7 Applications

The spatial nature of these livestock data lends them uniquely to a wide array of applications. In essence, livestock distribution data provide the fundamental units for any analysis involving whole animals: for estimating production they provide the units to which production parameters may be applied; for evaluating impact (both of and on livestock), any number of different rates might be applied; and for epidemiological applications they provide the denominator in prevalence and incidence estimates, and the host distributions for transmission models. The range of potential applications of livestock distribution maps is boundless, but the following sections present just a few examples.

LIVESTOCK BIOMASS

Livestock populations are usually defined in terms of the number of individuals of a particular species in a given administrative region, or as standardized densities per unit area. The combination of individual species maps into an overall map of livestock distribution calls for the conversion of animal numbers into standard units of livestock biomass.

An example is given for the Mekong Region in Figure 7.1, wherein the distributions of cattle, buffaloes, small ruminants, pigs and chickens have been combined into a single map of livestock biomass measured in standard livestock units of 250 kg. In this case, livestock densities have been multiplied by animal live weights derived from FAO country-level estimates of carcass weights.

From maps such as these, the relative importance of monogastric species, for example, as opposed to ruminants, can be more confidently assessed. A single measure of livestock distribution also makes comparisons with other agricultural sectors and other regions easier.

Whilst one can envisage the value in combining ruminant species into a single composite value, for example, to estimate overall grazing pressure per unit of land, the value of combinations of species as disparate as cattle and chickens is less clear.

LIVESTOCK PROJECTIONS

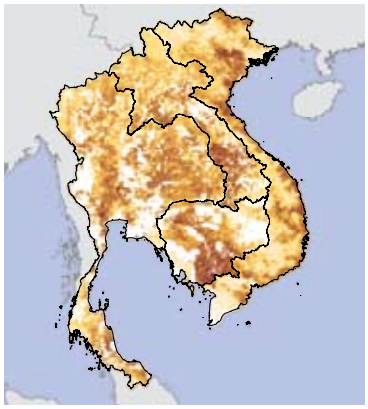
The livestock distribution maps presented here are snapshots in time, although in reality livestock populations are not static. The most reliable way of assessing likely changes in livestock populations is to measure them through repeated surveys. However, given that such frequent data are rarely available, estimates need to be made. Projected changes in livestock population levels are regularly provided by FAO at the country level (see, for example, FAO, 2003). Whilst these values could be applied directly to modelled distributions, they would not reflect any change in the distribution of populations. To estimate re-distribution would either require the use of models of livestock spread (described below) or call for the linking of re-distribution to better-known parameters for which projections are available. In addition, given the close links between livestock distribution and environmental conditions, the potential effects of climate change should also be incorporated into medium- and long-term projections.

Some preliminary attempts have been made to project the spread of cattle in West Africa over a 20-year period as part of a study evaluating the economic impact of tsetse and trypanosomiasis control (Shaw *et al.*, 2006). These are described in the following subsections.

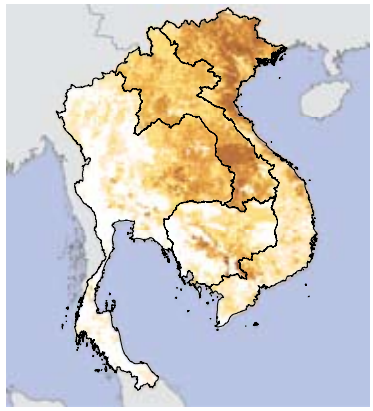
Carrying capacity and spread

The various elements of cattle population growth were calculated separately and then combined in several stages. First, breed-specific growth rates per animal, as supplied by herd growth models, were applied to a map of the current density of cattle to give first estimates of livestock growth.

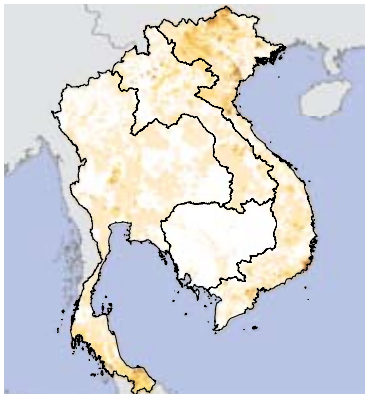
7.1 DETAILED SPECIES MAPS FOR THE MEKONG REGION, COMBINED TO PRODUCE A MAP OF TLUs



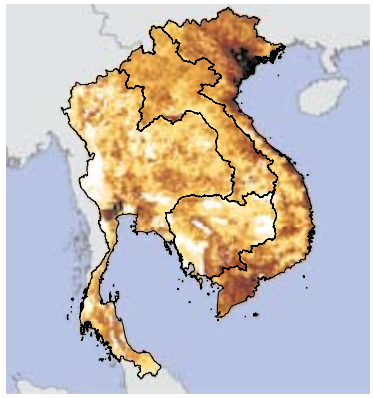
Cattle



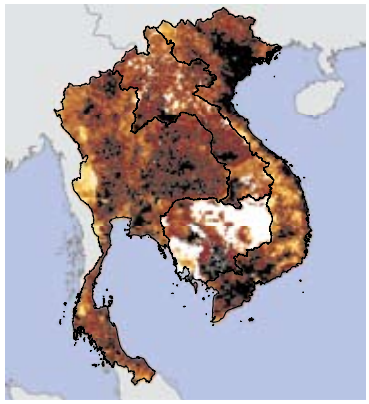
Buffaloes



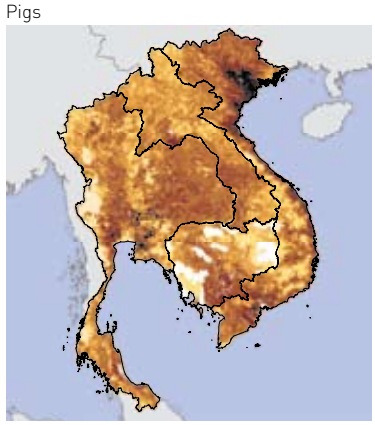
Small ruminants



Pigs



Chickens

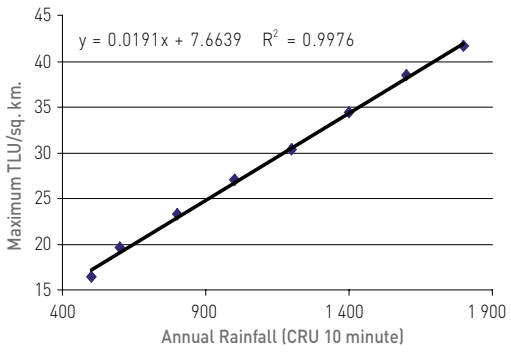


Tropical Livestock Units

Number per square km

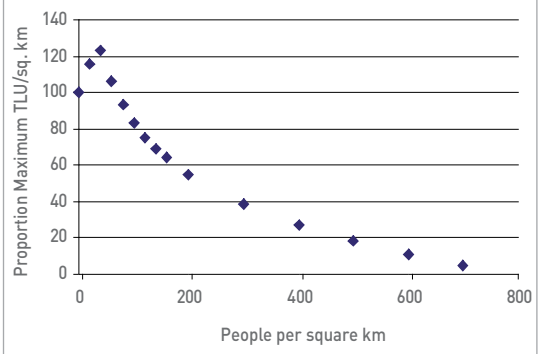
0	1–5	10–20	50–100	>250
< 1	5–10	20–50	100–250	

7.2 LIVESTOCK CARRYING CAPACITY AND ANNUAL RAINFALL



Source: Shaw *et al.*, 2006, derived from Jahnke, 1982.

7.3 LIVESTOCK CARRYING CAPACITY AND HUMAN POPULATION



Source: Shaw *et al.*, 2006.

When added to the existing population density, these provide an estimate of a theoretical cattle population after 20 years. This first output produces livestock population densities in some foci that significantly exceed likely carrying capacities, and must, therefore, be adjusted either by reducing calculated densities (equivalent to increasing off-take) or by 'exporting' animals from the high-concentration areas to surrounding, less heavily stocked regions.

The second of these possibilities has been adopted here, requiring first that carrying capacities are defined and, second, that techniques are developed to assign exported animals to neighbouring areas, as described in the following sections.

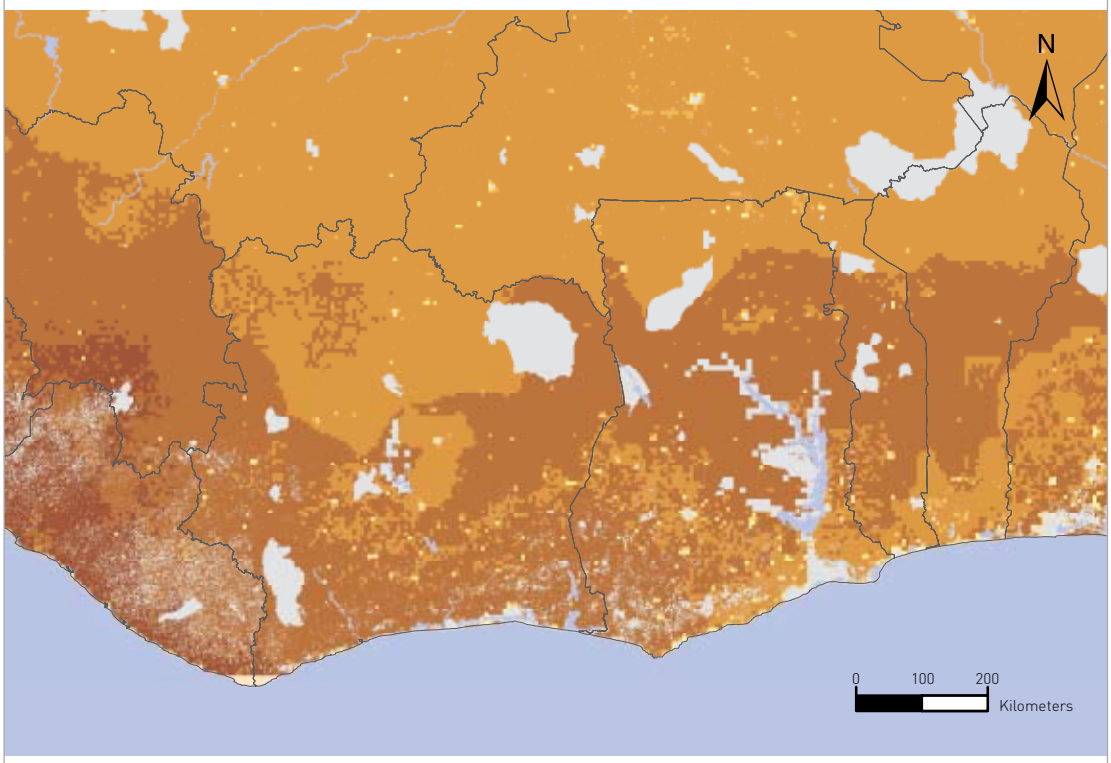
Mapping the carrying capacity

Carrying capacity is a controversial subject and, in recent years, the concept has fallen from favour amongst many ecologists. Nevertheless, livestock populations cannot increase indefinitely, and limits are reached beyond which animals are exported or slaughtered. Numerous attempts have been made to define thresholds for different zones (amongst which those cited in Jahnke, 1982), covering a range of rainfall bands. For the study area, these are summarized in Figure 7.2.

This relationship does not, however, incorporate any influence of competing land use by cropping and/or human settlement, or the use of crop residues as fodder, or indeed the effects of mobile livestock populations in transhumant areas. Information on year-round carrying capacity in relation to human population density has been compiled by Shaw, 1986, based on work and studies originally reported in Putt *et al.*, 1980, with values expressed as a proportion of the 'maximum' carrying capacity, with no human population, assumed here to be equivalent to that defined by Jahnke, 1982. The estimated relationship between livestock carrying capacity and human population density is shown in Figure 7.3.

For current purposes, these estimates, expressed in TLUs (where one TLU is equivalent to 250 kg of biomass) were converted to cattle densities (Figure 7.4) so as to match the units of the livestock density map (Figure 7.5). To do this, specific weights were assigned to types of cattle, as follows: 0.75 TLU for zebu cattle; 0.55 TLU for trypanotolerant taurine cattle; 0.705 TLU for low-productivity system oxen; and 0.74 TLU for high-productivity system oxen. It should be noted also that the estimated carrying capacity assumed that the land currently without cattle would be cleared or managed to make the habitat suitable for cattle keeping.

7.4 ESTIMATED CARRYING CAPACITY FOR CATTLE IN WEST AFRICA

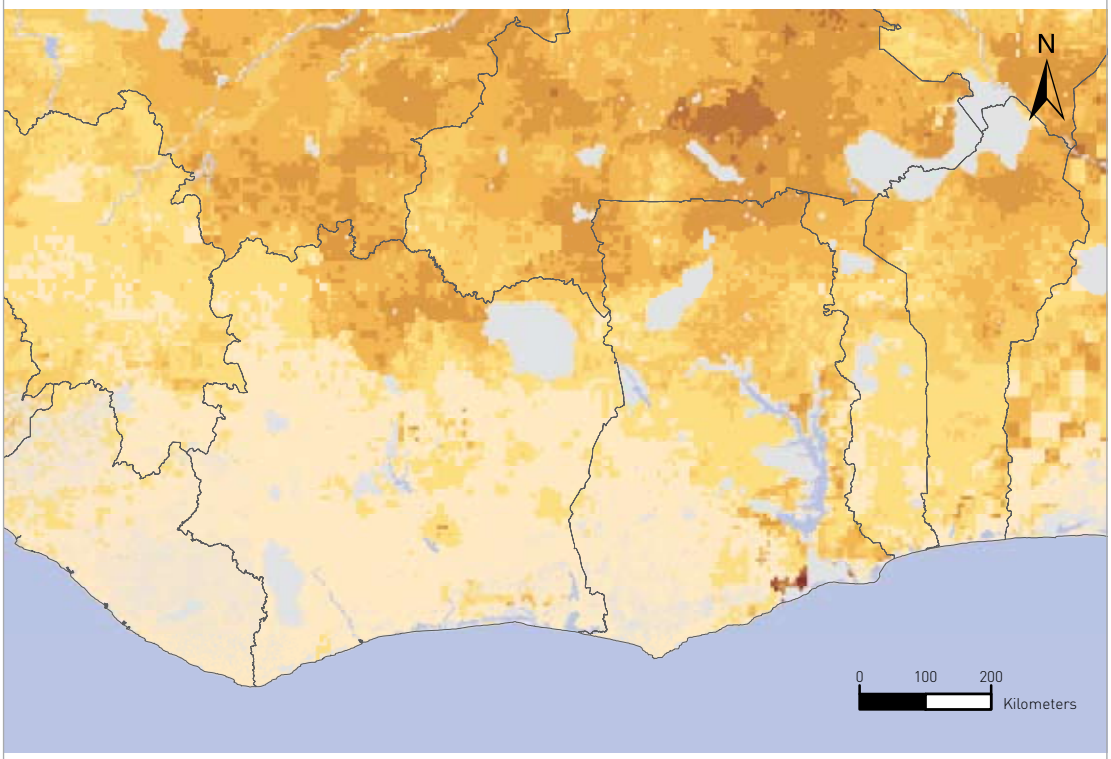


Source: Shaw *et al.*, 2006.

Spread modelling

Methods of assigning emigrating populations to neighbouring areas from defined foci are still in their infancy. Some rely on simple diffusion, usually density-independent, and use some function of distance from the point of export to define areas of spread. Others attempt to incorporate the effect of long-distance dispersal events that emulate the establishment of new foci separated from the core areas: so-called 'stratified dispersal'. A recent set of models (Gilbert *et al.*, 2004) combines short- and long-range dispersal to define sequential areas of spread in 'time-steps', and allows for defining the rate of spread by short-range diffusion per time-step, as well as the number and maximum distance of new foci established over long distances. This is achieved by using the compound 'stratified' dispersal kernel shown as a red line in Figure 7.6, which combines the conventional short-distance curvilinear decrease (blue line) with a linear function to determine the probability of long-distance movements (black line), thereby increasing the

7.5 ESTIMATED EXISTING CATTLE DENSITIES IN WEST AFRICA



Number per square km

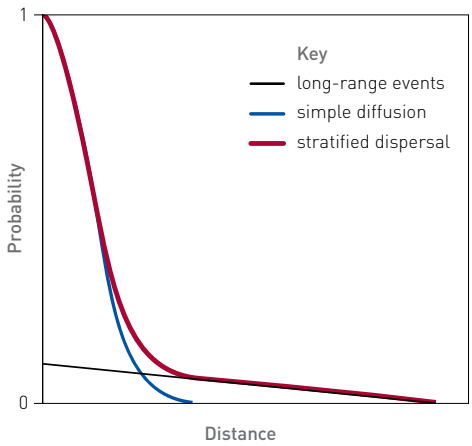
<1	10–20	100–250	International boundary
1–5	20–50	>250	Water
5–10	50–100		Unsuitable for ruminant

numbers of long-distance establishment events without influencing the short-distance diffusion pattern.

This approach thus allows for the identification of sequential bands of expansion from known foci: in the current case, areas of overstocking. Each time-step is coded separately and therefore fixed proportions of the population to be exported can be assigned. In the analysis described here, four time-steps were defined and assigned 40 percent of the population to be exported from areas classified as overstocked to the first time-step; 30 percent to the second; 20 percent to the third; and 10 percent to the fourth and final time-step. This means that 40 percent of the stock remained in the 'overstocked' areas, which assumes that some improved production system is adopted within 20 years. In each case, spread was prevented into areas defined as unsuitable for livestock and was scaled according to proximity to roads.

The resulting predicted livestock density after 20 years of tsetse and trypanosomiasis control is shown in Figure 7.7, for which the starting density was that given in Figure 7.5.

7.6 DISPERSAL KERNEL USED TO MODEL THE SPREAD OF LIVESTOCK



Source: Gilbert *et al.*, 2004.

LIVESTOCK PRODUCTION SYSTEM CLASSIFICATION

Livestock should not be considered in isolation from their surroundings, nor, as already illustrated in relation to biomass, should they be mapped only as single entities. The established links between livestock numbers, human populations and cultivation levels (Bourn and Wint, 1994) argue for paying greater attention to the quantification and mapping of these associations.

Since the 1970s, a number of farming system classifications have been proposed. Ruthenberg, 1980, for example, distinguishes among collection, cultivation and grassland utilization. For cultivation, his classification is based on the type and intensity of rotation used. For grassland utilization, Ruthenberg refers to the continuum from pure nomadism, through transhumance to sedentary animal husbandry.

Earlier, Grigg, 1972, had also distinguished characteristics of agriculture but failed to develop a systematic approach. This resulted in a rather disparate collection of systems and little reference to livestock production.

Seven broad farming systems mapped in a global study by the World Bank and FAO[39] combined current state-of-knowledge assessments of natural resources, prevailing farming activities and livelihood strategies to define them (Dixon *et al.*, 2001). This approach led to a classification based broadly on agro-ecology, presence or absence of irrigation and location (urban/coastal), but did not incorporate livestock in any detail.

Relatively simple statistical classifications of cattle and human population levels, cultivation intensity and elevation have also been investigated (Wint *et al.*, 1997; 1999). Whereas these classifications have the advantage of providing data-driven definitions of 'farming systems' and can delineate areas where these parameters have similar numerical values, they are sensitive both to geographical region and value range and cannot be replicated systematically in time and space.

FAO, 1996, developed a classification of livestock systems based on agro-ecology and the distinction between mixed and pastoral, irrigated and rainfed, and urban/landless areas. Emerging from this is one of the more widely used classifications developed and mapped by the International Livestock Research Institute (ILRI) (Thornton *et al.*, 2002). Figure 7.8 shows the decision tree that was used to map these livestock-oriented production systems.

The system is based on four modes of production (livestock grazing; rainfed crop and livestock production; irrigated crop and livestock production; and landless livestock production) in three agro-ecological zones defined by LGP and temperature (arid/semi-arid; humid/sub-humid; and temperate/tropical highlands). A number of global datasets was incorporated into the classification. The LGP (Fischer *et al.*, 2002)[40] was used to define all climatic zones except the highland temperate category, for which were used two climatic databases from the International Centre for Tropical Agriculture (Jones

[39] http://www.fao.org/farmingsystems/
[40] http://www.fao.org/waicent/faoinfo/agricult/agl/agll/gaez/index.htm