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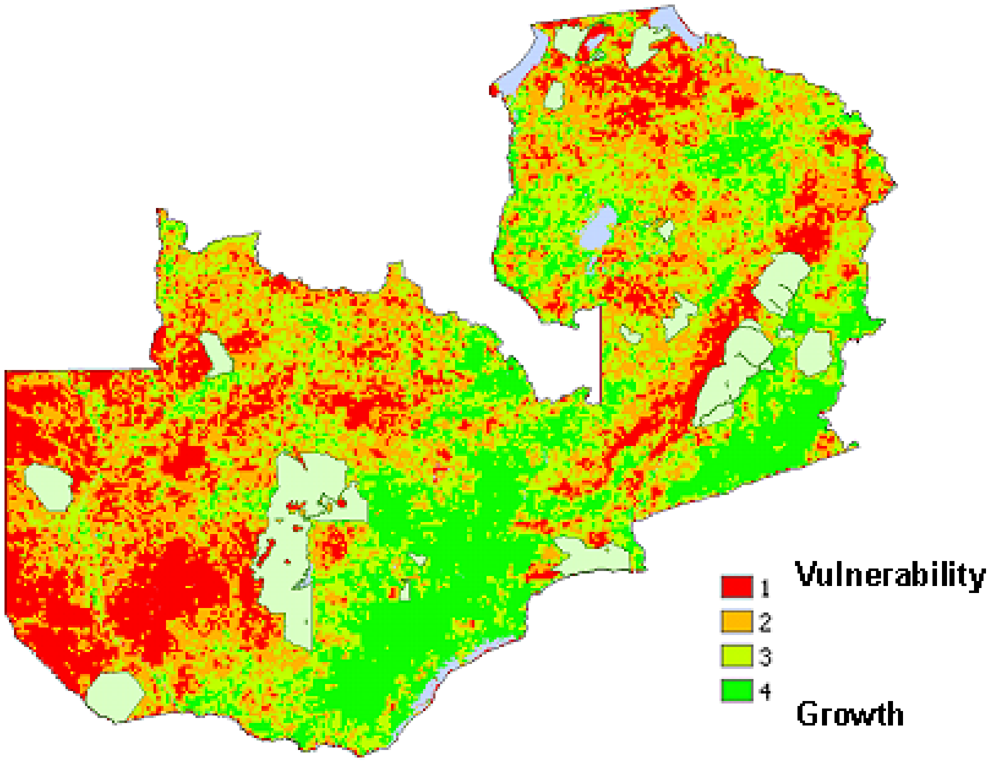
CONSULTANT'S REPORT

INTEGRATED LAND USE ASSESSMENT OF ZAMBIA: THE GEOGRAPHY OF THE LIVESTOCK SECTOR AND SUSTAINABLE PRO-POOR GROWTH



Prepared for the Forest Management and Planning Unit of the Forestry Department, FAO
by

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The Cover illustration is a representation of the areas of Zambia calculated to be appropriate for policy interventions designed to reduce vulnerability - in green, or to promote conditions for growth - in red (see Figure 16)

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1. INTRODUCTION

Zambia's natural resources continue to decline both in quality and quantity. The forests in particular are vulnerable to factors such as extensive practices of shifting cultivation and slash and burn; ever-increasing demands for wood-based energy (firewood and charcoal); unsustainable commercial utilization of indigenous tree species; over-grazing; and forest fires. Rural poverty in Zambia is high, even by African standards: it is estimated that 83 percent of the rural population lives in poverty (FAO 2004). The correlation between poverty and deforestation/resource depletion is high in Zambia, especially in areas near urban centres, and is likely to occur in both directions: a scarce and dwindling natural resource base will be a major contributor to poverty in areas where this is an important element of peoples' livelihoods, and poverty may encourage activities that threaten the natural resource base.

The Government of Zambia has expressed a need for up-to-date information on the stock and utilization of natural resources to assist in planning and managing land resources in a sustainable manner. This information is currently unavailable because of inadequate resources, a lack of inventory equipment and low capacity among government staff to carry out resource assessments. The Government's focus of interest concerning land use is to put in place an integrated land use assessment system that will improve the management of land resources, and thus contribute to poverty alleviation. Integrated land use assessments will also encourage cross-sectoral coordination and collaboration; bringing together stakeholders from diverse disciplines related to land use management.

Therefore, the Government of Zambia, through its Ministry of Environment and Natural Resources, with the objectives of reducing poverty, promoting economic growth and building human capacity, requested technical and financial assistance from FAO to design and implement an integrated land use assessment survey. A Technical Cooperation Programme (TCP) project was initiated in 2005, with additional funding provided by the FAO-Netherlands Partnership Program (FNPP) and by governmental counterpart funds. The main activities included assessing the need for and building capacity in Integrated Land Use Assessment (ILUA), and assistance with planning and implementing an ILUA. FAO's Forestry and Agriculture Departments collaborated to design and plan the ILUA: building upon an approach developed for National Forest Assessment (NFA). Variables related to sectors beyond forestry (cropping, livestock, and environment) were included, and field manuals and survey forms were developed. The major objectives are listed in Annex 2.

The ILUA has now been carried out and a number of contextual documents and preliminary analyses of the livestock-related aspects of the ILUA has been produced (Kalinda 2007). These have concentrated on preliminary characterisation of livestock parameters for selected provinces. Some further aspects of ILUA survey data analysis have now been analysed focussing more on spatial and cross-sectoral assessment of the data; the investigation and generation of policy related information from the basic survey data; and an assessment of the relationships between livestock and forestry.

The work reported here concentrates largely on spatial analysis of the ILUA data and is intended to provide information of direct relevance to identifying policies that enhance the contribution of the livestock sector to environmentally sustainable, pro-poor growth in Zambia. It will be one of several documents that can be drawn upon, including those mentioned above, to produce a more formal and complete livestock sector and policy review. A structure for this is suggested in Annex 5.

To meet these objectives the survey data analyses have aimed to answer three major questions:

1) *Where is livestock-related rural poverty focussed*? To address this, a number of policy-relevant questions are investigated: Where are the people? Where are the livestock? Where are the livestock

owners? Where are the poor? Where are the poor livestock owners? Where are people dependent on livestock for their livelihoods?

2) *Where are particular types of policy intervention most appropriate?* Using an established framework of policy interventions domains the locations in Zambia were identified where policies and institutions targeted at reducing vulnerability are most important, and where those targetted at promoting conditions for growth are most important.

3) *Is there any demonstrable impact of livestock on the forest environment?* In relation to the environmental sustainability of livestock sector development, statistical relationships between livestock and various indicators of environmental degradation are examined.

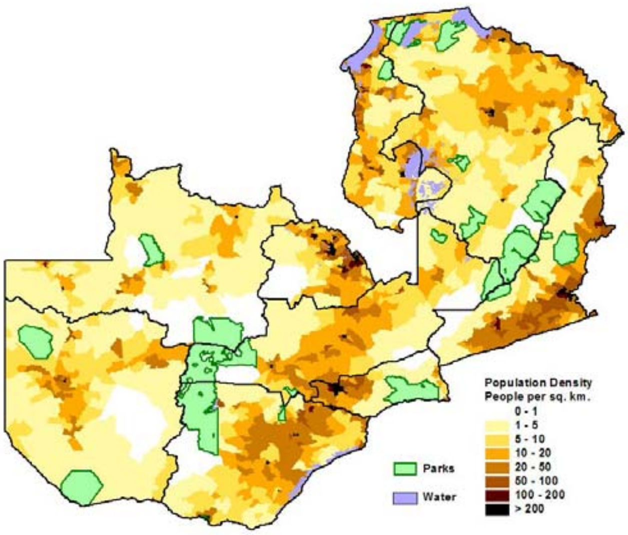
The document is divided in to sections reflecting these major questions, preceded by a description of the agricultural resource setting and the methods used to analyse the survey data, and followed by a brief conclusions and recommendation section. Several Annexes are also provided containing technical details and descriptions of the spatial data that are provided with the report.

2. THE RESOURCE SETTING

Until 1975, Zambia's economy was based on copper but as world prices fell, the Government of Zambia (GRZ) started focusing on alternative sources of economic growth, employment and foreign exchange earnings. Zambia's economy has generally deteriorated since 1990, with the Gross Domestic product (GDP) only growing at 0.5% per annum, while the GDP per capita is not only low at US$ 392 but has been declining at -2% per annum (FAO2004).

2.1. People, cultivation and livestock

Figure 1: Population distribution

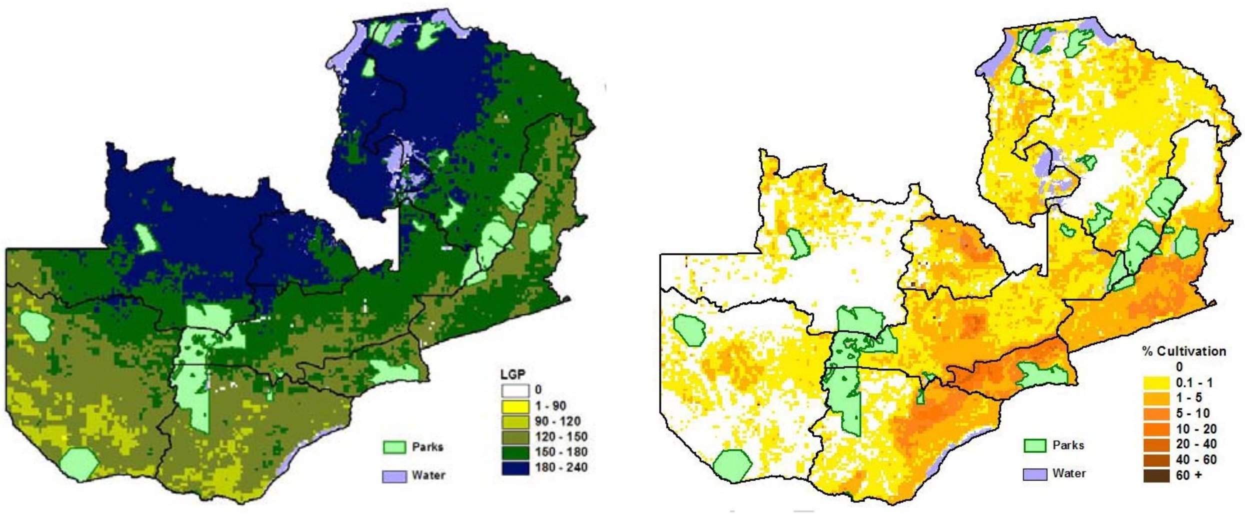


Zambia's population of 10.4 million is spread over a land area of 743,390 km^2 – an average density of only 14 persons per km^2 – but is growing at a rate of 2.6% per annum. About 60% of the population lives in the rural areas and 83% of the rural population is classified as poor, compared to 56% in urban areas (FAO 2004).

Figure 1 shows how the ward level population density derived from the 2000 census. There are relatively few people in northern and western regions, with foci around major cities, and high densities in the central, southern and eastern parts of the country, and in the copper belt.

Figure 2 shows how cultivation is distributed in relation to length of growing season, as provided by the FAO Gridded Livestock of the World datasets. The length of growing period – an indicator of agricultural potential – is lowest in the south-west, rising fairly steadily towards the north and east. By contrast the cultivation levels are highest in the south and east – corresponding roughly to the distribution of the human population, as is often the case in developing countries where the amount of land suitable for crops is not limiting.

Figure 2: Length of growing period and cultivation density



Zambia's livestock resources are summarised in Table 1 and in Figure 3. Most recent (2000) estimates of the livestock population are 2.6 million cattle, 140,000 sheep, 1.2 million goats, 309,000 pigs and 29 million poultry (FAO 2007) . It is estimated (FAOSTAT 2003) that about 47% of the total land mass is suitable for pasture – giving current average 2005 stocking rates of 7.5 km^{-2} for cattle and 4 km^{-2} for small ruminants. Whilst absolute livestock numbers have increased over the last two decades, in proportion to the human population, there has been a steady decline. Small ruminants and poultry have the highest growth rates, whilst numbers of cattle and pigs have more or less stagnated.

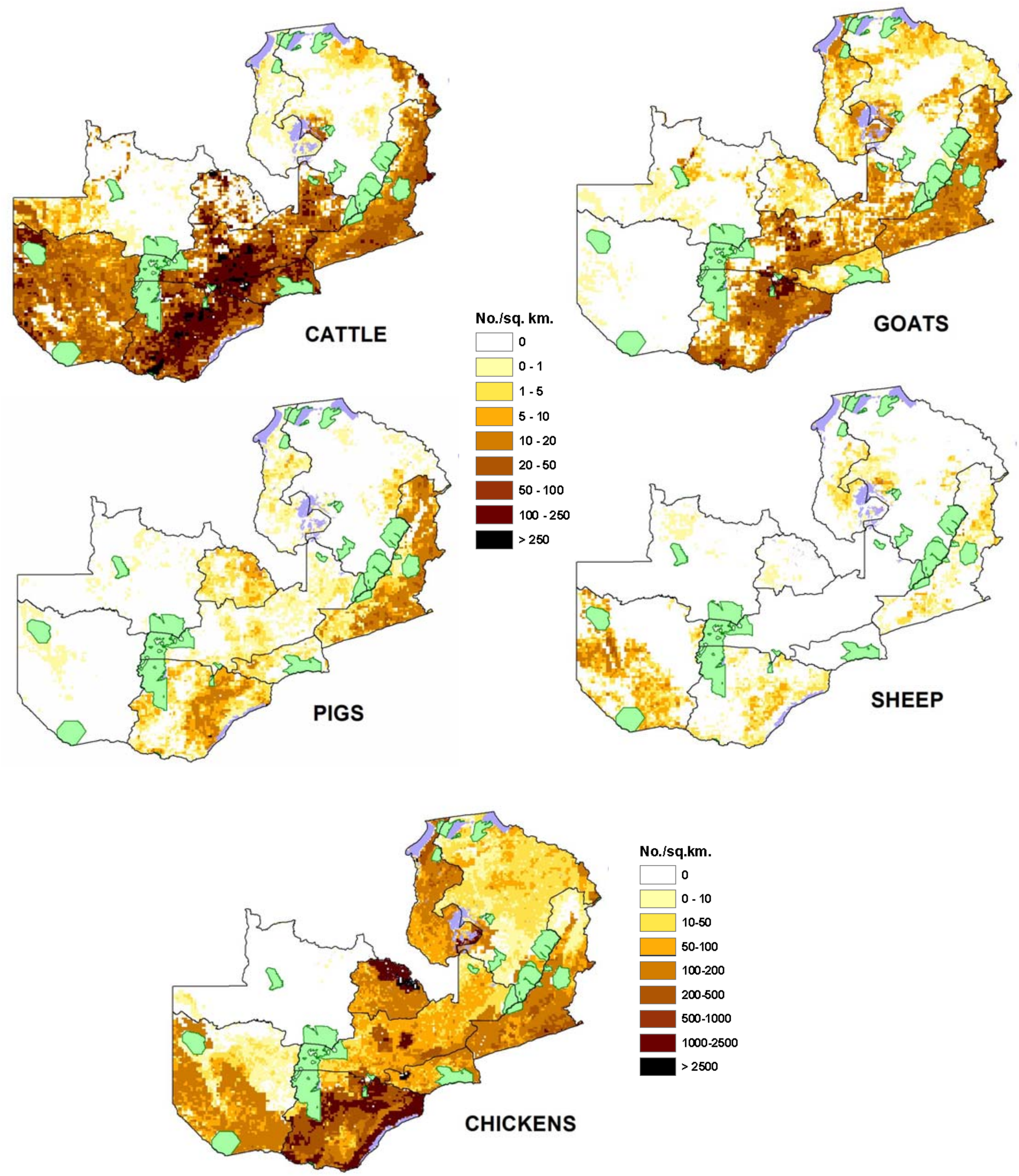
Table 1 Livestock resources in Zambia expressed (thousands)
Source: FAOSTAT (2003)

Species	Year			Annual growth rate (%)	
	1980	1990	2000	1980-1990	1990-2000
Cattle	2,181	2,878	2,621	2.8	-0.9
Sheep	28	60	140	8.1	8.8
Goats	258	534	1,249	7.6	8.9
Pigs	218	295	309	3.0	0.5
Poultry	20,638	15,700	29,000	-2.7	6.3

The FAO Gridded Livestock of the World[1] (GLW) provides distribution maps of Zambian livestock, derived by statistical modelling techniques from government livestock census data produced in 2001. The maps (Figure 3) clearly illustrate quite distinct distribution patterns for the various animal species: cattle are concentrated in the south and west (Southern, Central, Western and Eastern Provinces accounting for 88% of the population); goats are largely found in the south and east, but not the west (Eastern and Southern Province accounting for 79% of the population); chickens are also in these areas, but extend further to the north and east; pigs are distributed in much the same way as goats (mainly concentrated in the Eastern and Southern Provinces, which account for 82.2% of the population), but the populations are somewhat more patchy; and sheep are rather rare, though spread fairly evenly across all provinces.

[1] http://www.fao.org/AG/againfo/resources/en/glw/home.html

Figure 3: Livestock distributions
Data source: FAO (2005) Gridded Livestock of The World



2.2. Livestock production systems

There do not seem to be detailed country-specific descriptions of the livestock production systems in Zambia that could be used for stratification in analysis (see Section 3). FAO (2004) reports on three very general livestock systems in Zambia: a large traditional farming system (holdings of < 5 ha): a relatively small commercial system (holdings of >20 ha); and a small, emerging semi-commercial system (holdings of 5-20 ha). Cattle dominate both commercial and traditional sectors.

Traditional system (mixed crop-livestock systems)

The traditional system accounts for 85% of the farming community and accounts for most of the livestock in Zambia. Small-scale farming is, in most parts of the country, dominated by crop production (mostly maize and sorghum), and cattle are kept principally for draft purposes. In the drier parts of the country, such as in Western Province, cattle predominate. Cattle are generally grazed on communal lands, housed at night and during parts of the growing season to avoid crop damage, and are mainly based on the indigenous Sanga and Zebu breeds. Acting as wealth; cattle may be converted into cash to meet specific financial needs such as purchase of food during periods of drought. Most of the goat population is managed with minimal inputs: roaming freely during the day and housed at night. Traditional poultry production is based on indigenous chickens and with minimal inputs apart from housing. Pig production is also based on local breeds and most are left to scavenge around homesteads.

Commercial system (beef and dairy ranching and poultry)

Commercial cattle production is organised within the Zambia National Farmers Union (ZNFU) and is mostly for beef production, involving large scale ranching on titled land with free ranging or controlled grazing. Intensive production in feedlots is mainly used for commercial dairy production. There are about 50,000 dairy cows representing 5% of the commercial herd. Cattle productivity in the commercial system is reported to be high with milk production averaging 4,000 kg per annum, low calf mortality rates of 1-2%, reproductive rates between 65-70% and off-take rates of around 17-18% (Mwenya *et al.* 1994; Huhn 1991).

Emerging system (dairy and poultry)

The emerging system comprises small scale but commercially oriented farmers, primarily selling milk, eggs and poultry. This sector is small but dynamic and few statistics are available for it. An emerging beef system exists, but is much smaller.

Livelihood zones

Other zonations related to agriculture have been defined for Zambia, for example the livelihood zones that are defined for using a variant of the standardised approach developed by the World Food Programme (WFP) and others to describe rural livelihoods (see figure to right). These are not heavily influenced by livestock distributions; e.g. the major foci of livestock populations are assigned as Crops, Wages and Trading. As a result, the zones have not been incorporated into these analyses.

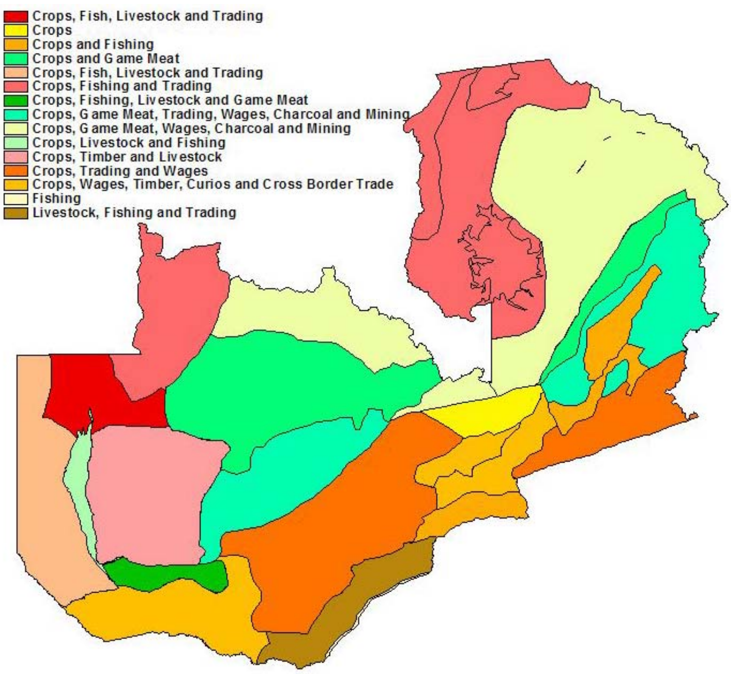
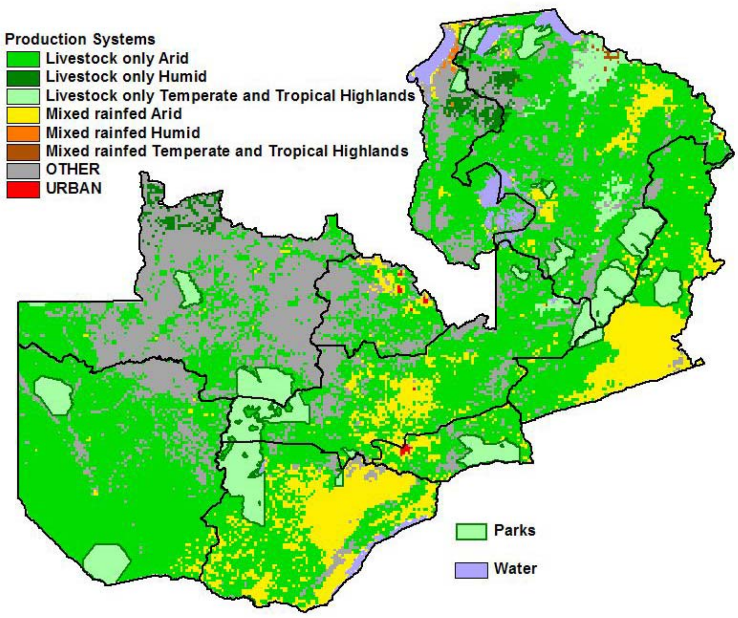


Figure 4: Livestock production systems



Unfortunately the spatial distributions of the systems described above are not given so, whilst they provide useful descriptions of the livestock sector in Zambia, they are of no use in analysis. Global Livestock production systems, as defined by the widely used, ILRI / Sere and Steinfeld classification (Thornton *et al*., 2002; Seré and Steinfeld, 1996) are derived from a classification based upon land cover, human population density and length of growing period. Whilst these are not highly specific, they do provide a consistent framework by which to stratify data for analysis in terms of livestock. Figure 4 shows that the predominant arid areas are divided between 'livestock only areas' (greens) and 'mixed rainfed areas' (yellow); the latter coinciding with longer growing periods and higher population densities. The majority of mixed crop and livestock production occurs in the south and the east. A large area is loosely classified as 'other' (grey) – which includes land cover types of forest, wetlands, water bodies, barren or sparsely vegetated, snow or ice and urban and built-up areas – is a predominant class in the sparsely populated north and west. Livestock numbers for each system are shown in Table 2, for information.

Table 2 Livestock resources in Zambia by production system

Source: FAO (2007) Gridded Livestock of the World

Species	LGA	LGH	LGT	MRA	MRH	MRT	OTHER	URBAN	FAOSTAT '05
Cattle	1,602,420	3,420	12,740	728,030	170	670	246,110	6,440	2,600,000
Goat	603,240	7,760	10,260	474,710	3,060	820	168,800	1,350	1,270,000
Sheep	111,070	1,840	820	18,470	110	20	17,670	0	150,000
Pig	163,040	1,600	870	140,700	180	20	32,340	1,250	340,000
Poultry	15,403,090	220,420	190,570	9,475,610	60,510	9,600	4,223,380	416,820	30,000,000

LG = Livestock Only; MR = Mixed Rainfed; A = Arid; H = Humid; T = Temperate/Tropical Highland

3. METHODS

3.1. Data provided

The ILUA data consist primarily of a diverse set of survey data values for some 250 regularly spaced sample locations or 'tracts' set half a degree (about 50 kilometres) apart. These survey data relate to forestry, agriculture and associated land use, and provide a wealth of information that can be mined to assess conditions on the ground and to investigate links between these sectors. The data are provided as a password protected Microsoft Access relational database. The tables therein either contain household data relating to cropping, forestry, livestock, income and the like, or detailed forestry related information recorded for several plots and subplots within each tract. Examples of the household data forms – the F7 group pertaining most closely to livestock – are provided in Annex 3.

3.2. Modelling methods

Whilst mapping these data at the tract level can readily provide an indication of spatial pattern – showing whether for example certain characteristics are clumped or evenly dispersed – the actual data cannot directly provide information about what lies between the sample points. To resolve this, several techniques are available of which perhaps the most straight forward is 'spatial interpolation', which assumes smooth changes in values between points of known data. Sophisticated forms of interpolation are available – for example kriging – which is akin to using moving averages to get values between points on an ordinary 2 dimensional graph. These methods are most useful to visualise and enhance data when there are few gaps in the known information, and providing it is reasonable to assume the information for each point location is representative of it neighbourhood.

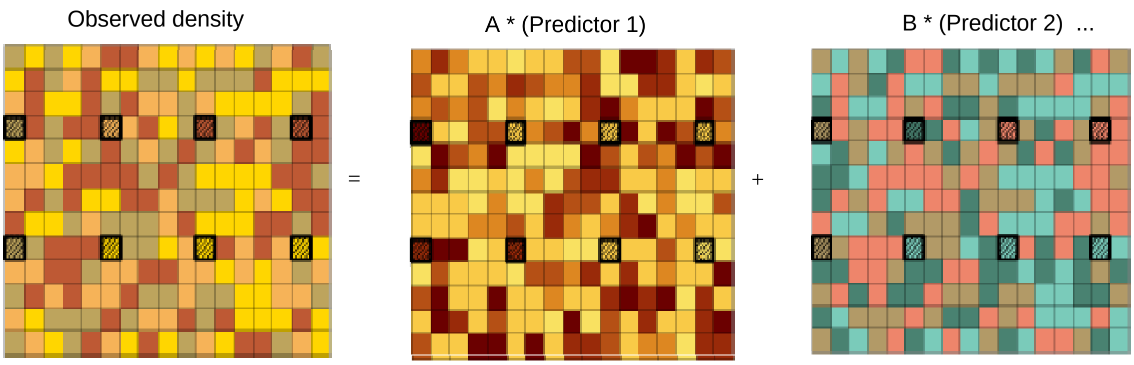
Such assumptions are less valid where data values vary considerably between sample locations – as is common for ecological and environmental parameters – or when there are no data for many neighbouring sample locations. This is commonly caused by blanks in the database that cannot be confidently assigned as zeros and was often the case with the ILUA survey data. The use of direct interpolation methods was therefore discarded as generally inappropriate.

One way around these problems is to model the distributions of the parameters of interest – by linking sampled data values with environmental and other conditions at that location, and assuming that these relationships hold throughout the study area. Data gaps then only have the impact of reducing the amount of information available to build the models rather than forcing the use of ever more tenuous trends between widely spaced points.

Such statistical methods have been widely used for many years to produce maps of animal, plants and diseases, using largely environmental predictors for target variables, and so are particularly suited for use with livestock and forestry related data which are also likely to be linked to environmental criteria.

The underlying processes of distribution modelling are summarised in Figure 4. Statistical relationships are identified between training data (*i.e.* known values of the parameters to be modelled) and a series of predictor variables, both extracted for every tract. These relationships are then applied to a standardised series of rasterised predictor variable images to predict values at the resolution of the predictor imagers. This results in a modelled distribution between tract locations and where data are not available.

Figure 4: Variable modelling



Step 1: Convert all data maps to images with same pixel size (resolution);
Step 2: Extract values for observations to be modelled at each tract, and for each predictor variable at the same sample points (hatched squares);
Step 3: Calculate a regression equation of the form:
*Observed variable = Constant + A * (Predictor 1) + B * (Predictor 2) + ...*;
Step 4: Providing the equation is statistically significant (*i.e.* reliable), apply the right hand side of the equation to **all** pixels in the predictor variable images to produce the predicted variable;
Step 5: Repeat the process for each of a series of analysis zones (e.g. ecozones).

As a result, the technique can be used to predict the values of target variables in areas for which no training data are available, thereby filling in gaps (*e.g.* where the ILUA data were blank or unconfirmed zeros) – creating continuous maps that reflect the environmental variability that underlies the variables being predicted.

3.3. Predictor variable archive

The statistical modelling technique relies on access to a wide range of predictor variables that can be used to define the relationships between target and predictor values. . Because they are reliable surrogates for a wide range of environmental, ecological and climatic variables, satellite and are often correlated with land use as well as land cover, satellite data were used to form the core of the distribution modelling predictor archive. These are also useful predictors because they are readily processed to derive summary climate and vegetation indicators with measures of seasonality and variability. Other indicators are, however, also likely to be useful as predictors: demographic, topographic, hydrological, agricultural and infrastructural variables, for example.

Following the compilation of appropriate training data and the selection and compilation of the predictor archive, the next important step in the modelling process is to compile a standardised predictor data file with values extracted for each analysis location. Sample locations were defined as ILUA tract centroids. The final form of the extracted archive is thus a 'flat file' consisting of: 'point id, point x, point y, target variable 1, target variable 2, ... target variable *y*, predictor 1, predictor 2, predictor 3, … predictor *x*', which means that the input data may be point attribute values for the tracts, polygon values extracted for the tracts using a spatial join tool (that assign data by location), or values extracted for each point from raster imagery. The image archive should ideally be a standard resolution and projection to simplify the extraction procedure, or at the very least collected into groups with a common resolution and projection. The image archive can be derived from other raster images, or, in the case of polygon data, converted from vector polygon to raster imagery.

About 100 parameters have been selected as predictors (see Annex 4); the majority derived from extensive time series of remotely sensed climate or vegetation indicators. Several sources were used: Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR) images from NASA, as well as SPOT imagery from Europe. These include Day and Night-time Land Surface Temperature, Middle Infra Red, Normalised Difference Vegetation Index, Enhanced Vegetation Index, Potential Evapotranspiration and Precipitation.

All are initially supplied as a series of monthly or decadal (10 day) images spanning several years, which amounts to several hundred images per variable – too many to include sensibly as predictor variables. As a result these data sets have been subject to temporal Fourier analysis, which produces a reduced set of biologically relevant variables for each parameter including the mean, two seasonality descriptors (phase and amplitude) for the first three Fourier components, as well as minima, maxima, range, and three estimates of variability. The Fourier process is also described in some detail Scharlemann *et al*. (2008) for the MODIS imagery.

Additional variables, taken directly or derived from public domain global datasets, include: length of growing period, cultivation percentage; human population; elevation; slope; the presence of tsetse (the vector of trypanosomiasis); and proximity to roads, rivers and built up areas derived using standard GIS procedures. Livestock densities have also been used where appropriate, as discussed further in Section 2 above. Details of predictors and sources are provided in Annex 4.

3.4. Analysis zones

Distribution modelling exercises conventionally not only produce models for an entire study area, but also for sub-regions, or zones, within it, on the assumption that relationships among training data and predictors variables are not consistent across the whole area, but may vary both qualitatively and quantitatively in different sectors. Dividing the analyses into zones provides the option to use completely different models in different areas, which are likely to be more appropriate locally.

The zonations are commonly based on variables that stratify environmental variability, such as ecozone or length of growing period, or classifications of agriculture or land cover. A number of such analytical zones have been used to stratify the modelling in this analysis.

a) Ecozones were defined using non-hierarchical clustering techniques, either within the ADDAPIX programme (Griguolo and Mazzanti 1996) or ERDAS Imagine software (Leica Geosystems®). The input parameters were drawn from the suite of predictor variables and included elevation and a series of remotely sensed parameters (the mean, Fourier component 1 phase of middle infrared, land surface temperature, vegetation index, air temperature, vapour pressure deficit).
b) Agroecological zones were defined by length of growing period, derived by a standard distribution modelling process for Zambia from existing low resolution FAO and International Institute for Applied Systems (IIASA) Length of Growing Period estimates.
c) The livestock production systems as defined by Seré and Steinfeld (1996) and mapped by Thornton *et al*. (2002) – see Figure 4.
d) Land cover classifications derived from the Global Land Cover 2000 datasets produced by Joint Research Centre at Ispra, Italy.

3.5. Model identification

The primary modelling process relies on multivariate analysis using stepwise multiple regression of continuous variables (densities, percentages, etc.). Relationships between target and predictor variables may not be linear, and it is therefore advisable to test non linear relationships. This is readily achieved by numerically transforming the variable values prior to statistical analysis. Models were thus assessed with dependent and independent variables; using untransformed data and using natural logarithmic transformations – resulting in four possible combinations: both sets of variables untransformed, log of dependent variable, log of independent variables and log of both sets of variables.

3.6. Model selection and evaluation

For each target variable, therefore, models were constructed for four transformations, each with sub models for the four zonations with a total of 16 categories. This combination means that more than 40 models were produced for each target variable.

All models were initially evaluated by observing R^2 values – and discarded if the formal significance level (p) was less than 0.001 (0.01%). Of the surviving models (which were the great majority), the zonation yielding the highest R^2 values was selected, within which the model for the transformation giving the highest R^2 for each sub-zone was chosen. The final models were thus an overlain combination of sub-zonal models of varying transformations, with the most statistically significant overlain last. They were implemented by predictor image manipulations using custom written Visual Basic software, designed specifically to calculate zonal linear equations of raster image inputs.

4. ANALYSIS OF LIVESTOCK INFORMATION IN ILUA DATABASES

The following analyses use statistical modelling to convert the ILUA survey data into continuous mapped surfaces. Each output is overlain by the actual tract data – displayed as graduated circles –

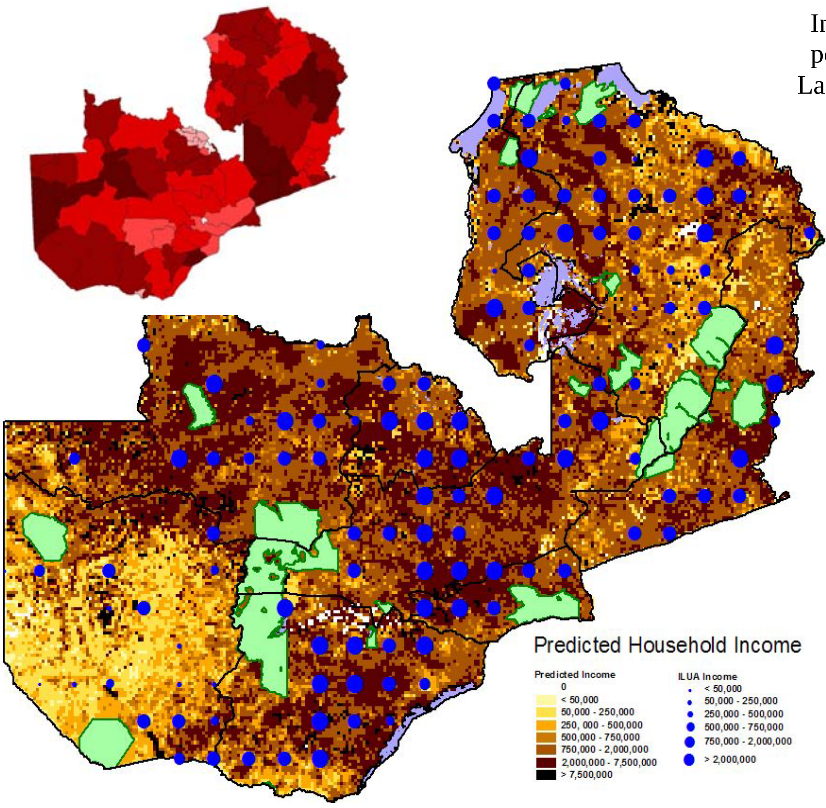
to help evaluate the fit of the modelled data to the original observations. The absence of a circle for tract data implies either a zero or a blank, (which is often but not consistently a zero). Each output is also accompanied by a chart of the average values of the modelled target variable within the Seré and Steinfeld (1996) production systems to provide a further indication of the way the data vary within Zambia and to shed light on possible links between target value and livestock production system. The ILUA survey code for the data modelled is indicated in the figure captions.

This section describes an analysis of the ILUA data in relation to answering policy-relevant questions about the livestock sector in Zambia: ultimately, we want to know where the livestock-dependent poor are; where are people depend on livestock for their livelihoods?

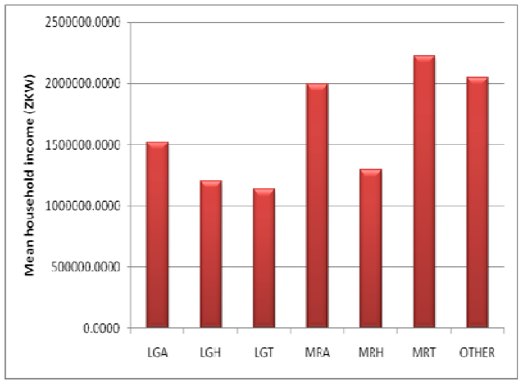
4.1. Where are the poor?

Figure 5 shows the modelled distribution of total household income, and clearly identifies areas where income is significantly lower than elsewhere – most notably a large are in Western Province and in parts of the north and the east. Income is relatively high around the major cities. This translates into relatively high income in the mixed rainfed production systems except in the more humid areas where it is similar to that found in the livestock only systems. This system is very small and its visibility in the statistics is likely to reflect only local variation. It is noteworthy that one of the important predictors of low income was the presence of the tsetse fly.

Figure 5: Household income (F7 A3**)**



Inset is the percentage poverty rate, derived from poverty zones from the Survey Dept (Ministry of Lands) collected in 2000 census. Supplied by FAO



The modelled distribution matches the survey data rather closely as there are few high income tracts in areas predicted to support low income. The model outputs also show a quite similar pattern to the inset poverty rate where high poverty rates are matched by relatively low predicted incomes in most areas. There are some obvious mismatches in the north east and west central regions, though this does not necessarily imply conflicting results as the sampling rate may be low, or income distributions may vary substantially: a high poverty rate does not inevitably mean a low average income.

4.2. Where are the livestock and the livestock keepers?

Livestock densities are needed to quantify livestock's possible impact on the environment. Section 2 has shown the distribution of livestock according to earlier sources – the Gridded Livestock of the World (FAO 2007). An additional objective of the current analyses was to use the ILUA data to update the GLW livestock distribution maps, which were derived from the national livestock census of 2000. It was hoped that this would be possible using well established distribution modelling methods based on ILUA-derived livestock densities to calibrate ('train') the modelling process. The ILUA data are given as numbers of animals per household, for a maximum of 15 households per tract, within a 5 kilometre radius circle from the tract centre. Locations for households were not generally recorded, nor was the land area associated with the animals. A total of 1680 households were surveyed over 221 accessible tracts throughout Zambia. Of the total 221 tracts surveyed, 139 were recorded as containing households, for an average of 12 households per sampled tract

Since the total number of households within a tract was not recorded, two ways of estimating the number of animals within a tract (and hence the national populations) were assessed. First was to calculate the number of animals per person, and multiply that figure by the number of people within a tract as derived from the most recent human population census. The census gives population numbers at the level of the ward, and could therefore be used to estimate the number of people within a tract radius. Second was to calculate the number of animals per household and link that to the number of households within a tract or ward, thereby providing an estimated number of animals per tract or ward. As the ILUA database did not contain numbers of households per tract, the recent population census data were again used to make these estimates.

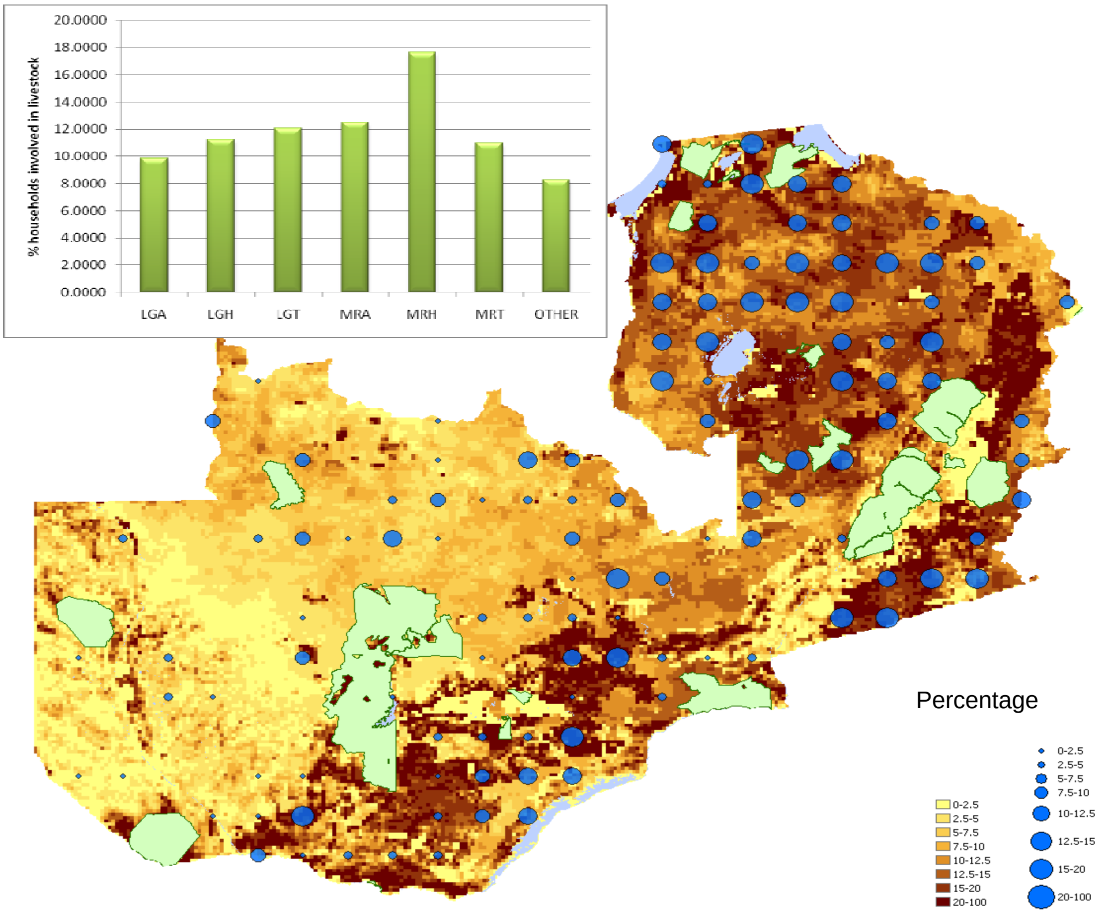
A second, though less rigorously collected, set of data – from a post harvest survey (PHS) database – was also provided, which, like the ILUA database provided, counts of livestock numbers per household, but georeferenced not by tract but by administrative ward. This second source of recent livestock data was used to supplement the ILUA livestock counts. Combining these figures with the known number of households per ward from the population census produced an estimate of livestock numbers (and hence densities per ward) for those wards for which PHS data were available.

Because of the vagaries of the PHS wards sampled and the wide separation of the ILUA tract locations, these two sets of results overlapped for only a quarter (80) of the ILUA tracts. Whilst the relative distributions were similar – showing higher animal numbers in similar locations – there was very little statistical correlation between the calculated densities for the same locations. This suggested that the two densities calculated – the ILUA via numbers/person and the PHS via numbers/household – were not the same. This in turn suggests that either the methods used to extrapolate the livestock populations were inadequate or the survey data themselves were not reliable. Both are eminently possible as livestock owners are notorious for providing inaccurate reports of their animal holdings, and the extrapolation methods relied on a representative sample and accurate multipliers; neither guaranteed.

Either way, neither data set could be used to generate reliable livestock population maps to update the existing FAO databases. Thus, the only reliable source of data on livestock densities for the ILUA tracts was the FAO GLW.

The distribution of livestock keepers was first addressed by modelling the percentage of households recorded that considered livestock to be a primary activity (Figure 6), then by analysing which households owned each type of animal (Figure 7). Few households claimed livestock as a main activity – a maximum of 18% in the small mixed rainfed system in humid regions, and only 6% in the 'other' system, largely located in the northern central areas. Whilst this figure does not otherwise vary greatly between systems, there is a distinct regional pattern showing the livestock oriented households to be concentrated in the south of the country and to a lesser extent in the north east. The central northern and western parts are conspicuous in their lower levels of stated involvement with livestock. This may mean than livestock were a close second in these areas, but without quantitative confirmation of this they could not reliably be included within the 'livestock oriented' household category for analysis.

Figure 6: Percentage of households with livestock as primary activity (F7 A.2, 210)

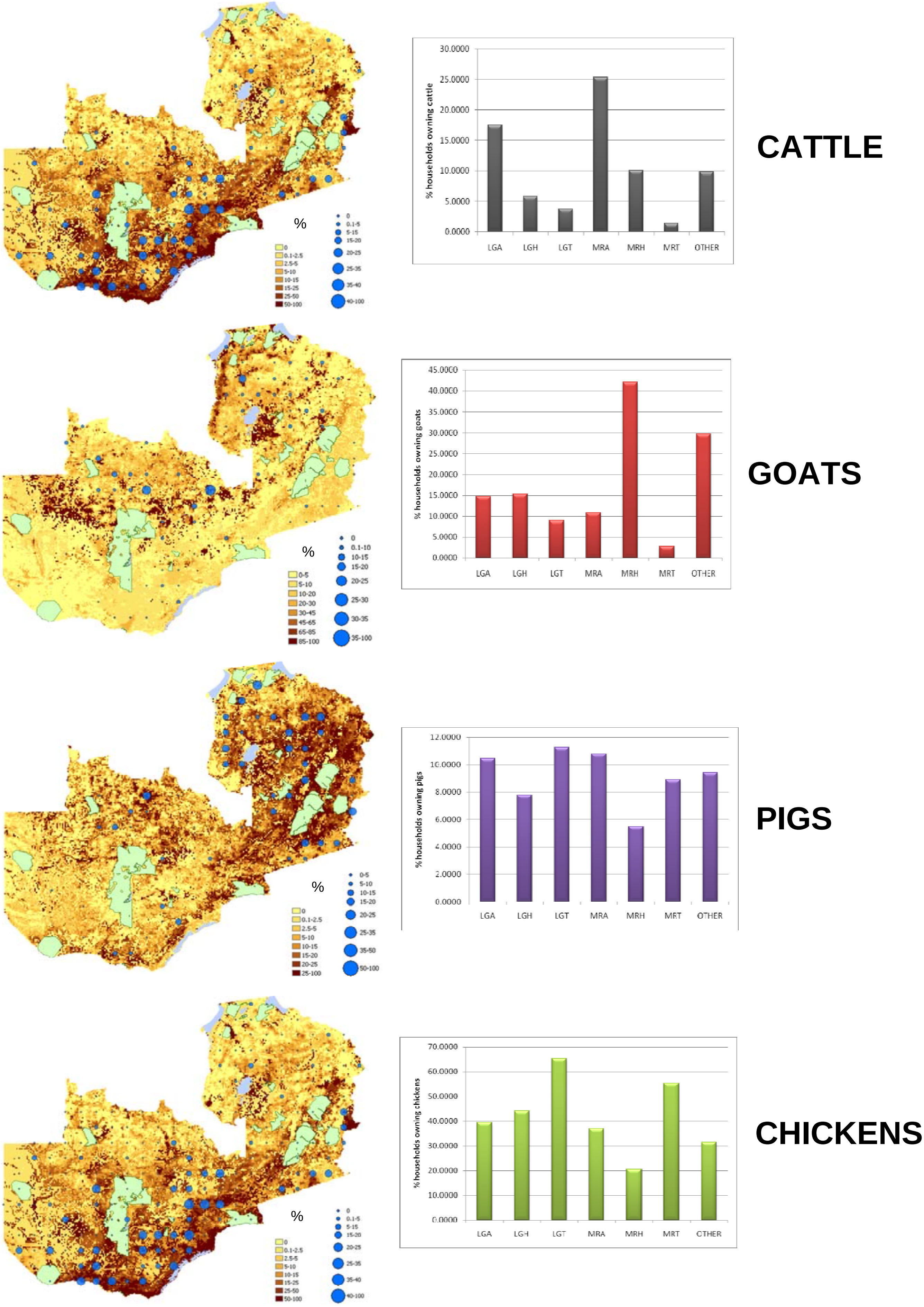


The percentage of households that own each livestock species is significantly higher than those that count livestock to be a main activity – implying that many households own livestock as a supplement to their stated main activity. There are distinct spatial patterns – cattle in the south, goats in the north and centre, pigs to the east and chickens throughout but especially in the north and east. For pigs, cattle and chickens these patterns largely follow the distributions of the animals. For goats, however the data suggest that low densities are associated with wide ownership (by implication of small numbers of animals), whilst high densities are associated with rather low ownership levels (presumably of larger herds or within more populated areas).

In relation to the production systems, some patterns also emerge: cattle are most widely owned in the arid systems – both livestock only and mixed rainfed. Goats are kept in the unclassified systems or in the small humid mixed rainfed system. Pig ownership levels are generally low, especially in the humid systems, and a more of the households in tropical and highland systems own chickens than elsewhere.

Figures 9 and 10 provide the spatial context for the livestock ownership in relation to income. The income of areas with widespread livestock ownership is greatest in the south and east – whilst the numbers of poor households with livestock are highest in the south west and the north east. This distribution of poor livestock ownership appears to hold true for all livestock species in that a higher proportion of poor households in the south west and north east own livestock than elsewhere.

Figure 7: Percentage of households that own animals (F7 C6-C10)



4.3. Where are the poor livestock keepers?

Two aspects of this question have been assessed: a) is the type of livestock kept by a household related to its income level? and b) do poor livestock owners live in particular parts if the country and does that differ according to the type of animal owned.

For the first of these, Figure 8 suggests that cattle ownership is prevalent amongst the richer households, and correspondingly rare amongst those households with an annual income of less than one million Zambian Kwacha – (somewhat less than a dollar a day) – of which only 10% owned cattle. By contrast, chicken ownership is shown to be substantially more widespread amongst the lower income groups, with nearly half of these households owning them, as opposed to a fifth of the better off households.

Pig and goat ownership also appears to be related to income: the highest income groups are not recorded as owning these species, and only 5% or fewer of the poorest households own pigs or goats– whereas double that proportion of the 'middle income' households keep these animals.

This argues a similar pattern of ownership in Zambia as in many other parts of Africa, even the poorest own poultry in significant numbers, whilst goats and pigs tend to be kept by those with slightly higher incomes, but not by those with relatively high incomes. Cattle are owned by all income groups, but especially by those with more money.

Figure 8: Percentage of of households owning different types of livestock by income class
(F7, A3, C6-10)

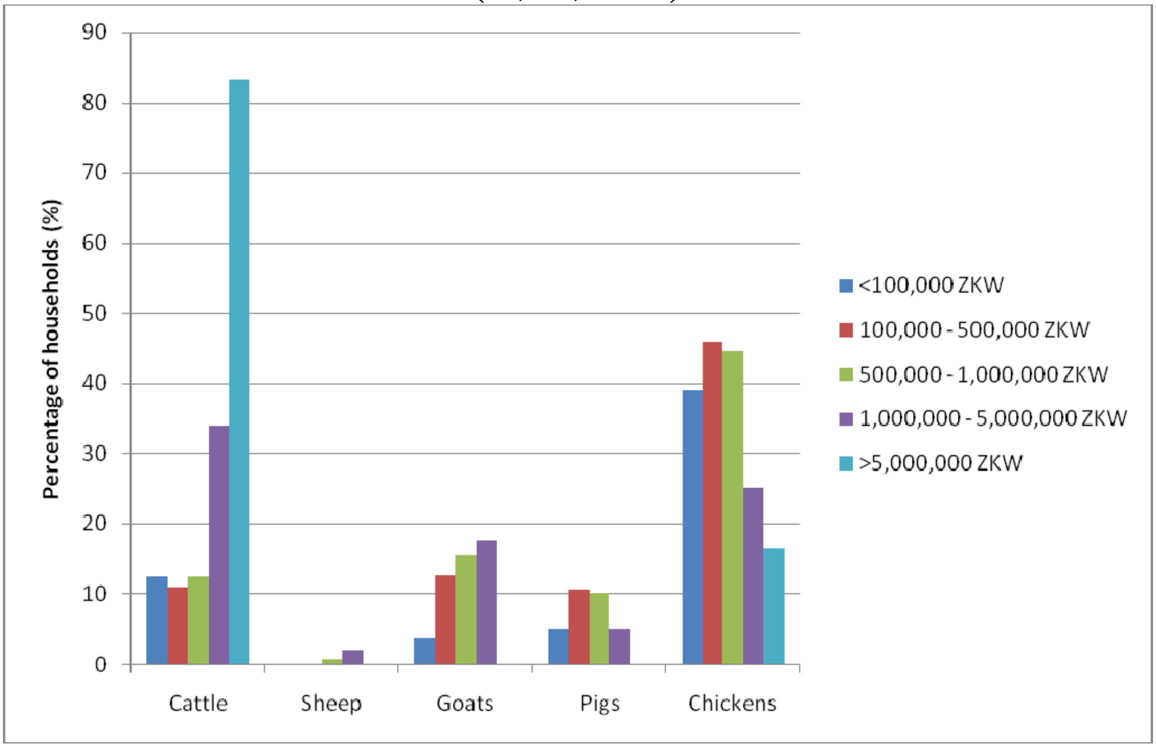


Figure 9: Income and livestock ownership

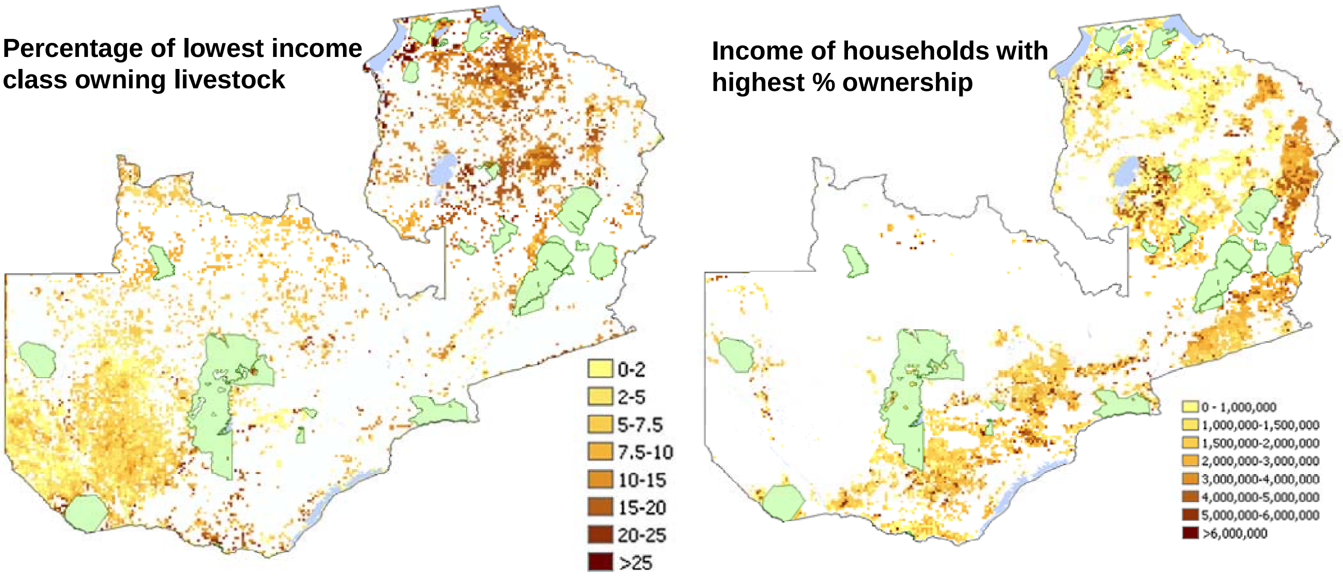
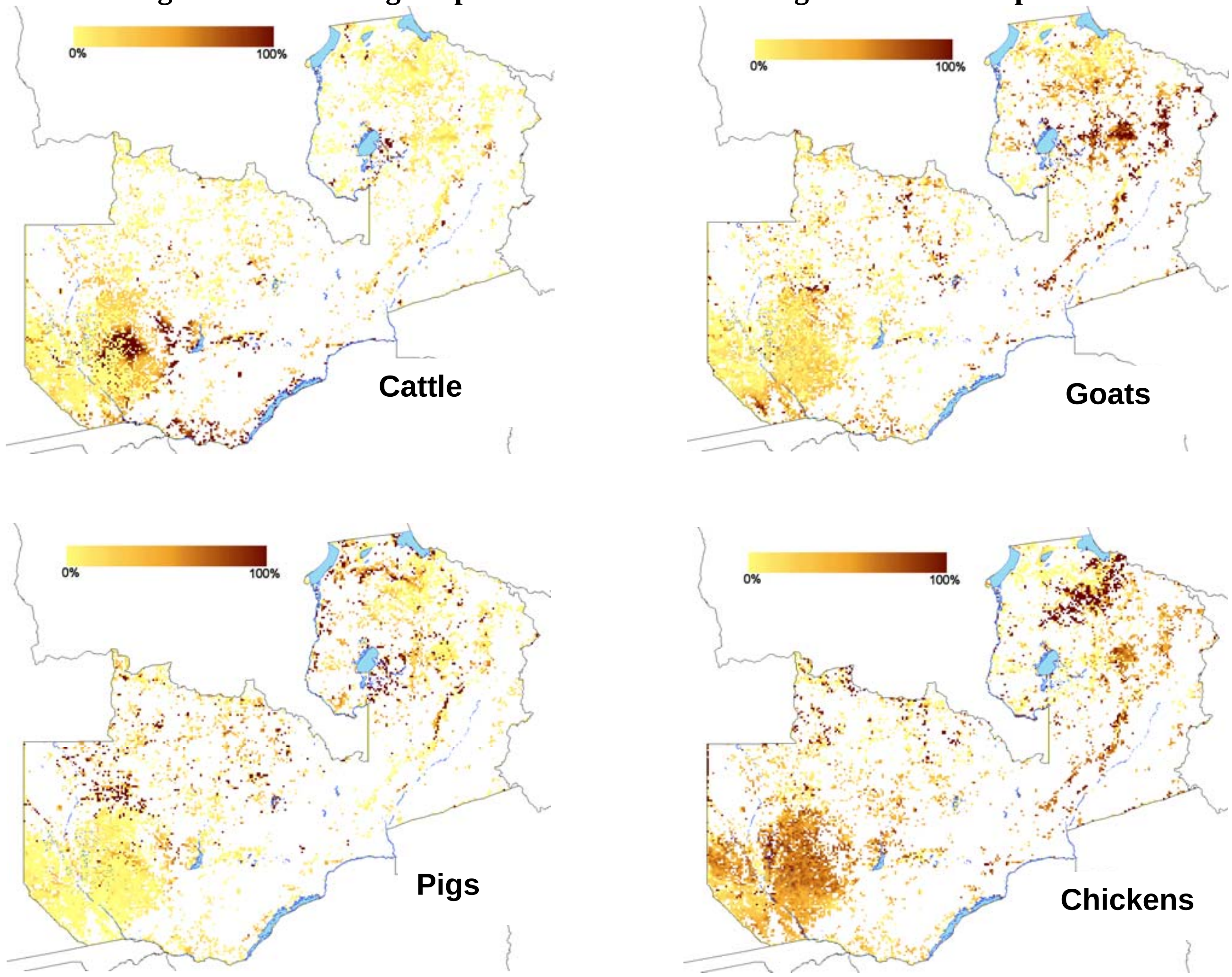


Figure 10: Percentage of poorest households owning each livestock species



4.4. Where do people make money from livestock?

Figure 11: Expenses and income from livestock-related sales
(F7. A.2; A.3; A.4; A.5; B.1; B.2; C.1; C.4; C.5; C.6; page F7c)

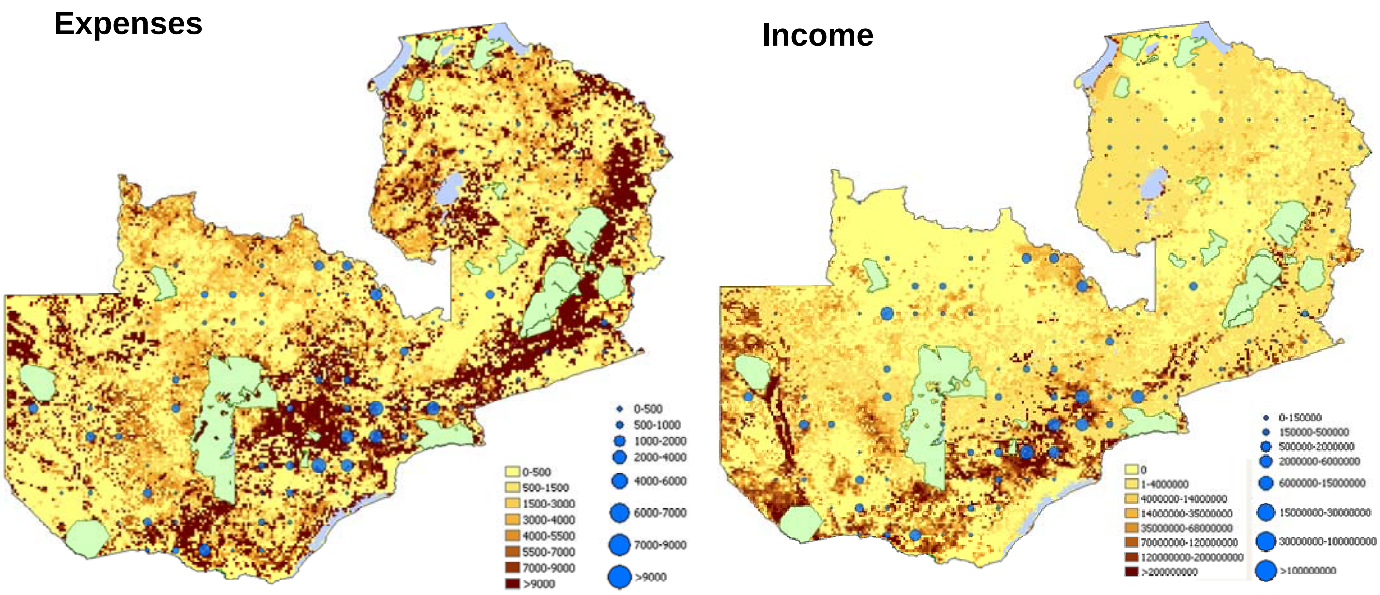
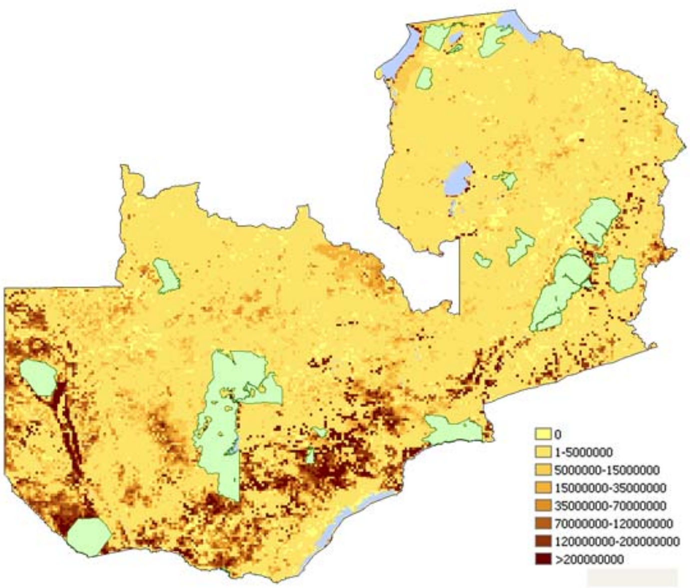


Figure 12: Net income from livestock related sales
(by subtraction of Figure 11 data)



The income and expenditures related to livestock sales and the resulting net income from such activities provide some indication of the profitability of livestock keeping though the data are not robust enough to distinguish species specific patterns. Expenses appear to be less variable and spatially focussed, than does income from sales. Net income, at least from sales, is shown to be quite restricted in its distribution, and concentrated in the south and the west.

4.5. Specific policy intervention domains.

In the context of helping to develop pro-poor livestock policies and institutions, FAO's Pro-Poor Livestock Policy Initiative (PPLPI) recognises three broad 'policy 'intervention' domains': (i) reducing vulnerability; (ii) creating conditions for growth; and (iii) coping with growth. Taking these individually, each has a number of broad objectives that must be addressed.

In order to achieve the objective of 'reducing vulnerability', policies and institutions must address: (a) prevention and management of natural disasters; (b) access to land; (c) access to water; and (d) access to feed. Securing access to these basic inputs is a necessary condition for smallholders to start making productive use of their livestock assets.

To 'create conditions for growth', policies and institutions must support: (a) access to agricultural extension and animal health services; (b) access to credit; (c) access to improved inputs; and (d) access to output markets. Access to production-enhancing inputs and markets is a necessary condition for smallholders to start profiting from their livestock assets.

To achieve the third objective of 'sustaining growth', policies and institutions must address issues of: (a) food safety and quality, particularly in its relation to trade; (b) agricultural research; and (c) environmental sustainability. The sustainable production of livestock products and by-products that satisfy certain sanitary and phytosanitary (SPS) standards is essential if smallholders are to compete in, rather than to be forced out of markets.

Whilst these objectives represent a sequence in the development of a sector, it is not necessarily the case that attaining one of these stages will lead on to the next – for some households access to markets will always (or at least in the foreseeable future) be difficult, making growth elusive, but livestock will remain an important element of their livelihoods and food security. What is important is that the livestock sector makes an optimal contribution to sustainable poverty alleviation and growth – and that means that the natural resource base is conserved – and the policy environment must be set up to facilitate this. Optimising this contribution of the livestock sector to sustainable, pro-poor growth means that each of the intervention domains must be addressed.

This simple framework of intervention domains has been used by the PPLPI to review and evaluate livestock sector policies (Pica-Ciamarra and Robinson 2008). Within each domain policy objectives are identified and the existing policies and instruments are reviewed to see whether these objectives are met in a consistent and effective way. Gaps and inconsistencies can thus be identified and addressed. Furthermore, the concept of intervention domains can be applied to locate the people are who fall into the different categories and therefore where polices directed at particular objectives need to be targeted.

To identify those areas most suited to the different domains it is necessary to compile (and model) numerical indices. Such indices first must be scaled equivalently, so that high values of one correspond to similarly high values of another. For example each factor contributing to vulnerability can be scored low, medium or high (1,2, or 3). Factors can then be treated with equal importance or, if appropriate information is available, they can be weighted according to their relative importance. The scores for each factor, weighted or otherwise, are then summed to provide an overall index.

In this analysis, contributory factors for each of two policy domains: a) reducing vulnerability, and (b) creating conditions for growth, were scored by dividing the values into quartiles (yielding a minimum of 1 and a maximum of 4), which were then combined for each policy domain. These two policy domains, can be reasonably considered two extremes of a continuum: at one end people are highly vulnerable, and at the other end people have ideal conditions for growth. These two domains were thus combined in the same way, by first assigning a quartile rank to each tract, and these then summed (most suited to vulnerability related interventions = 1 and most suited to growth related interventions = 16), and subsequently modelled.

Figures 13 sets out the models and accompanying charts for the vulnerability policy domain factors: (a) diversification or household activities; (b) access to land; and (c) access to feed (this latter represented as expense of feed supplied to livestock, because the direct measures of access to feed were often incomplete or missing). Access to water was initially incorporated, but did not model well – as the data were incomplete and combination of access to artificial and natural water sources proved unreliable.

In all the maps, darker colours and larger dots imply higher values.. All show spatial pattern, implying that most vulnerability (low diversification, high feed expense, poor access to water and land) occurs in the north west, the northern central and south western sectors of the country. Access to agricultural land is somewhat less variable than the other three indicators, but generally follows a similar pattern. The relative distribution of these factors in relation to the livestock production systems, however, reveals quite different patterns. Diversification of household activities is greatest in the humid areas (both livestock only and mixed), in line with the relatively long of growing period in these systems allowing a diverse range of activities. The availability of agricultural land tends to be higher in the livestock only systems and in the arid areas of the mixed rainfed system. These are less suitable for intensive crop production and are more sparsely populated. The pattern of access to feed in relation to livestock production systems is more difficult to interpret – with expenditure relatively high across all classes, bar mixed rainfed arid, in which it is relatively low.

Figure 13: Contributors to individual vulnerability domain interventions

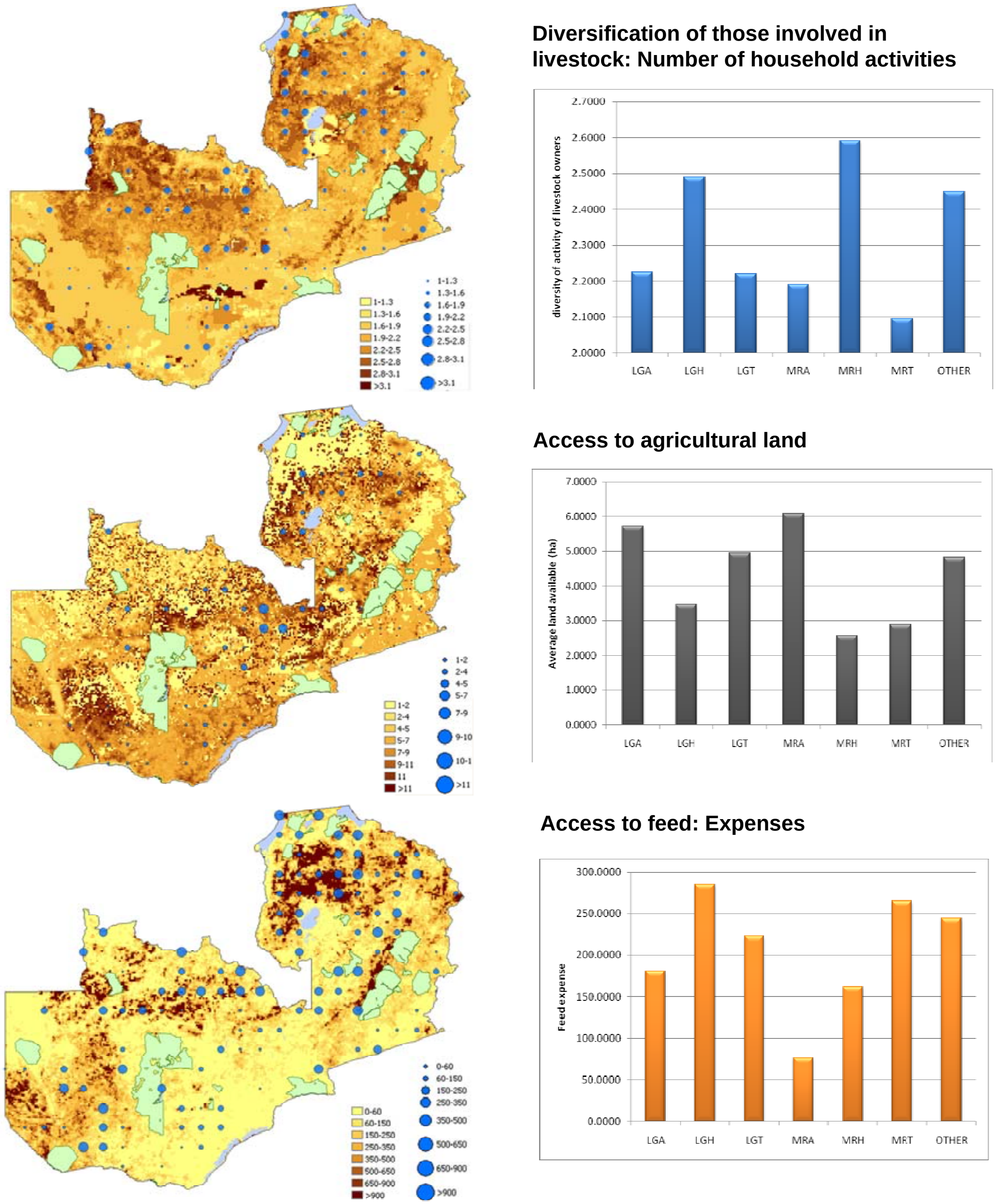


Figure 14: Contributors to individual growth creation domain interventions
(F7 C2), All scored 1 - 4

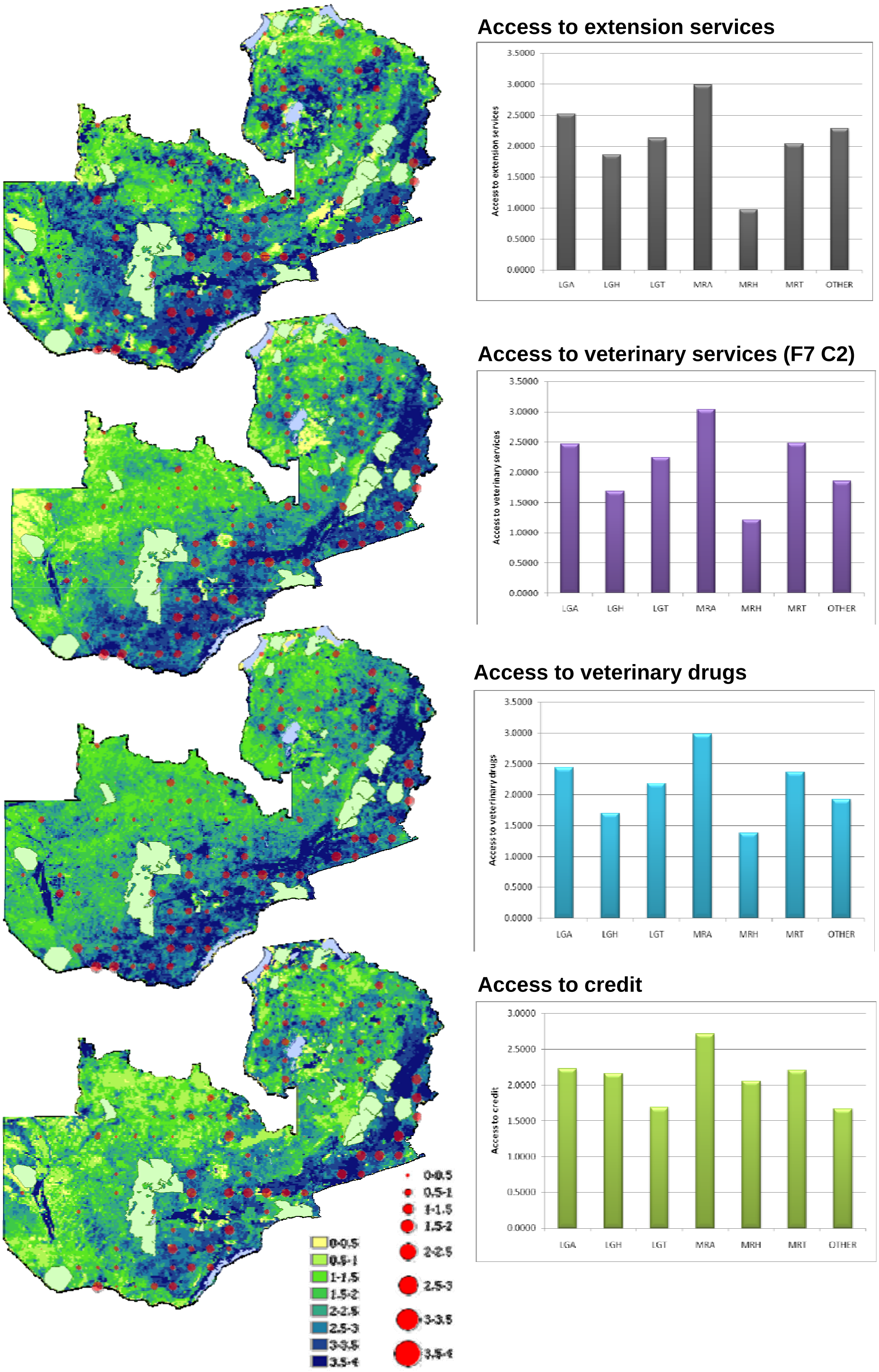


Figure 14 sets out the equivalent data relating to the interventions for promoting growth. Five indicators have been identified, four representing access to services (credit, extension, veterinary staff and veterinary drugs) with population as a fifth indicator of accessibility to markets for both purchase and sale of goods. Three have similar patterns, with the 'best' conditions in the south and west (access to veterinary staff, drugs and credit) whilst a fourth (access to extension services is more evenly distributed across the country, with low values restricted to the south west, the north east and parts of northern central Zambia. The population density (Figure 1) is added to the combined access surfaces, thus weighting population density over individual (and closely correlated) access measures.

Figure 15: Calculated vulnerability and growth creation domains

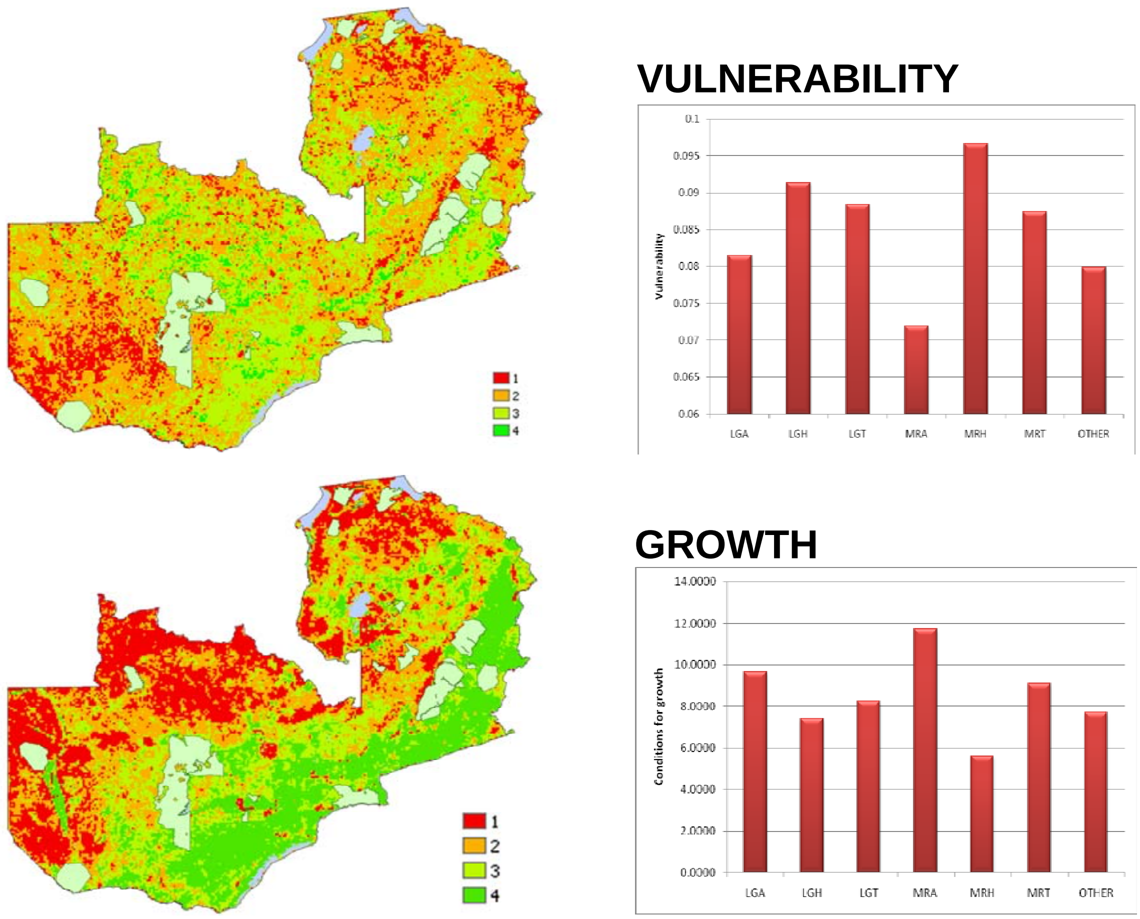


Figure 16: Combined growth and vulnerability indices for policy intervention domains

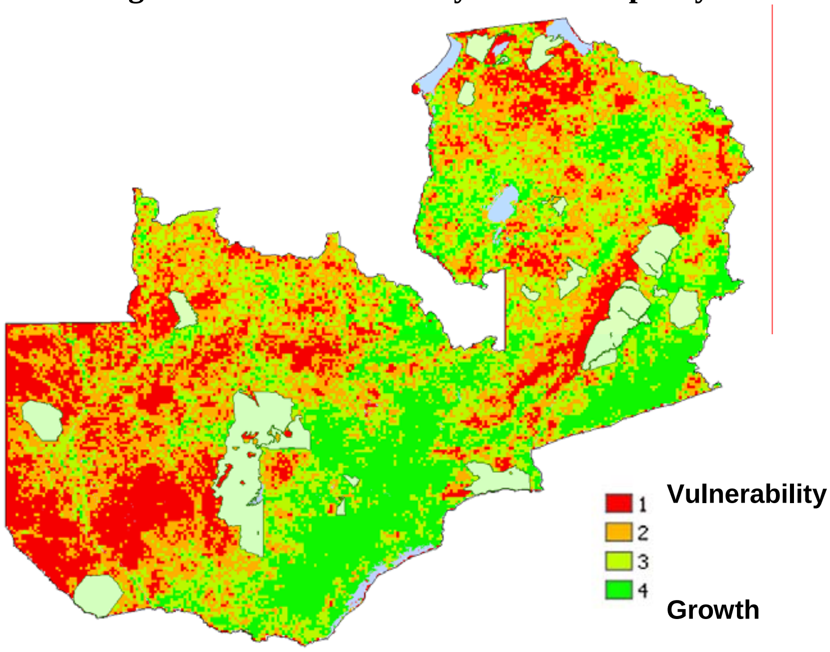


Figure 15 provides the combined indices for conditions for vulnerability and those for growth – displayed so that high vulnerability and low growth are colour coded in the same way. Despite the diversity of measures used to generate the two measures both provide very similar spatial patterns. Vulnerability is most apparent in the south west, with conditions for growth being least conducive in the same areas, but also in the northern central regions.

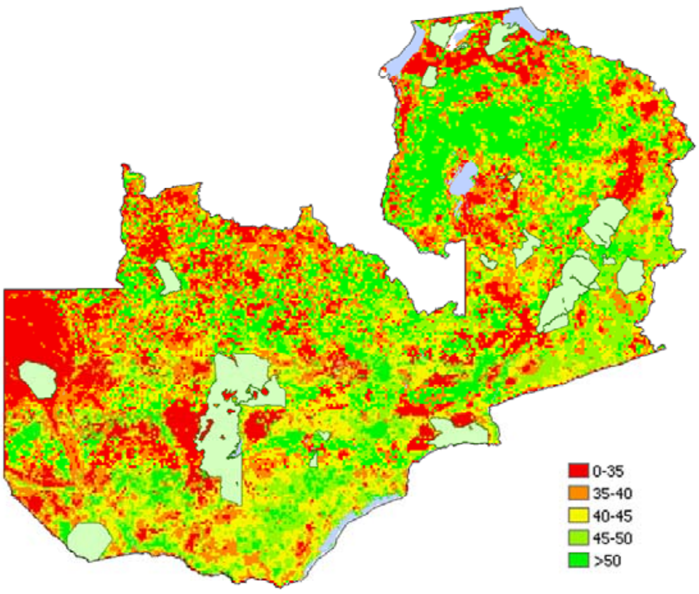
Of especial interest to policy makers is a map which combines the growth and vulnerability indices. Figure 16 shows the results of using the same quartile ranking and combination technique to add the growth and vulnerability indices. Given the similarity in the growth and vulnerability measures, it is no great surprise that the combined index, created in the same way by summing ranked quartiles, gives a distribution that is consistent with its constituent indices and striking in its pattern. Greatest vulnerability occurs in the south west and north east, and the best conditions for growth are in the south and south east. These patterns are very distinct implying that all indices point to the same conclusions.

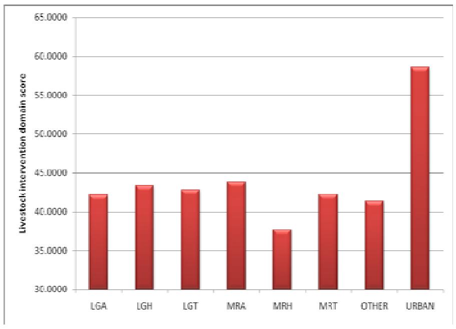
4.6. Continuous livestock intervention domains

Following the promising development of these individual policy intervention domains a single index that was calculated as a continuous score, calculated from the same suite of variables, rather than the combination of two separate indices each based on different inputs.

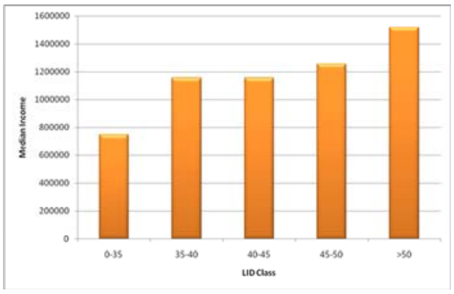
To test this approach, a single policy domain index was calculated using the un-weighted combination of variables standardised to a 0-100 range. The following input variables were included: (a) access to feed; (b) diversification; (c) access to agricultural land; and (d) access to livestock services (the average of: extension, veterinary, drugs and credit) together with three standard datasets from outside the ILUA survey: (e) length of growing period; (f) population density; and (g) market access.

Figure 17: Continuous livestock intervention domain scores





Average income for each domain class



The resulting livestock intervention domain scores (which could range from 0–100) are shown in Figure 17. The patterns are similar to those shown in Figure 16, suggesting that both approaches provide valid descriptions of the policy domain distributions. Both show relative vulnerability in the west, and the north, whilst conditions for grown tend to dominate in the southern and central areas. The continuous score has the advantage of being more easily divisible into value categories, and this can be used to highlight the intermediate scores in the south.

The accompanying plots suggest that, with the exception of the urban system, livestock production systems do not reflect the intervention domains – in that there is little difference in score between them. By contrast the income levels of the five domain classes are clearly related to the domain score, and increase in line with it. This is an encouraging validation of the results – it is reasonable to expect incomes to be lowest in highly vulnerable areas and highest in areas with the best conditions for growth. It further suggests that, in the absence of any of the constituent variables, income could be used as a first proxy for intervention domain score.

4.7. Interaction between livestock and the environment

Livestock do not live in isolation from their surroundings, and interact with their environment in many ways, both positive and negative. One of the main components of the ILUA datasets are the detailed forestry data acquired from plot surveys; information about perceived environmental constraints at the household level; and more general land cover at the tract level. These data provide an opportunity to analyse the relationships between livestock, forest and environment.

Two classes of relationships have been highlighted as being of special interest: (a) the possible impact of livestock on forest structure and regeneration as implied by the frequency distributions of tree size (diameter at breast height (DBH)) and tree cover; and (b) the broader impact of livestock on environmental health, described by the constraints of erosion, soil fertility and burning.

4.7.1. Levels of livestock and status of the forest

High livestock densities might be expected to be damaging to smaller trees through browsing, and thereby reduce rates of regeneration. Livestock numbers might also be expected to be higher in areas where trees have been cleared or where canopy cover is comparatively low, and thus the availability of grazing relatively high. Figures 18 and 19 support both these suggestions as they show that where cattle and sheep densities are high, the majority tree cover class is reduced, and the average DBH is lower than in the less densely stocked tracts.

Figure 18: Tree cover class in relation to animal density

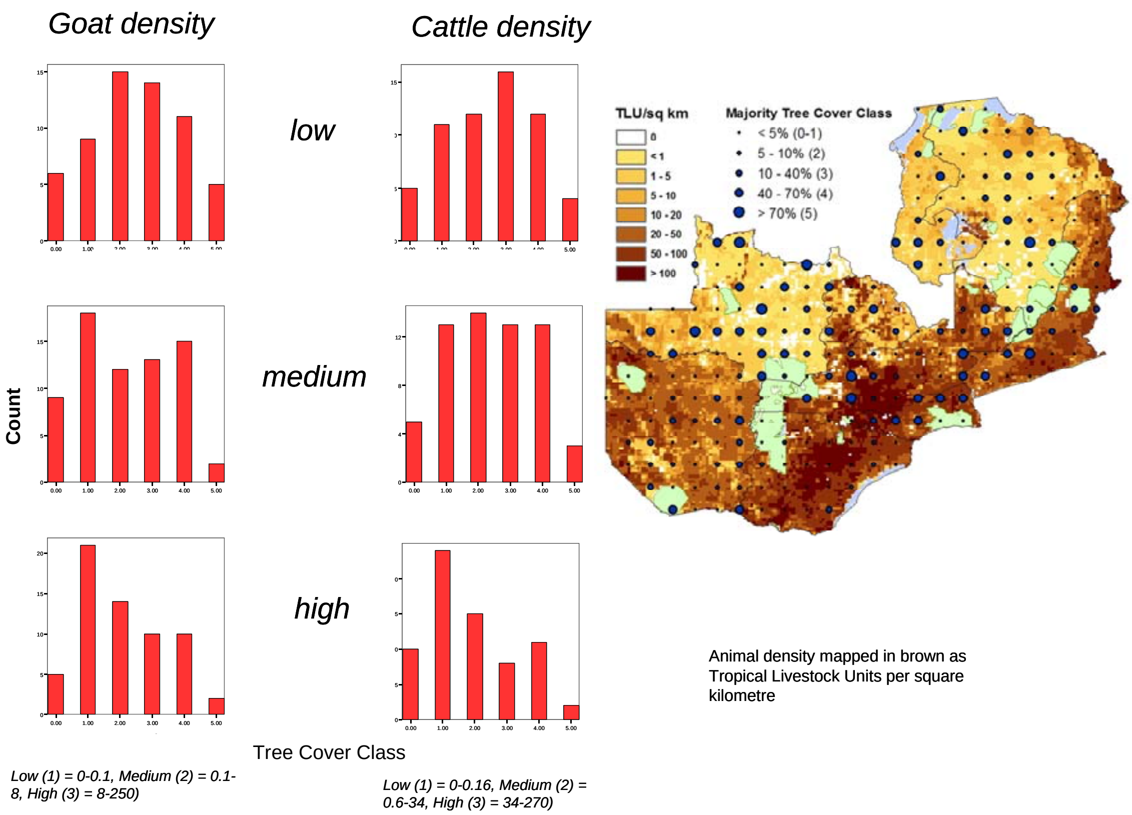
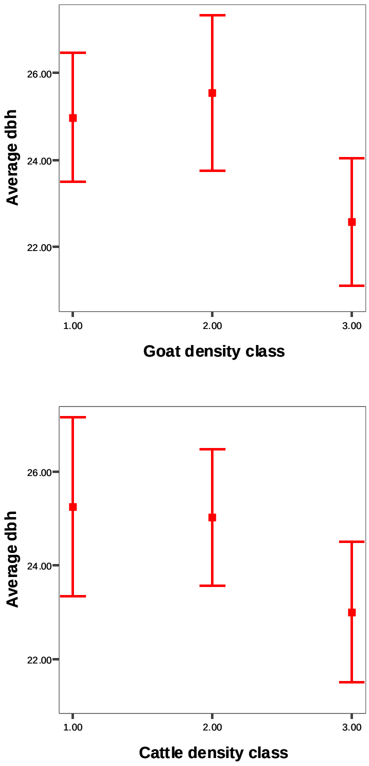
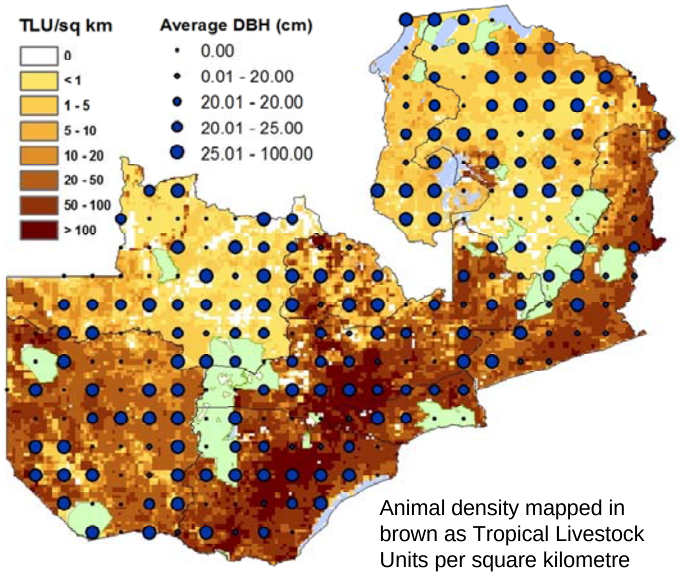


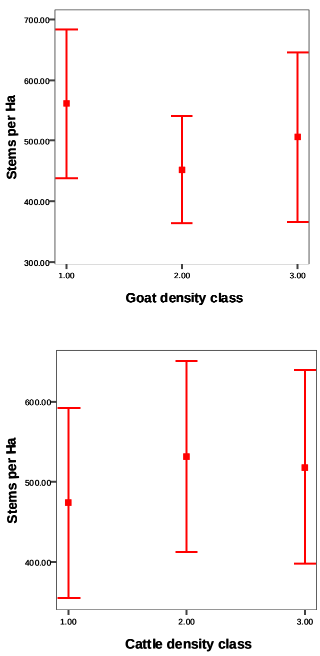
Figure 19: Average DBH in relation to animal density

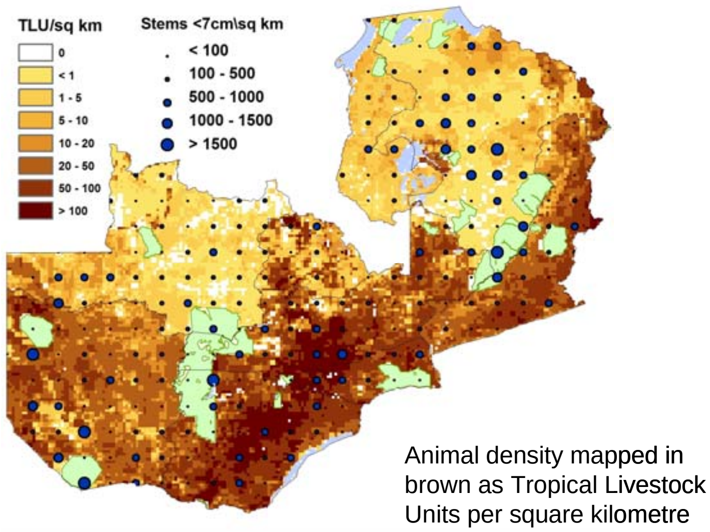




Error bar plots showing mean and 95% confidence interval of the mean
Goat density classes: Low (1) = 0-0.1, Medium (2) = 0.1-8, High (3) = 8-250
Cattle density classes: Low (1) = 0-0.16, Medium (2) = 0.16-34, High (3) = 34-270

Figure 20: Regeneration (stems/ha <7cm DBH) in relation to animal density



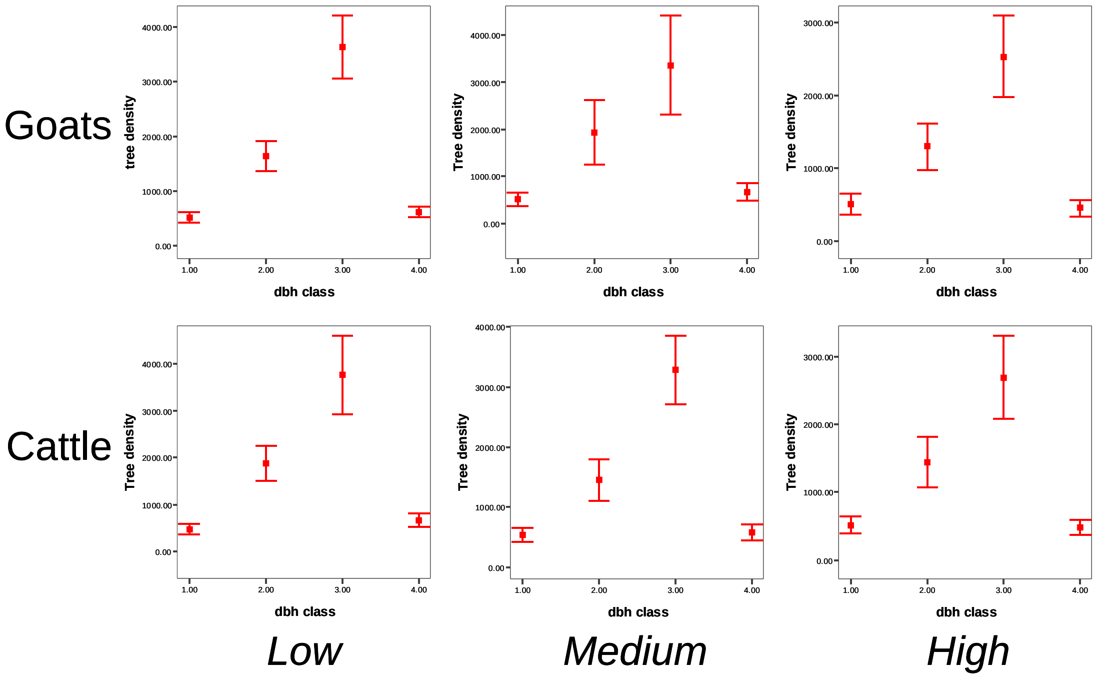


Error bar plots show mean and 95% confidence interval of the mean
Goat density classes: Low (1) = 0-0.1, Medium (2) = 0.1-8, High (3) = 8-250
Cattle density classes: Low (1) = 0-0.16, Medium (2) = 0.16-34, High (3) = 34-270

This does not, however, prove that livestock reduce regeneration, or alter the structure of the forest. It could also be that livestock are kept in larger numbers in more open areas that have fewer and smaller trees. To investigate this further, the actual numbers of saplings (Figure 20) and other DBH classes (Figure 21) were examined, but in the forest land use class only, so as to remove the possibility that lower sapling density was a result of a preference for non forest habitats rather than reduced regeneration within forests.

Both sets of results suggest a weak association between livestock and forest structure. Levels of regeneration are marginally lower where goats are more numerous. In contrast, sapling numbers are, on average, higher where there are more cattle. None of the differences are formally statistically significant reflecting the levels of variability within each class (as indicated by the size of the error bars).

Figure 21: Density of all DBH classes in relation to animal density



Error bar plots showing mean and 95% confidence interval of the mean
Goat density classes: Low (1) = 0-0.1, Medium (2) = 0.1-8, High (3) = 8-250
Cattle density classes: Low (1) = 0-0.16, Medium (2) = 0.16-34, High (3) = 34-270
DBH calsses 1=<7, 2-2-20, 3=20-40, 4=>40

All plots in Figure 21 show the same pattern, with rising stem density up to 40cm DBH, and with stems above 40cm being recorded at about the same density at the regeneration class. There are however some significant differences in overall stem density levels: high densities of both cattle and goats are associated with lower densities of the largest stems. There are also significantly fewer 7-20cms stems at high cattle densities and 20-40cm stems at high goat densities. This might reflect either preferential use of particular forest types or a demonstrable impact of livestock on stem size composition.

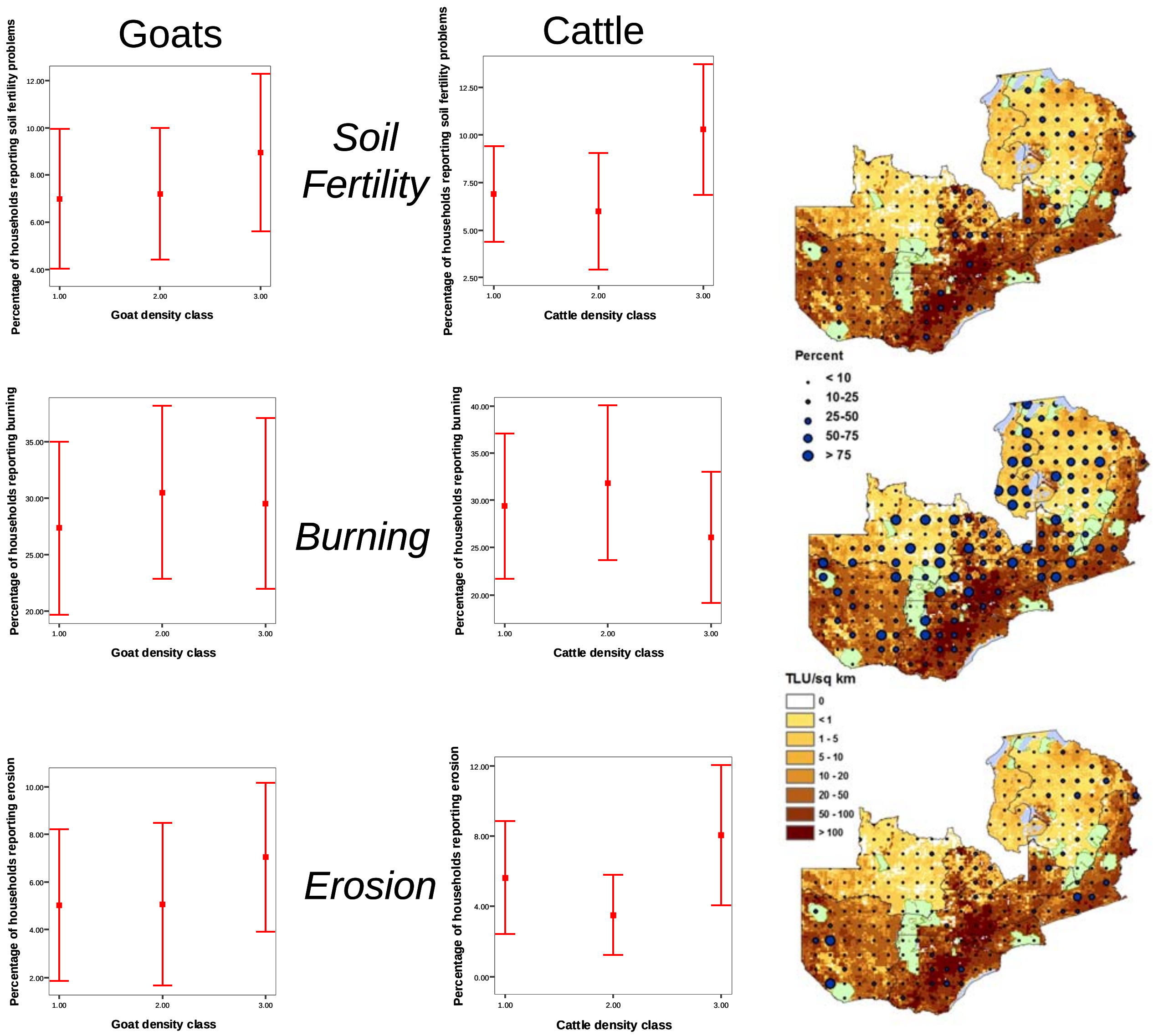
This suggests that the reduced tree cover associated with high livestock densities (Figure 18) is also a feature of forested land, and not just a reflection of livestock being more abundant in less forested areas

4.7.2. Livestock levels and environmental indicators

Two aspects of the more general potential impact of livestock on the environment have been assessed: (a) the perceived impact, as indicated by the percentage of households reporting reduced soil fertility, or increased levels of burning and erosion (Figure 22); and (b) a measure of the proportion of the household land area affected by each of these adverse conditions (Figure 23).

The spatial distributions of both perceived problems and areas affected are similar. Burning is widespread throughout the country. In contrast, both loss of soil fertility and particularly erosion are quite patchy, and are most evident in the more heavily populated regions of the south west and centre, as well as in limited but relatively sparsely populated parts of the north east.

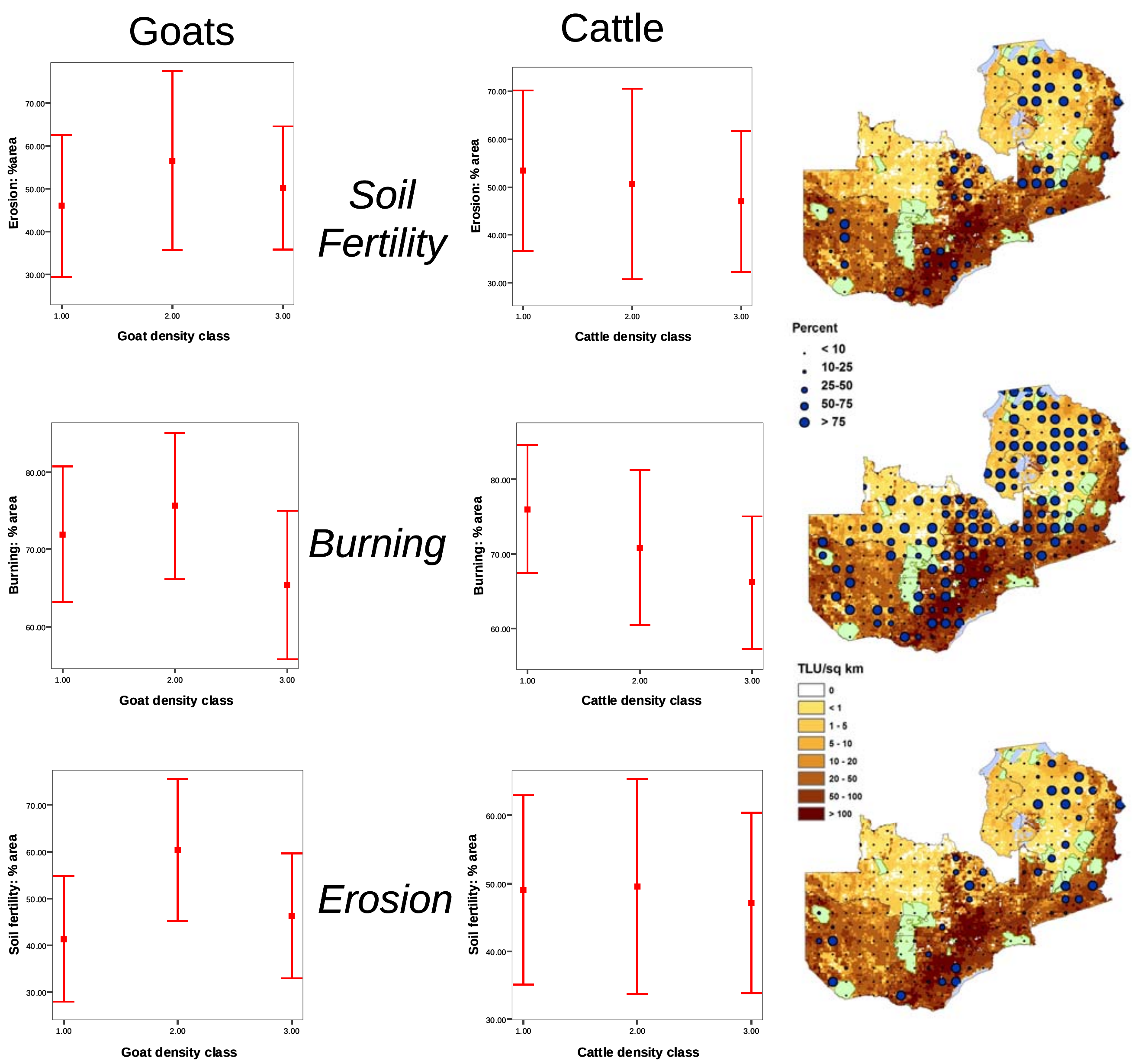
Figure 22: Percentage of households reporting environmental problems



Error bar plots showing mean and 95% confidence interval of the mean
Goat density classes: Low (1) = 0-0.1, Medium (2) = 0.1-8, High (3) = 8-250
Cattle density classes: Low (1) = 0-0.16, Medium (2) = 0.16-34, High (3) = 34-270

As with the results reported in the previous section the apparent impact of high livestock densities on the environment is comparatively weak. Erosion and reduction in soil fertility are more frequently perceived to be a problem where animal densities are high, and burning appears to be relatively unaffected by animals numbers.

Figure 23: Proportion of areas surveyed with environmental problems



Error bar plots showing mean and 95% confidence interval of the mean
Goat density classes: Low (1) = 0-0.1, Medium (2) = 0.1-8, High (3) = 8-250
Cattle density classes: Low (1) = 0-0.16, Medium (2) = 0.16-34, High (3) = 34-270

This perceived impact is not necessarily the same as that suggested by the areas of land affected, which tend to be a smaller proportion of the area surveyed for all three environmental indicators evaluated. This may mean that these problems are only reported by households with smaller amounts of land, rather than reflecting a genuinely lower overall impact.

5. CONCLUSIONS AND RECOMMENDATIONS

The ILUA survey data have proved to be a valuable source of data for the spatial analysis of its livestock related data in relation to both poverty and the forest element of the environment. The survey data have generally proved to be amenable to well-established spatial distribution modelling techniques which have allowed the comparatively sparse tract-based information to be interpolated to more detailed maps of a range of strategically useful information. This has included the location of livestock keepers; the pattern of household income; and thus the distributions of the poorest keepers of each livestock species. It has also included various factors related to development potential, including access to environmental, demographic and veterinary resources.

As spatial analysis techniques are designed to combine maps to produce new insights into the situation on the ground, it has also proved effective to combine these 'enhanced' distributions into indices that highlight the areas where policy interventions related to reducing vulnerability are most likely to be needed, and where policy interventions relating to creating conditions for growth are more likely to be appropriate. This underlines the value of integrated surveys of field conditions in informing policy and decision making.

This is the one of the first times such analyses have been attempted within a geographic analysis context and based on national data. Two analytical techniques were assessed, and both appear to show sufficient promise and internal consistency to present exciting new possibilities for deriving information from conventional survey data that can be turned directly into targeted policy recommendations. Indeed a major function of this document is for it to be used to compile a formal livestock sector review and policy strategy document.

More conventional analyses have also been performed, which investigate the impact of livestock in relation to the forest vegetation – the primary subject of the ILUA survey. It is clear that high densities of livestock – both goats and cattle – are found in plots with reduced tree cover, and within forested areas, in areas with lower average DBH. There is little statistically valid evidence, however, that high livestock densities are found in areas of reduced regeneration, but rather in areas with fewer intermediate or large stems. This is due largely to the variability of the results, which precludes more detailed analyses. Livestock keeping, however, is a long established practice in Zambia and is associated with differential use of particular ecological conditions, so the results seen may also be a consequence of preferential use of certain types of forest land, rather than reflecting an actual impact of livestock keeping on the land cover characteristics.

The evidence for a detrimental impact of livestock on the more general environment is also weak: reduced soil fertility and increased erosion are reported more often where animals are more abundant, but the areas affected are smaller, suggesting that only the smaller holdings are adversely affected.

These analyses have also shown certain deficiencies in the data provided which have limited the analyses which are possible, and in particular the use of these data for producing new estimates of livestock populations for the country. Two gaps have proved particularly important. The first is that the denominators needed to convert recorded numbers of animals to densities or populations for wider areas have not been recorded and have had to be taken from different (and not necessarily compatible) datasets. Suitable denominators could either be the number of people or households within a defined area of land covering all or part of the sample tract. In future surveys, livestock and other data should be collected with modelling in mind – so that the most can be extracted from the survey.

In addition, it needs to be fully realised that livestock owners are not renowned for providing accurate estimates of their holdings to survey personnel, and that reliable figures cannot be obtained by 'add-on' questions to surveys of other parameters.

It may prove necessary to validate these estimates by visual inspection of the animals claimed, or by using additional, less direct techniques to acquire reliable numbers. One such is to use the female cow history approach pioneered by Cousins at ILCA (now ILRI) to assess livestock production parameters in addition to stock numbers. Whilst very labour intensive, it does provide the opportunity for stock owners to talk about their charges, and thereby to establish a degree of trust between livestock keeper and surveyor. Alternative techniques involve direct counting via aerial survey or integrated air and ground survey, as widely used in Botswana, South Africa, Kenya and West Africa.

The second deficiency – at least in the version of the database supplied to the consultants – concerns the treatment of blanks in the data, which can either be interpreted as zero or as missing data. This should be consistently one or the other for the whole database, and the assignation of known or inferred zero values should form part of the data entry and cleaning process, prior to analysis.

Some of the data are not internally consistent – for example net income from livestock can far exceed stated household income. Whilst this may not invalidate the analyses of a block of data within the same category (*e.g.* income and expenditure from livestock sales) it does invalidate the wider analysis of values derived from different blocks of information. Simple checks could be included with in the data entry procedures that could flag entries that 'do not add up'.

Despite these problems, the ILUA survey data are a goldmine of information that with careful filtering can provide a wealth of information about integrated land-use within Zambia. The current analyses have barely scratched the surface of what could be done if resources could be found to provide medium to long term analytical expertise. A number of topics can be identified as priorities for further investigation:

1) Cultivation and cropping have been completely ignored in the current analyses – and the three way interaction between forestry, livestock and cropping should be examined as a priority.

2) The relative contribution of sales of animals, products and services such as oxen to the household economy should be investigated in more detail with a view to better identifying those who are vulnerable or who are in the growth phases of rural economic development.

3) The analysis of household economies should be incorporated rigorously in these surveys – so that the relative contributions made by the different sectors (crops, livestock, forestry, handicrafts, retail, remittances, etc.) can be accurately evaluated. In particular there are a number of topics that could be investigated in more detail, using indicators that are used in other surveys. These include: household wealth indices; livestock production system descriptors such as grazing patterns, seasonal & additional feed sources; details of access rights both to grazing and to water, particularly of institutions involved;
and livestock use and consumption. Obtaining such information would, however, significantly increase the survey size and complexity, and may be better reserved for a specialist livestock survey.

4) The policy domain analysis could be substantially extended to incorporate more variables into the indices, and perhaps combined with parameters yet to be extracted from the forest and cropping sections of the database.

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7. Terms of Reference: Household Data Analysis Consultant - Integrated Land Use Assessment (ILUA) - Zambia

Objectives
Under the direct supervision of AGAL and FOMR (FAO) the household data analyst will provide technical assistance and support to the Forest Management and Planning Unit of the Forestry Department in: analysing ILUA household data and linking it to ancillary and ILUA geo-spatial data with special attention to pertinent livestock issues in Zambia.

Background
The Integrated Land Use Assessment (ILUA) in Zambia was initiated in 2005 with the aim of establishing a long term monitoring system to provide sound data on the status of forests, agriculture and livestock, including management, users and uses. The project is ongoing, with an expected completion date in April 2008. A land use/land cover map has been completed at 70 percent on the basis of nationally agreed terminology and harmonised national classification system. The establishment of permanent sample plots for land use resource monitoring and actual data collection was completed in December 2007. A template for a national ILUA database has been created and made available at the Zambian Forestry Department, and personnel have been trained in data entry and processing. Data entry has been completed and processing is ongoing. Policy analyses are currently being undertaken by national consultants with the objective to link the collected data to sectoral and inter-sectoral policies in collaboration with a national information and GIS consultant.

Mission
The household data analysis consultant is expected to complement his work with the above mentioned national consultants and generate statistical and relevant geo-spatial information based on ILUA household data, as well a final report with the focus on livestock issues.

Tasks
In collaboration with AGAL and FOMR (FAO) the subscriber/consultant will:
1. Review all relevant documentation; as provided in electronic format by FAO;
2. Validate and perform quality checks on the household survey database (perform any final cleaning required);
3. Compile and collate all available ancillary digital data relevant to the analysis (population/households; livestock; environmental data; livelihoods; land cover; and other data set that are found relevant);
4. Provide an organized and geo-registered spatial dataset of relevant data to Zambian counterparts;
5. Perform exploratory (internal) analysis of the household survey data in order to elucidate household typologies; livestock ownership patterns; and the role of livestock in livelihoods (as far as the available data can provide answers to these questions);
6. Analyse the household data and link them to the spatial data compiled in 3 and 4 above. The analysis should be done with pertinent policy issues in mind, as identified in collaboration with FAO staff and national consultants;
7. With AGAL and FOMR as intermediate link, liaise with the national policy analysts in Zambia;
8. Write report which should feed into the final national ILUA report and will include information outputs (in table and geo-spatial format) and pertinent recommendations for follow-up analysis by colleagues in Zambia.

FAO’s obligations
Project should provide the consultant with: a) all relevant documentation, including: questionnaires; field manual, reports to date, ToRs, etc. (well organized and clearly explained); b) cleaned database; c) whatever information is available on the distribution of households in Zambia; and e) any other relevant ancillary data that may be available, such as the most recent available Zambian livestock census breakdowns and matching administrative unit maps in digital format.

Duration
30 days.

Deadline
Draft report to be presented by the middle of April 2008 for FAO’s comments. Final report to be delivered by the end of April 2008.

8. OBJECTIVES OF ASSISTANCE PROVIDED BY THE TCP

The main objectives of the assistance rendered by the Technical Cooperation Project are set out below

i) Support land use institutions in developing their capacity to collect, compile, process and disseminate reliable and update information on land use to policy makers through training of national, provincial and district staff on land use assessments in line with new concepts and integrated approaches.

ii) Assist land use institutions in planning and carrying out a national integrated land use assessment, in order to develop up-to-date and sound baseline information on state, management and use of natural resources, thus setting up a long-term resources monitoring system.

As a result the project will:

(i) improve the capacity of land use institutions to plan and implement land use assessments, monitor the resources, manage the related information and contribute to enhance sustainable natural resource management;

(ii) define a national land use assessment methodology on the basis of the approach developed by the Support to National Forest Assessment programme of FAO and taking into account the criteria and indicators for sustainable natural resource management and the information needs for national use and international reporting;

(iii) set up of a monitoring system of land use resources and establish permanent registered sample plots for future surveys; implement the first nation-wide pilot integrated land use assessment by collecting base socio-economic and biophysical field data;

(iv) prepare an updated land use/cover map, based on nationally agreed terminology and national classification system;

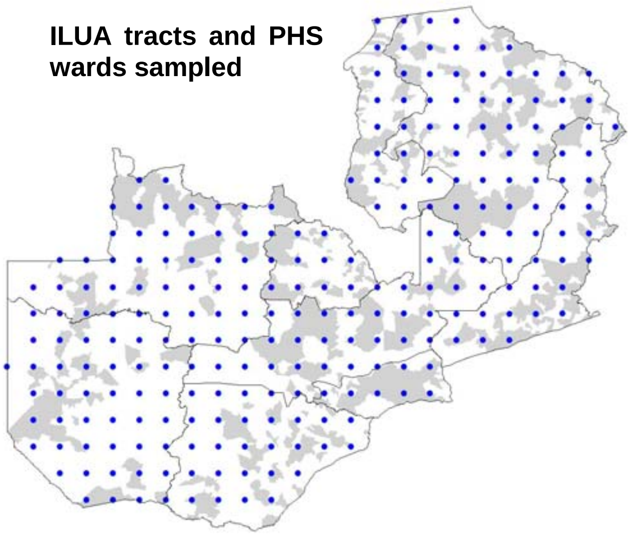
(v) establish a national database on the land use resources and integrate it in the existing data and information management systems based on the GIS;

(vi) define follow-up actions in the Zambia Forestry Action Plan and institutional development strategies on resource assessment; and

(vii) carry out cross sectoral policy analysis, review national priorities and report corresponding recommendations.

9. DATA SUPPLIED FOR ANALYSIS

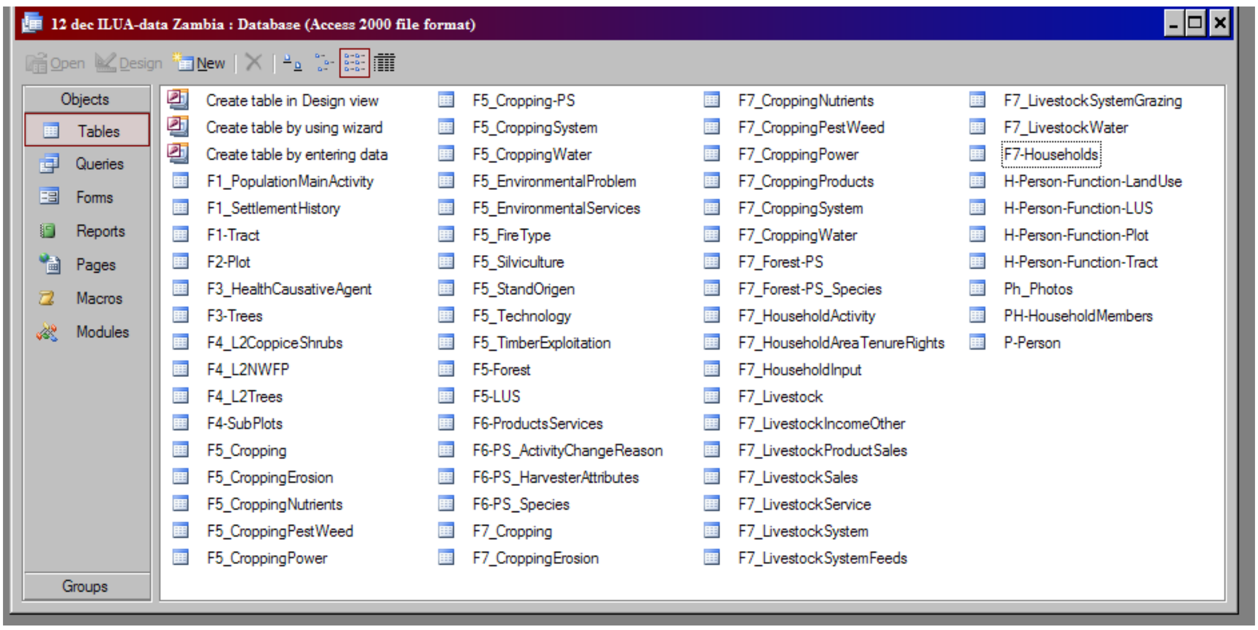
Post harvest survey household data



Extracts from a Post Harvest Survey (PHS) were supplied as an additional source of livestock counts for a sample of wards. Some 3300 households were surveyed, and numbers of all livestock recorded. Wards were coded and named within the database, to allow mapping using a Zambia wards polygon file also supplied. An Adobe pdf of ward population by name was also supplied, and provided a source of ward household numbers that could be extracted to Microsoft compatible format (using manual cut and paste) then matched to the polygon file names to provide a means of calculating ward livestock populations from the PHS livestock per household. These are provided in spreadsheet *\maps\strata\zambwardliv.xls*, which can be joined to shape file *zambia_wards* using the *ID_* column

Integrated Land Use Assessment data

The main ILUA database consists of a relational Access database containing 60 tables, in ten categories as displayed in the screen shot of the opening database screen, below.



The household data for the 248 tracts are contained within the 'F7' group of tables as shown in the following pages. The Forestry and Land Use data analysed in Section 5 are part of F3 (F3 Trees) , F4 (F4 Subplots) and F5 (F%-LUS) groups.

1. **ILUA Zambia** **F7a**

2. **Tract N°** ……. **Household N°** …… **HOUSEHOLD**

200. **Enumerator (s)**……………………………

A. General information on the household

201. **Household N°** [ ] 202. **Village**…………… …………………. 203. **Distance to tract** __ __, __Km

A1. Household composition

Household composition					
204. **Member name**	205. Relationship to Head	206. Sex	207. Age	208. Education	209. Respondent
	C	M/F		Y/N	

A2. Household activities

	210a. Activities		210b. **Main activity**
	1	Crop production	
	2	Livestock/ Herding	
	3	Forestry	
	4	Urban/ Peri-urban	
	5	Tourism	
	6	Fishery	
	7	Mining/extraction	
	Others	Others	

A3. Total annual household income

	211. *Total household income*	
	1	< 100,000 ZKW
	2	100,000 – 500,000 ZKW
	3	500,000 – 1,000,000 ZKW
	4	1,000,000 – 5,000,000 ZKW
	5	≥ 5,000,000 ZKW

A4. Distribution of agricultural area and land tenure

Category	**Total area (ha)**	273. *Land tenure*: 1. Title	2. Customary	3. Rent	99. Other:
270. Agricultural land					
271. Crop land					
272. Fallow					

A5. Value of inputs including labour during the last 1 year

	226. *Input category*		227. **Expenses** ('000 ZMK)
	1	Hired person, labour	
	2	Feeds, fodder, etc	
	3	Veterinary fees, drugs, vaccinations, etc	
	4	Tools	
	5	Spareparts, maintenance of machinery, housing, etc.	
	6	Hiring of power sources: animals, machinery, etc.	
	7	Transport, storage, etc.	
	8	Herbicides, pesticides, fertilizer, etc.	
	9	Irrigation facilities	
Other			
Total expenses			

CROPPING

B1. Crop products

146. Product category	147. Product ranking	151. Number of fields	152. Total area	153. End-use	154. Income
C			ha	C	'000 ZKW
Total income **					

B2. Crop production system

	140. *Cropping system* *	
	1	Multiple cropping
	2	Improved cultivars
	3	Crop rotation
	4	Fallow
	90	Not known
Other		

	141. *Water* *	
	1	Rain fed
	2	Irrigation - manual construction, gravity fed
	3	Irrigation - major equipment
	4	Adequate drainage of excess water
	90	Not known
Other		

	142. *Nutrients* *	
	1	Adequate fallow
	2	Organic fertilizer
	3	Mineral fertilizer
	90	Not known
Other		

	143. *Pest / Weed* *	
	1	Pesticides
	2	Fungicides
	3	Herbicides
	4	Mechanical control
	5	Biological control
	90	Not known
Other		

	144. *Erosion* *	
	1	Tillage
	2	Crop residue incorporation
	3	Cover Crops
	4	Leveling, contour tillage, terracing
	90	Not Known
Other		

	145. *Power Sources* *	
	1	Manual
	2	Animal
	3	Mechanized means
	90	Not known
Other		

155. *Notes (cropping)*:……………………

……………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Multiple choice possible* * To be calculated by the enumerator*

1. **ILUA Zambia** **F7b**

2. **Tract N°** .... **Household N°** …… **HOUSEHOLD**

LIVESTOCK

C1. Livestock production system

Livestock category			Cattle	Sheep	Goats	Pigs	Poultry	Other
220. **Grazing***	Common grazing							
	Fenced unimproved							
	Fenced improved							
	Tethering							
	Zero grazing							
221. **Feeds***	Crop residues							
	Fallow land for grazing							
	Specific fodder							
222. **Housing**	Livestock housing at night							
223. **Breeds**	Share of local breeds	%						
Management	224. **Decisions**	C						
	225. **Herder**	C						

C2. Accessibility to services

Service category		228. Did you use it?	229. Do you need it?	230. How accessible is it ?	231. How far?
		Y/N	Y/N	C	Km
1	Credit services				
2	Extension services				
3	Veterinary services				
4	Veterinary drugs				
Other					
Other					
Other					

C3. Accessibility to water resources

Water source type*		*Dry season*		*Wet season*	
		232a. Access	233a. Distance	232b.Access	233b. Distance
			Km		Km
1	Well				
2	Natural (river, stream, lake)				
3	Dam				
4	Borehole				
5	Seasonal drinking water				
6	All weather drinking water				
Other					

C4. Total sales of livestock, poultry and bee-keeping products (last one year)

234. Products		234b. Unit of quantity	*Dry season*			*Wet season*		
			235a. Quantity sold	236a. Income from sale	237a. Ranking importance	235b. Quantity sold	236b. Income from sale	237b. Ranking importance
				'000 ZMK	C		'000 ZMK	C
1	Meats							
2	Milk							
3	Butter and cheese							
4	Eggs							
5	Hides and skins							
6	Honey							
Other								
Other								
Other								
Total income								
Sum income (dry + wet)**								

C5. Income received other than through sale of products in last one year

238.Income*		239. **Value** ('000 ZMK)
1	Hire of draft power	
2	Rental of bulls	
Other		
Other		
Total income**		

240. *Notes (Livestock):* ……………………………………

…………………………………………………………………

…………………………………………………………………

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…………………………………………………………………

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* *Multiple choice possible*   ** *To be calculated by the enumerator*

1. **ILUA Zambia** F7c

2. **Tract N°** ……. 201. **Household N°** …… **HOUSEHOLD**

C6. Total sales of poultry and livestock during the last 1 year

				Inputs				*Output*						
241. **Livestock type**		242. **Unit of quantity**	243. **Current stock**	244a. **Purchased quantity**	244b. **Expense of purchase**	245. **Born**	246. **Gifted in**	247. **Died**	248. **Stolen**	249. **Consumed**	250. **Gifted out**	251a. **Sold quantity**	251b. **Income from sale**	252. **Opening stock**
		C	Unit	Unit	'000 ZMK	Unit	Unit	Unit	Unit	Unit	Unit	Unit	'000 ZMK	Unit
1	Cattle -Young stock													
2	Cattle - Weaners male													
3	Cattle - Weaners female													
4	Cattle - Adult male													
5	Cattle - Adult female													
6	Cattle - Oxen													
7	Sheep													
8	Goats													
9	Pigs													
10	Chicken - Layers													
11	Chicken - Broilers													
12	Chicken - Free range													
13	Turkeys													
14	Ducks													
15	Other poultry													
16	Guinea pigs													
17	Rabbits													
Other														
Other														
Other														
Other														
Other														
Other														
		Total expenses **							**Total income ****					

** Multiple choice possible* *** To be calculated by the enumerator*

1. **ILUA Zambia** **F7d**

2. **Tract N°** .... 201. **Household N°** …… **HOUSEHOLD**

P…./….

FOREST AND TREE PRODUCTS AND SERVICES

															Extraction			*Legislation*		*Forestry incentives*	
80. Land Use / Forest type	99. Product /Service category	99a. P/S Rank	111a. Species Rank	111. Species	104. Conflicts	105. Demand trend	106. Supply trend	103. User rights	102. End-Use	262. Income from P/S	101b. Organization level	101c. Gender balance	101d. Child labor	261. Distance to the P/S	108. Frequency	109. Trend	110. Change reason	101e. Awareness	101f. Compliance	101g. Awareness	101h. Application
C	C	C			C	C	C	C	C	'000 ZMK	C	C	C	Km	C	C	C				
			H																		
			M																		
			L																		
			H																		
			M																		
			L																		
			H																		
			M																		
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			L																		
			H																		
			M																		
			L																		
			H																		
			M																		
			L																		
Total annual income from P/S (to be calculated by interviewer/enumerator)																					

68. Notes: ....

10. PREDICTOR AND SPATIAL DATA DATASET DETAILS

All data and maps are provided as a downloadable file *faozambiailuaergo.zip. For data security, the the full URL is not provided here, but has been supplied to the project, or can be obtained from the second author.* ***The file should be unzipped with the use folder option box checked to maintain the folder structure described below.***

Table 3 lists the data and GIS files supplied for download. All are in the folder ***nfa.*** ESRI rasters are also provided with corresponding layer (lyr) files to give the classification and symbology used

Table 3: Data and Maps

Subfolder	Name	extension	filetype	Description
predimg	z5predimg	zip	Archive	Idrisi Format raster images of predictor archive, See predictor data worksheet for names
	z5varall	sav	SPSS data	SPSS datafile of predictor values for each ILUA tract
strata	zgsere5k	folder	ESRI raster	Sere and Steinfeld Prodiction Systems. Legend in af_fsys2000.dbf
	zgglc2k	folder	ESRI raster	Global Land Cover 2000, legend in Africa_v3_legend.dbf
	z5msk1	folder	ESRI raster	Country mask
	zambia_wards	shp,dbf,shx,	ESRI shape	zambia wards with population for 2000
	zambwardliv	xls	excel	PHS ward livestock, indexed to Zambia_wards
	zamprov	shp,dbf,shx,	ESRI shape	Province
	Zambtract	Xls, dbf	Excel & DBF	Tract values for forest and environment analyses. Dbf for mapping in ArcGIS, xls with additional worksheets with columns names
glw	zgglwchdn	folder	ESRI raster	FAO Gridded Livestock of the World Chicken Density (modelled)
	zgglwctdn	folder	ESRI raster	FAO Gridded Livestock of the World Cattle Density (modelled)
	zgglwgtdn	folder	ESRI raster	FAO Gridded Livestock of the World Goat Density (modelled)
	zgglwshdn	folder	ESRI raster	FAO Gridded Livestock of the World Sheep Density (modelled)
	zgglwpgdn	folder	ESRI raster	FAO Gridded Livestock of the World Pig Density (modelled)
	zglwcppc	folder	ESRI raster	FAO Gridded Livestock of the World Crop Percentage (modelled)
	zgglwlgp	folder	ESRI raster	FAO Gridded Livestock of the World Length of Growing Period (modelled)
	zgpxmsuitmg	folder	ESRI raster	FAO Gridded Livestock of the World Suitability for monogastrics (modelled)
	zgpxmsuitrum	folder	ESRI raster	FAO Gridded Livestock of the World Suitability for ruminants (modelled)
poldom	cred	folder	ESRI raster	access to credit (modelled)
	adrugs	folder	ESRI raster	access to drugs (modelled)
	aext	folder	ESRI raster	access to extension services (modelled)
	afeed	folder	ESRI raster	access to feed (modelled)
	aland	folder	ESRI raster	access to land (modelled)
	avet	folder	ESRI raster	access to veterinary services (modelled)
	diversity	folder	ESRI raster	diversity of occupation (modelled)
	ls-purch	folder	ESRI raster	expense from livestock purchase (modelled)
	growth	folder	ESRI raster	conditions for growth map (modelled)
	growth-q	folder	ESRI raster	quartiles of conditions for growth map (modelled)
	grow-vuln	folder	ESRI raster	combined growth and vulnerability index (modelled)
	vuln	folder	ESRI raster	vulnerability map (modelled)
	vuln-q	folder	ESRI raster	quartiles of vulnerability map (modelled)
	lid	folder	ESRI raster	Livestock Intervention Domains
ilualiv	phh-cattle	folder	ESRI raster	percentage of households that are cattle owners (modelled)
	phh-chick	folder	ESRI raster	percentage of households that are chicken owners (modelled)
	phh-goats	folder	ESRI raster	percentage of households that are goat owners (modelled)
	phh-pigs	folder	ESRI raster	percentage of households that are pig owners (modelled)
	phh-ls-act	folder	ESRI raster	percentage of households where livestock is the main activity (modelled)
povinc	z5havinc	folder	ESRI raster	average household income (modelled)

Table 4 details the predictor archive properties – filenames, sources, data type and units and processing type and personnel. These are all provided in ArcGIS 9.2 compatible format raster images The images are at 5km resolution and are all contained in a Winzip archive: *\nfa\maps\predimg\z5predimg.zip*.

Table 4: Predictors and Stratification Criteria

Predictor Variable	Filename	Units	Source	Processing
Evapotranspiration	z5ep*	Scaled,	VGT4AFRICA, Vito Belgium	Fourier, by SEEG and ERGO[1]
Precipitation	z5pp*	mm	VGT4AFRICA, Vito Belgium	Fourier, by SEEG and ERGO[1]
Normalised difference vegetation Index	z515*	Scaled index	MODIS, NASA	Fourier, by SEEG and ERGO[1]
Enhanced vegetation index	z514*	Scaled index	MODIS, NASA	Fourier, by SEEG and ERGO[1]
Night Land Surface Temperature	z508*	Scaled Temperature	MODIS, NASA	Fourier, by SEEG and ERGO[1]
Day Land Surface Temperature	z507*	Scaled Temperature	MODIS, NASA	Fourier, by SEEG and ERGO[1]
Middle Infra Red	z503*	Scaled Temperature	MODIS, NASA	Fourier, by SEEG and ERGO[1]
Length of Growing Periiod	z5lgprc	Days	MODIS, NASA	Modelled, by ERGO
Human Population density	z5gpw3dn	Density/sq km	Global Population of the World, CEISIN	None
Longitude	xll	Degrees		None
Latitude	yll	Degrees		None
Elevation	z5strm1k	Meters	Shuttle Radar Topography Mission, NASA	None
Slope	z5slpll	index	Shuttle Radar Topography Mission, NASA	Derived by ERGO
Distance to Roads	z5rdsdg	degrees	Derived from Roads layer in Landscan Dataset	Derived by ERGO
Distance to Nighttime lights	z5lgtdg	degrees	Derived from Nighttime lights layer in Landscan Dataset	Derived by ERGO
Distance to Rivers	z5rvdg	degrees	Derived from USGS Hydro1k datasets	Derived by ERGO
Probability of Presence of Glossina morsitans	z5mor1K	Probability	Data produced for FAO PAAT and IAEA	Modelled by ERGO
Probability of Presence of Glossina pallidipes	z5pald5	Probability	Data produced for FAO PAAT	Modelled by ERGO
Probability of Presence of Glossina fuscipes	z5fscm5	Probability	Data produced for FAO PAAT	Modelled by ERGO
Small water bodies 2001	z5swbp1	Proportion of year with water	VGT4AFRICA, Vito Belgium	Derived by ERGO
Small water bodies 2002	z5swbp2	Proportion of year with water	VGT4AFRICA, Vito Belgium	Derived by ERGO
Small water bodies 2003	z5swbp3	Proportion of year with water	VGT4AFRICA, Vito Belgium	Derived by ERGO
Small water bodies 2004	z5swbp4	Proportion of year with water	VGT4AFRICA, Vito Belgium	Derived by ERGO
Chicken Density	z5glwchdn	density per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Pig Density	z5glwpgdn	density per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Sheep Density	z5glwshdn	density per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Goat Density	z5glwgtdn	density per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Cattle Density	z5glwctdn	density per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Cropping Percentage	z5lwcppc	% per sq km	FAO Gridded Livestock of the World	Modelled by ERGO
Stratification Variables				
Ecozone	z5ptez	Code	FAO PAAT	Generated by ERGO
Agroecozone	z5lgpcd	Code		Classified by ERGO
Farming System	z5sere	Code	FAO LEAD	Classified by ERGO
Land Use Type	z5lccd	Code	Global Land Cover 2000, JRC, Ispra	Classified by ERGO

[1]: See Tables 5 for Fourier Variable scaling and Table 6 for Fourier Variable naming conventions

Table 5: MODIS Image Values, Rescaling Criteria

Parameter	Fourier Variable	Image values are
MIR (03)	A0, A1, A2, A3, Min, Max, Var	Reflectance values * 10000
LST (07,08)	A0, A1, A2, A3, Min, Max, Var	(Degrees Centigrade+273)*50
NDVI (14) and EVI (15)	A0, A1, A2, A3, Min, Max,	Index Value * 1000
ET	A0, A1, A2, A3, Min, Max,	Mm/10days
NDVI (14) and EVI (15)	VAR	Value * 10000
ALL	D1,D2,D3,Da	Percentages
ALL	E1,E2,E3	Percentages
ALL	P1,P2.P3	Months*100. (Jan=1)

Table 6:MODIS image files, Naming conventions.

A) Fourier Processed Files: ABCDEEPP.EXT.

A Location	B Projection	C Start Year	D End Year	EE Climate Parameter	FF Fourier Variable and Component	EXT File Type
Z= Zambia	G=Geographic S=Modis Sinusoidal	0=2000	5=2005	03=MIR	A0=Mean	RST, RDC = Idrisi raster and document files
		1=2001		07=dLST	A1,2,3=Amplitude	IMG=ERDAS Imagine raster
				08=nLST	P1,2,3=Phase	
				14=NDVI	D1,2,3=Proportion total variance from each Component. DA=All	
				15=EVI	MN, MX, RN=Min, Max, Range	

The data are also provided as a flat file (see Section 3), in SPPS format with predictor values extracted for each ILUA Tract location (*\nfa\maps\predimg\z508varall.sav*). This file also contains the tract values for target variables subjected to the modelling procedures with variable names as detailed in Table 6.

11. SUGGESTED POLICY REPORT STRUCTURE

Running Title: <u>The livestock sector and sustainable pro-poor growth in Zambia</u>

1. Introduction

Sustainable pro-poor growth = growth + poverty reduction + environmental conservation
Livestock important in all of these, therefore must be involved in sustainable pro-poor growth.
Failure of technical programmes (not sustainable, limited coverage, etc.) therefore policy/institutional approach must be followed.
Livestock development domains and policy framework
report outline: three noble development objectives (growth, poverty reduction and env. protection)

2. The livestock sector in Zambia

status (distribution, livestock production systems)
government objectives (PRSP etc.) the policy and institutional context
national, regional and global trends and how these may be affected by population growth, climate change etc.

3. Livestock and economic growth

3.1. Contribution made by livestock

trade / GDP etc

3.2. Constraints to optimising the contribution of livestock

trade restrictions, market opportunities, diseases of trade? ....

3.3. What can be done about it

Policy domain	*relevance*
reducing vulnerability	
creating conditions for growth	++
sustaining growth	+++

changing institutions, adjusting policies, monitoring indicators, building capacities etc.

4. Livestock, poverty reduction and food security

4.1. Contribution made by livestock

where are the poor ... where are the l/s-dependent poor ...

4.2. Constraints to optimising the contribution of livestock

access to services, access to resources etc.

4.3. What can be done about it

Policy Domain	*relevance*
reducing vulnerability	+++
creating conditions for growth	++
sustaining growth	

changing institutions, adjusting policies, monitoring indicators, building capacities etc.

5. Livestock and natural resources

5.1. Livestock and the environment

positive impacts on agricultural production
negative impacts on GHG contributions, nutrient loading, land degradation

5.2. Integrated land use assessment

relationships between livestock, land use and forestry

5.3. How can things be improved

changing institutions, adjusting policies, monitoring indicators, building capacities etc.

6. Conclusions

7. References

8. Annexes