livestock and related industries, making it difficult for anyone to keep abreast with current realities.

This 'Working Paper' series pulls together different strands of work on the wide range of topics covered by the Animal Production and Health Division with the aim of providing 'fresh' information on developments in various regions of the globe, some of which is hoped may contribute to foster sustainable and equitable livestock sector development.

The work described in this paper follows directly on from earlier attempts to develop a novel approach to mapping poverty using environmental data. The aim was to get closer to understanding some of the underlying causes of poverty – something that is unlikely to be feasible using approaches based only on socio-economic data such as the traditional small area estimate (SAE) techniques. The environmental poverty mapping technique involved modelling geo-registered household expenditure estimates in Uganda, available from household surveys, using discriminant analysis of a range of environmental data – mostly derived from satellite remote sensing. This analysis was successful, resulting in a series of poverty maps and lists of environmental variables that were strongly correlated with poverty at different spatial resolutions.

At the time the original analysis the SAE technique had not yet been carried out on the Uganda household survey data for 2002, so no direct comparison of the two approaches was possible. Small area estimate maps for 2002 have since been published by the Uganda Bureau of Statistics (UBOS), so direct comparisons of the environmental techniques against these were now possible.

In the analysis described here we further examined the extent to which environmental data from remote sensing and other sources were correlated with welfare estimates from household survey data. We employed an alternative suite of statistical approaches, compared to the original study, with the ultimate aim of exploring whether different correlates of poverty were important in different parts of the country. As a bench mark, a single Ordinary Least Squares (OLS) regression model was developed for the whole country. The effects of zoning were explored by developing different OLS models for aggregations of households within different livestock production systems. Finally, Geographically Weighted Regression (GWR) was used explicitly to model the spatial variation and scale dependency of the regression coefficients.

The results re-emphasise the important contribution that environmental analysis can make to mapping rural poverty, and ultimately to understanding its distribution and causes.

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Abbreviations

AGAL	FAO Livestock Information, Sector Analysis and Policy Branch
AIC	Akaike's Information Criterion
AICc	Corrected Akaike's Information Criterion
ANOVA	Analysis Of Variance
AVHRR	Advanced Very High Resolution Radiometer
CCD	Cold Cloud Duration
CSI-SRTM	Consortium for Spatial Information - Shuttle Radar Topography Mission
CV	Cross-Validation
DEM	Digital Elevation Model
ERGO	Environmental Research Group Oxford
FAO	Food and Agriculture Organisation
GAM	Generalised Additive Model
GIS	Geographic Information System
GLW	Gridded Livestock of the World
GPW	Gridded Population of the World
GRUMP	Global Rural and Urban Mapping Project
GWR	Geographically Weighted Regression
IGAD	Inter-Governmental Authority on Development
IGAD LPI	IGAD Livestock Policy Initiative
ILRI	International Livestock Research Institute
LGP	Length of Growing Period
LST	Land Surface Temperature
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MIR	Middle Infra-Red
NASA	National Aeronautics and Space Administration
NDVI	Normalised Difference Vegetation Index
OLS	Ordinary Least Squares
PPLPI	Pro-Poor Livestock Policy Initiative
RMSE	Root Mean Square Error
SAE	Small Area Estimate
Tair	Air Temperature
TALA	Trypanosomaiasis And Land-use in Africa
UBOS	Uganda Bureau of Statistics
UNHS	Uganda National Household Survey
VIF	Variance Inflation Factors

Executive summary

In 2006 the Food and Agriculture Organization (FAO) Pro-Poor Livestock Policy Initiative (PPLPI) published results from the development of a novel approach to poverty mapping in which household survey data were analysed using a suite of environmental variables (Rogers *et al.* 2006; Robinson *et al.* 2007). Discriminant analysis was used successfully to model household expenditure, resulting in a series of poverty maps of Uganda and lists of environmental variables that were strongly correlated with poverty at different spatial resolutions. The spatial data used to model poverty included direct measures of key climatic variables (such as temperature), descriptor variables of key ingredients of poverty-related processes (such as agricultural potential, agricultural production systems and access to markets and services) and proxies for constraints on the health of people, crops and livestock. Whilst such an analysis cannot provide conclusive evidence as to the causes of poverty, it certainly highlights environmental factors that are strongly associated with it.

In this analysis the extent to which spatial data from remote sensing and other sources (which act as proxies for environmental conditions) are correlated with household survey data on expenditure is further examined. For each rural household in the 2002 Uganda National Household Survey (UNHS-2) values from a subset of environmental variables were extracted, based on the results of earlier studies. Averaging data up to a series of different spatial resolutions the spatial variation and scale dependency of regression coefficients was model using: (i) Ordinary Least Squares (OLS) regression for the whole country, (ii) a regional approach based on a different OLS model for different aggregations of a map of livestock production systems, and (iii) Geographically Weighted Regression (GWR).

The model results were compared with each other at a range of pixel resolutions, and also with the Small Area Estimate (SAE) maps derived from the same household survey data.

Across Uganda, vapour pressure deficit (VPD) (negative) and population density (positive) were the two most influential factors associated with (i.e. predictive of) the level of rural household (expenditure). When this was broken down into livestock production systems, the Normalised Difference Vegetation Index (positive) and access to markets (negative) were the most influential in the arid and semi-arid systems and cattle (positive) and VPD (negative) were the most influential in livestock-only systems.

Comparison of these environmental regression models of poverty with the SAE poverty maps revealed that all such models had lower errors than the SAE model. The GWR performed better than the regional OLS, which, in turn, performed better than the country-wide OLS. GWR in particular was able to generate higher resolution estimates of poverty with comparable errors to the much coarser SAE model, offering a seven-fold increase in spatial resolution.

There was significant spatial variation in the GWR regression which did not match the zonation offered by the livestock production systems, suggesting that alternative zonings should be explored in future when developing regional regression models.

Environmental approaches clearly have a role to play alongside more traditional econometric poverty mapping methods, and there is scope to combine the two to explain better the linkages between poverty and the environment and to develop spatial models for more accurate poverty mapping.