Zone classification based on length of growing period—Africa (Kruska et al. 1995)

As part of a program aimed at assembling livestock distribution coverages across Africa, Russ Kruska and Philip Thornton of ILRI kindly made available the ARC/INFO data sets on Africa for length of growing period (at two levels of aggregation) and cattle density distribution. These were plotted by Shawn Laffan of the Geography Department of the Australian National University, under sub-contract to ASIT Consulting (Figures 3 and 4). Figure 3 shows Africa subdivided into 14 zones based on 'normal days' of length of growing period, together with six zones based on the number of 'intermediate days', as described above (Fischer et al. 1995). Further detail is provided under Task 2 with respect to the cattle density distribution, which is presented in Figure 4 juxtaposed with a map where the distinction is made between only four zones (arid, semi-arid, sub-humid and humid).

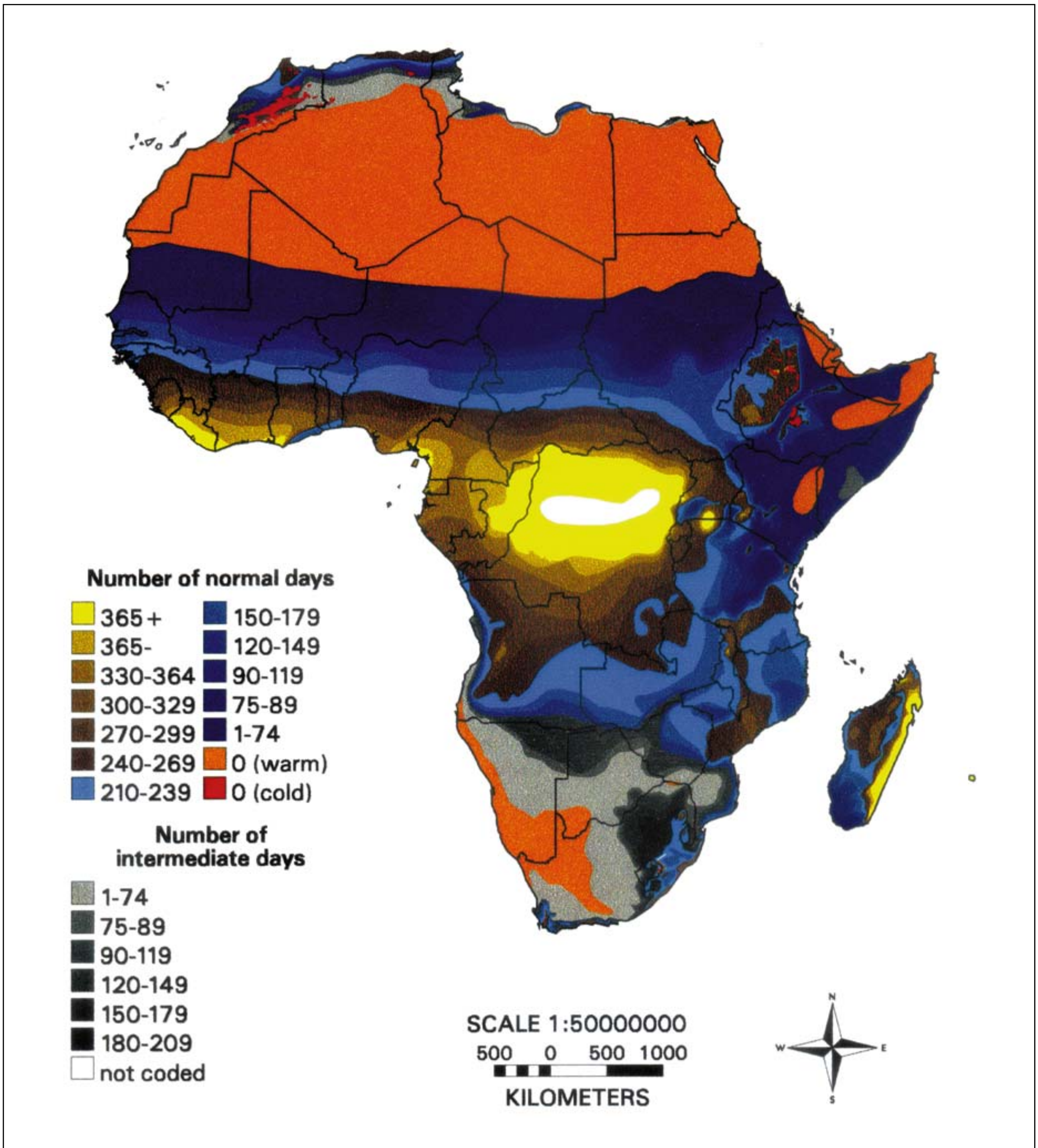

Figure 3. **Length of growing period zones—Africa (ILRI)**

Agro-ecological classification of Seré et al. (1996)

This classification is also based on the length of the growing period (LGP), which in this case is defined as the period (in days) during the year when rainfed available soil moisture supply is greater than half potential evapotranspiration (PET). It includes the period required to evapotranspire up to 100 mm of available soil moisture stored in the soil profile. It excludes any period with daily mean temperatures less than 5°C.

A major attraction of this approach is the relatively simple formula used to estimate the length of growing period, indicating that it could be relatively easy to compute provided global climatic data sets were available.

This approach started with the FAO/TAC LGP classification comprising 11 zones. For the purpose of a livestock system classification in which few clusters were sought, these were reduced to three: arid and semi-arid (< 180 growing days); humid and sub-humid (more than 180 growing days); and temperate and highland (temperature constraint). It is therefore a rather crude aggregation of the LGP concept. Three livestock production systems were considered: grazing systems; mixed rainfed systems; mixed irrigated; which equals 3 × 3 = 9 land-based systems. Two land-detached systems for monogastrics and ruminants were also included.

arid:	LGP less than 75 days
semi-arid:	LGP in the range 75–180 days
sub-humid:	LGP in the range 181–270 days
humid:	LGP greater than 270 days

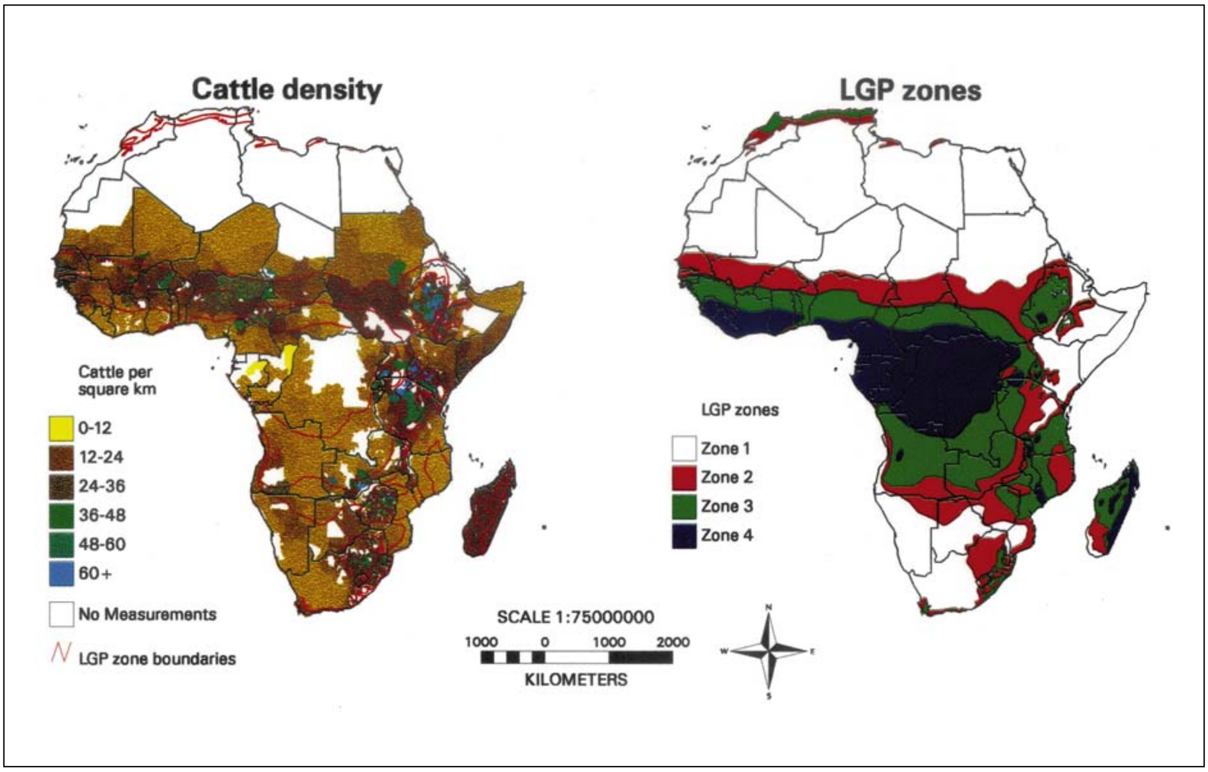

Figure 4. Cattle density distribution and LPG zones in Africa (ILRI)

Tropical highland areas and temperate regions are defined by their mean monthly temperatures. Temperate regions have one or more months with a monthly mean temperature, corrected to sea level, less than 5°C. Tropical highlands are tropical areas with daily mean temperature during the growing period in the range of 5–20°C.

This classification distinguishes between solely livestock systems, Grassland Based Systems, Rainfed Mixed Farming Systems, Irrigated Mixed Farming Systems, Landless Monogastric and Landless Ruminant Systems. Unfortunately, data distinguishing the number of livestock in irrigated and dryland systems could not be obtained for individual countries. In any case, the area of land that is irrigated is a small proportion of that available for agriculture, and in most countries is dominated by crops (Seré et al. 1996).

The study by Seré et al. (1996) contained estimates of land area, livestock numbers, livestock production and productivity indicators within each of the 11 agro-ecological systems for different regions of the world. These included: sub-Saharan Africa (SSA); Asia (ASIA); Central and South America (CSA); West Asia and North Africa (WANA); Organization for Economic Cooperation and Development (OECD) member countries, excluding Turkey which was included in WANA; eastern Europe and Commonwealth of Independent States (CIS); and other developed countries (Israel and South Africa) (ISA).

Ecozones, farming systems and length of growing period (Slingenbergh and Wint 1997)

Raster images for length of growing period (LGP) in 16 classes, national boundaries and human population level were available, initially for the African continent (FAO AGAH), and subsequently for the world (FAO AGL). Two primary outputs were required: vector maps of LGP zones (concatenated into 6 classes) within each Country; and population levels for each of these Zones.

The original 16 LGP zones were reclassified into six, and the resulting image comprised approximately 550 LGP zones by country (Figure 5).

The work of Wint and colleagues on African ecozones and farming systems is continuing (FAO 1997, 1998). Satellite data on land-surface and atmospheric characteristics are being used in the search for zonation criteria that are more ecologically based, including:

a) the Normalised Difference Vegetation Index (NDVI), commonly used as an indicator of vegetation cover;

b) a measure of ground surface temperature, derived from one of the thermal infra-red channels (channel 4; 10-day composite) on the NOAA satellite platform (AVHRR data; 1 km × 1 km resolution) by the NASA Global Inventory Monitoring and Modelling Systems (GIMMS) group; and

c) a measure of surface rainfall, the Cold Cloud Duration (CCD), derived from the METEOSAT satellite (8 km × 8 km resolution).

In addition, digital elevation model (DEM) data were obtained from a 0.083° resolution elevation surface for Africa, produced by the Global Land Information System (GLIS) of the United States Geological Survey, Earth Resources Observation Systems (USGS, EROS) data centre.

Farming systems in Kenya have corresponded quite closely with ecological zonations based on length of growing period (FAO 1998). Two sets of ecozones were identified, one with 11 zones, the other with 16. The major effect of increasing the number of zones was to split the drier areas into more categories. MANOVA analyses showed that 11 zones encompassed 77 and 46% of the variation in cattle and crops, respectively, as compared with 78 and 46% for the 16 zones.

Regression relationships were identified between remotely sensed surrogates for climate, human population, elevation, and known livestock and cropping distributions. These were used to predict livestock densities and cropping levels within a series of ecozones defined by unsupervised classification of the remotely sensed data. Elevation was found to be an important determinant of the ecozones, but as Hutchinson (1989a, 1991) has shown, that would primarily be through its impact on rainfall and temperature, the influence varying with latitude. For example, the most consistent predictors of cropping percentage in Kenya and Ethiopia appear to be human population number and elevation, as befits heavily populated areas concentrated in extensive highlands (FAO 1997). In Somalia, Sudan and Uganda, the predictors are more diverse, with rainfall and, to a lesser extent, vegetation cover being most frequent. Human population and elevation also predict cattle densities most often in Somalia, Sudan, Kenya and Ethiopia. Rainfall is also a frequent predictor, especially in Uganda and parts of Sudan. Cattle densities appear to be more closely related to population, especially in the more arid areas such as Mali and Chad, while elevation features predominantly in Niger. Elsewhere temperature or rainfall are more closely related to cattle numbers than are other eco-climatic variables.

Length of growing period relates closely to the satellite-derived ecozones (FAO 1998). The primary discriminating predictors were maximum temperature, minimum rainfall, mean NDVI and elevation, with the remainder being largely rainfall related. The AVHRR data were able to discern relatively slight variations within more arid areas, but were comparatively poor in discriminating between zones in the higher rainfall areas.

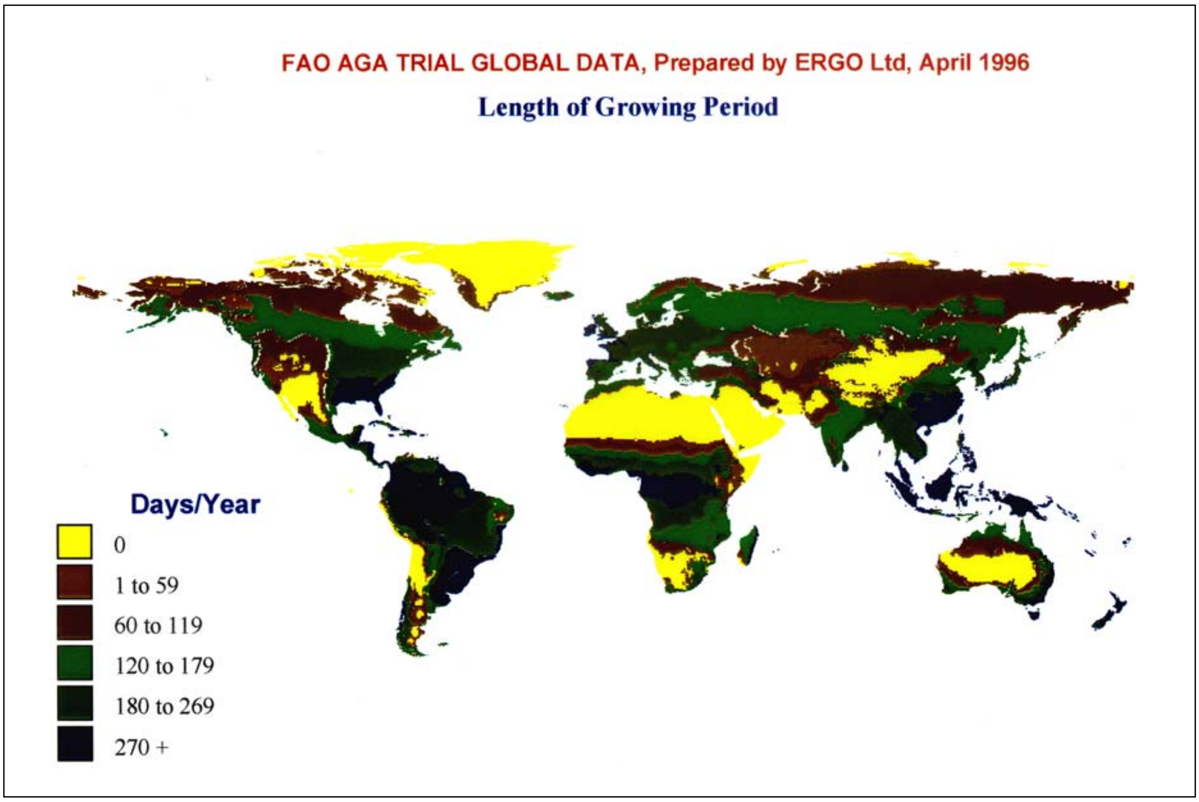

Figure 5. Length of growing period zones; six zones (FAO 1996a)

This study recommends that six zones be discriminated according to length of growing period (LGP), because this is consistent with ongoing work by FAO and others on LGP, complemented by satellite and other data, and estimates of total livestock biomass (Slingenbergh and Wint 1997). There should, nevertheless, be an expectation and provision for these zones to be further subdivided as additional resources and data become available.

These six zones are:

Zone	LGP (days)
Desert	0
Arid	1–59
Semi-arid	60–119
Dry subhumid	120–179
Moist subhumid	180–269
Humid	>270

It is important to appreciate that the choice of agro-climatic zones in this study was strongly influenced by the fact that FAO (1996a,b) studies provided livestock data that could be linked to these zones. The use of human population density data has been a useful step in providing initial estimates of livestock density distribution within countries, and for the most part these estimates appear to be sufficiently accurate to provide information to aid in the targeting and prioritisation of agricultural research. These estimates will be least accurate where the quality of the national data is low, where environmental regulations limit the location of livestock industries (e.g. intensively housed livestock units and feedlots), and where climatic extremes, land degradation or alternative land uses have a greater effect on livestock densities than on those for human populations.

Definition of agro-climatic (and agro-ecological) zones will improve through applying digital elevation models, climate surfaces, plant growth models such as GROWEST (Nix 1981; Zuo 1996), field and remote sensing data, and geographic information systems (e.g. FAO 1997, 1998). The collection of land use and livestock density data in Africa (Corbett et al. 1995; Kruska et al. 1995) and Latin America (G. Hyman, pers. comm.), complemented by local data (e.g. provincial livestock data in the yearbooks of the People's Republic of China), means that before too long it will be useful to revisit the data on livestock density distribution in the light of new and more relevant zonations. International collaboration in assembling and integrating these data sets could be expected to have major benefits in improving the targeting of research and in introducing land management practices that benefit both the environment and resident human and livestock populations.