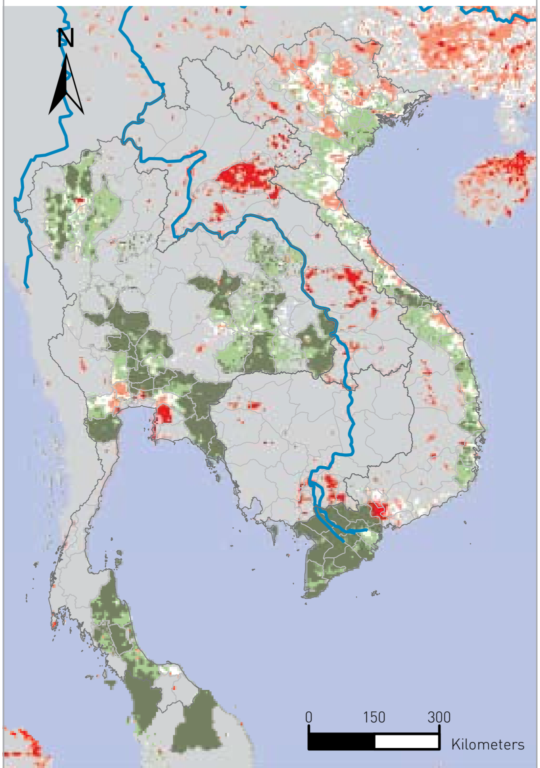
7.26 NUTRIENT LOADING DUE TO LIVESTOCK IN THE MEKONG REGION



Source: Adapted from Gerber *et al.*, 2005.

significance of countries will depend on the relative size of their livestock populations. Although this may under-estimate particularly high- or low-risk zones, it avoids the under-representation of some endemic countries with large livestock populations. Focusing on the application of annualized incidence rates may mask particular risks from antigenic divergence – the risk of 'exotic FMD types' – but more systematic study may reveal patterns of emergence that would refine risk assessment.

The global spread of bird 'flu

Animal density maps may be also used as an aid in interpreting disease distributions. Many epidemiologists, governments and the public in general closely followed the spread of bird 'flu from Southeast Asia during 2005 and 2006. A very widely available example is the use of the GLW poultry layers as a backdrop to the maps of disease outbreaks in poultry, made available via Google Earth by Declan Butler[48] (shown in Figure 7.25). This clearly illustrates the coincidence of poultry outbreaks in the Near East, West Asia and Africa with high poultry densities.

ENVIRONMENTAL IMPACT ANALYSIS

Livestock affect the environments they inhabit in a variety of different ways, for example, through overgrazing and soil erosion; production of methane and other greenhouse gases; nutrient recycling in extensive systems; excessive nutrient concentrations in the effluent from intensive systems; influence on land use; and displacements of wildlife. Efforts to quantify and monitor these effects can only be successful if estimates of livestock numbers are both reliable and available at appropriate resolutions.

The FAO Livestock, Environment and Development initiative[49] explores many aspects of the impact that livestock have on the environment (FAO, 2006a). For example, recently published studies (Gerber *et al.*, 2005) have provided nutrient balance maps of the Mekong region of Southeast Asia, using phosphate as an indicator. Estimated excretion values per animal for each species were applied to the livestock-density distribution models to provide an index of livestock-generated phosphate per square kilometre. A similar procedure was used to estimate phosphate uptake by crops. An input value was calculated for the rate of fertilizer application, by apportioning national fertilizer use only to regions supporting high-yielding crops, as indicated by subnational cropping data. The three

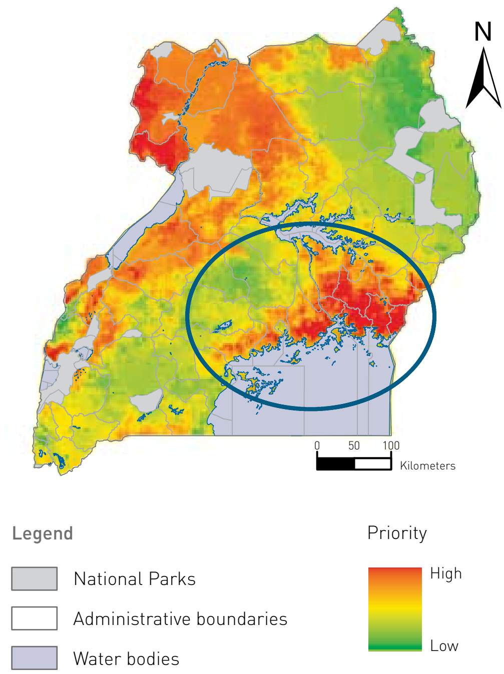
[48] http://declanbutler.info/flumaps1/avianflu.html
[49] http://www.lead.virtualcentre.org

TABLE 7.4 CRITERIA WEIGHTS FOR SELECTING PRIORITY AREAS FOR TRYPANOSOMIASIS CONTROL IN UGANDA

Factors	Weights
Density of the poor livestock keepers	0.2562
Trypanosomiasis risk index	0.5030
Length of growing period	0.0559
Cattle density	0.1546
Percentage crop cover	0.0304

Source: FAO, in preparation.

7.27 TRYPANOSOMIASIS CONTROL PRIORITY MAP FOR UGANDA



Source: FAO, in preparation.

components were then combined to estimate the phosphate balance. Areas of nutrient overloading were identified using the phosphate balance model. Then, by combining this with gridded livestock distribution data, it was possible to assess the relative contribution to nutrient loading made by livestock species, as illustrated in Figure 7.26.

SPATIAL TARGETING OF INTERVENTIONS

Many of the examples given above will be implemented to aid decision-making, for example, by field operatives and policy-makers. This will be done mostly with some component of spatial targeting, for example, where disease interventions might be best placed, or where it might be most important to mitigate environmental impacts. In this final example, it is demonstrated how such spatial targeting can be taken a step further by incorporating livestock data with other relevant spatial information in a decision-support model.

In planning trypanosomiasis control, two overriding questions are essentially involved: how to control, and where to prioritize efforts. The answer to the first depends on a multitude factors, such as the relative costs of different interventions, whether the objective is to control the disease or to eliminate the vector, and the local disease epidemiology and biology. To answer the second question requires a very clear objective, and the decision criteria will be often determined by economic rather than technical considerations. In Uganda, as in a number of other African countries, renewed efforts are being made to control trypanosomiasis, influenced largely by the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC), which advocates wide-scale eradication of tsetse. Whichever methodology, or combination of technologies, is ultimately used to intervene there is a clear need to target interventions appropriately.

In a collaborative project between the Coordinating Office for the Control of Trypanosomiasis in Uganda, FAO and ILRI, a multicriteria evaluation technique – weighted linear combination – was used to combine relevant spatial data to identify priority areas 'to control animal trypanosomiasis for the alleviation of poverty' (FAO, in preparation; and see Robinson *et al.*, 2002, for a detailed description of the methodology). Five relevant criteria were created and digitized to produce standardized maps for GIS analysis: (i) density of poor livestock keepers; (ii) trypanosomiasis risk index; (iii) LGP;

(iv) cattle density; and (v) percentage crop cover (details on how these were produced are given in FAO, in preparation). Weights were assigned to these criteria by decision-makers and other stakeholders in the livestock sector in Uganda, through an iterative process of workshops. A set of consensus weightings was eventually reached, as shown in Table 7.4.

The priority map given in Figure 7.27 was produced by summing the weighted input criteria.

A precursor to the map in Figure 7.27 was used to help target PATTEC interventions in Uganda: the red areas (high priority) contained within the blue ellipse in Figure 7.27 were selected as the zone where the initial activities would be implemented. Further GIS analysis reveals that this area contains some 754 000 head of cattle and a rural human population of some 5 million, of which about 2.6 million live below the US$ 1 per day threshold. Hence one can start to use these data to estimate the types and magnitude of impacts that might be achieved by targeted interventions.

8 Challenges and future directions

In its many forms, livestock production is an important component of most agricultural economies. Yet the livestock sector is frequently marginalized in terms of development priorities and allocation of resources, despite the ever-present media headlines highlighting the possible dangers of mad cows, FMD, bird 'flu and other emerging zoonotic diseases. The sector, particularly in low-income countries, is frequently perceived as intractable, dispersed and often located in the most remote rural areas away from towns and administrative centres – and therefore difficult to enumerate, monitor and develop effectively.

The production of digital livestock maps has opened up exciting possibilities, and will allow for a number of types of analyses that, until now, have been difficult if not impossible to carry out. Whilst such maps are a significant step forward in making global livestock statistics available, there are several priorities for further investigation and development.

It is quite clear from a detailed inspection of the metadata accompanying the GLIS that there is enormous variability in spatial resolution and species definition (particularly of poultry), and a wide range in the date of origin of the input data. It is to be hoped that increasing automation of the data management and modelling process will facilitate much more frequent updates, so that in due course new census or survey data can be incorporated into the Oracle database as the information becomes available and all products updated automatically. In reality there are likely to be delays as a result of validation and data cleaning procedures that tend to be specific to each data source. However, as subnational data reporting becomes more common, so the data formats should become more standardized

It is also quite clear that the modelling approaches used here are better suited to some species and production systems than to others. The origins of this environmental approach to livestock distribution modelling are to be found with cattle populations in Africa, where production is closely coupled with the land and such approaches are highly appropriate. In marked contrast, for example, are the often land-detached intensive poultry production systems of Europe and North America, for which environmental approaches are likely to be less well suited.

One province of Germany, for example, contains 3 million chickens; half a million are distributed among 'smallholders', for which this approach to distribution mapping is appropriate, but the remaining 2.5 million are held on only two farms. While a comprehensive map may try to integrate these two types of distribution by using environmental modelling overlain with 'raw' high-resolution data for the intensively reared populations, it may prove more appropriate to map populations from the two systems separately. The problem, however, lies in the level of detail in the reported data, which often precludes making such important distinctions.

Access to better data may mean that other methods, such as the United States Department of Agriculture's Farm Animal Demographics Simulator (FADS) (Freier *et al.*, 2007), could be used to disaggregate livestock in intensive holdings. The basic concept of FADS is to take an area, such as an administrative boundary, for which livestock population data are available and then to remove spatially all areas where the commodity in question would not be found (e.g. lakes, rivers, wetlands, parks, nature reserves, military land, and so on) – in much the same way that unsuitable areas are masked in the GLW process. Farms are then distributed in the remaining area, based on a series of weighting factors that are known to influence their location, such as road access (weighted in terms of suitability for large vehicles delivering feed or transporting live animals) and distance from cities (i.e. markets). Other factors that may relate to the location of farms producing particular commodities are included in the model as they become available.

While Table 6.1 shows that there is already good coverage of the major species and species groups, this could still be improved upon. Broader species coverage would include, for example, yaks, camelids and equines, and use a more consistent definition of the various poultry species. Similarly it would be desirable to have a much better definition of farm types (for reasons discussed above), distinguishing at least between smallholder and industrial production. These distinctions are beginning to be made, inasmuch as a number of countries already provide separate estimates of traditionally managed and 'other' livestock.

From a purely technical perspective, priority must be given to migrating towards a consistent 1 km resolution global (rather than continental) product. That is not to say that in all cases this increased spatial resolution would be reflected in the accuracy of the predictions, where mostly the limiting factor is the quality of the input data and the validity of the statistical model, but there are a number of technical reasons why this is important. First, it would allow us to take advantage of new high-resolution global datasets that may be used for suitability masking and distribution modelling (see, for example, Hay *et al.*, 2006). Second, it would improve the accuracy of the land area estimates, and result in closer correspondence between the raster data and the vector administrative boundary data – all resulting in more accurate livestock density estimates. Third, a single global product would facilitate analysis in relation to the rising number of other standard global 1 km products, and also facilitate automation of the modelling process and therefore the frequency of updates.

Perhaps the most pervasive challenge is to change the target resolution of annual international reporting requirements of agriculture ministries and statistical departments from national to subnational, allowing statistical modelling techniques to be regularly applied to update livestock distribution maps. Such information is usually available from agricultural censuses, and would require a fairly modest investment of resources into the acquisition, collation and analysis of existing data (such as those 'buried' in hard-copy census reports). Many countries now produce detailed digitized subnational agricultural census data (e.g. Brazil, Mexico, the United States) that would require only minimal processing in order to incorporate them into a global subnational resolution archive.

The reporting of subnational data to international agencies by networks would pay immediate dividends, provided, of course, such information was reliably geo-referenced. Some attention should also be given to assessing less credible statistics from regions for which conventional census techniques are inappropriate, and, perhaps, through a limited and carefully targeted monitoring and validation programme. FAO's CountrySTAT[50] is a pilot project launched by FAOSTAT to provide countries with methodologies for compiling, verifying, validating, organizing, analysing and disseminating subnational data related to agriculture and food for the purpose of facilitating data use by national policy-makers and researchers. It is well placed to be the start of such a system, and the data collected could be greatly enhanced by the modelling techniques described here.

Such an initiative, with regular updating and the inclusion of reliability statistics, would provide better livestock-related information for inclusion in poverty, food security and environmental assessments of the type described here. It would also increase the reliability of disease-risk mapping and benefit-cost analysis of disease-control measures.

To date, most attention and effort in livestock mapping has focused on animal numbers or densities, yet their economic importance relates mainly to the value of their products and services. Tentative first steps have been taken in mapping production of cattle meat and milk, but these efforts

[50] http://www.fao.org/es/ess/countrystat/

need to be improved upon and extended to include other species and products and to account for spatial mosaics of livestock production systems.

Livestock must eat to survive and in doing so often eat fodder grown on land that could equally well produce crops that people could eat. There is a potential conflict between land-use for producing animal feed versus its use directly for human food production, especially in ecologically marginal areas with large human and/or livestock populations, but where access to imported feed supplements is limited. Such areas can only be quantified and located if reliable information about livestock numbers, cropped areas and human population density is available at high spatial resolution.

Interactions between animal husbandry and other aspects of agricultural production and renewable natural resources utilization are intimately bound up with and, to a large extent, driven by, economic and social factors that have been largely ignored or avoided by quantitative livestock geography. Until these key elements of animal agriculture can be integrated effectively into a single quantified and geo-referenced framework, monitoring and evaluation of the sector will remain problematic.

As global spatial datasets are now more widely available and diversified, including information on topography, climate, vegetation, land-use, people and livestock, the characterization and mapping of agricultural production systems have become an expanding area of study. There is a real danger, however, that definitions will proliferate and cause confusion rather than clarity, unless a coordinated approach is adopted and objectives are clarified. The increasing availability of quantitative information means that the definition of farming systems can be driven by both quantitative and qualitative data, thereby moving towards higher-resolution mapping rather than the production of homogenous polygons that obscure local heterogeneity.

Much of the preceding discussion has (intentionally) sidestepped the fact that, in many parts of the world, the livestock sector is in a state of flux. Industrial production of pigs and poultry is increasing rapidly in the developing world, de-coupling the traditional association between land resources and livestock numbers because large-scale production units are often sited more for efficient access to inputs and transport of products than in terms of land suitability and availability of local natural resources. In contrast, the demand for meat from extensively reared stock is increasingly rapidly in much of the industrialized world.

Furthermore, while human populations and demand for livestock products increase relentlessly, with the accompanying urbanization of human populations and intensification of production, climate change may be about to reshape the agricultural (crops and livestock) geography of the planet. To these trends must be added the inevitable effects of globalization on the movements of animals and foodstuffs, and the spread of existing livestock diseases and the emergence of new ones.

Locating and mapping these trends is crucial to providing adequate decision support for strategic planning, but little has been achieved in these areas to date. The mapping of landless livestock and intensive production units, primarily for pigs and poultry, is crucial to quantifying such trends and, as discussed above, has yet to be adequately addressed, at least at the regional and global levels. This topic's importance is highlighted by the recent realization that the coexistence of traditional and intensive modes of production in urban and peri-urban areas is an increasing cause for concern, as the epidemiological significance of this proximity becomes more apparent and critical to the emergence and spread of zoonotic diseases.

The establishment of the GLIS at FAO represents an important advance in the automation of livestock data acquisition, distribution modelling and dissemination. However, substantially more will need to be done to encourage feedback from national data providers, not only to assess the validity of the outputs but also to return the data with some value added and promote wide interest and use of the global resources to which they have contributed.

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