8 Conclusions and future developments

The previous sections have reviewed the history of livestock production systems classifications and some of the attempts to map them. Examples have been presented that illustrate the diverse range of applications to which such maps have been put, and which by so doing emphasize how important it is to improve these estimates if we are to target more appropriately both the opportunities and risks that the livestock sector presents in the social, public health and environmental domains. Moreover, with the rapidly increasing demand for livestock products currently being experienced across the world, we need to develop systems that can be readily and frequently updated to monitor how livestock production systems are changing in response to growth.

The starting point for most of the attempts to define and map livestock production systems has been the classification system developed by Seré and Steinfeld (FAO, 1996). For its intended purpose, with no plan to present the data in a spatial context, the largely farm-based definitions of the systems present no problems. However, while the agroclimatic elements in the definition (LGP) can be mapped readily, the classification they adopted cannot be mapped in its entirety because spatial data on some key elements (e.g. the amount of dry matter fed to animals that comes from crop by-products) are simply not available. The spatial renditions of these systems have been a compromise resulting from the use of global spatial datasets (land cover, human population density and irrigation) to proxy the farm-based definitions (feed origins, stocking rates, the proportional value of livestock activities, and the proportional value of rainfed versus irrigated land use). Perhaps the proximity of the categories mapped by Thornton *et al.* (2002), subsequent developments thereof (Kruska *et al.*, 2003; Kruska, 2006); and the most recent, presented here, to the Seré and Steinfeld systems has in the past been overemphasized. First, the systems mapped by Thornton *et al.* (2002) can be more accurately described as estimating the 'potential' livestock production systems, since they incorporate no information on the actual distribution and abundance of livestock. Second, their mapping accuracy is heavily dependent on that of crop datasets derived from global land cover maps. As we have seen, these are remarkably variable and often inaccurate, to the extent that much of the use of other GIS layers in the Thornton *et al.* (2002) mapping is simply to overcome inaccuracies in the crop extent estimated from global land cover layers. (For example, if the crop layer were accurate, population density and LGP would not be required to reassign non cropland pixels to the mixed farming class.) Third, Thornton *et al.* (2002) do not exactly depict areas where livestock do occur (either with or without cropping) but rather areas where livestock 'may' occur. Therefore only information on livestock distribution can bridge the gap between 'potential' and 'actual' livestock production systems (Section 4).

All land use systems, including livestock production systems, can be seen as mosaics of different units of land cover and land use interconnected by spatial and functional relationships. This implies that efforts to classify livestock production systems cannot be disconnected from current efforts to develop standardized classification systems for land cover, land use, and land use systems. High resolution standardized land cover maps such as those developed by the Africover project offer an opportunity to move in this direction. These data have already been integrated with the global map of livestock production systems (Version 5), but without fully exploiting the thematic and spatial detail of this information. Although the limited and patchy availability of these high resolution land cover data make them directly useful, mainly at national or regional level, it is expected that they will guide conceptual developments also applicable to global level mapping.

Arguably, at the scale of Africover (approximately 1:100 000 to 1:200 000 – which roughly corresponds to 100 metres of spatial resolution) a substantially different mapping approach can be developed. First, these kinds of land cover data, although not perfect, provide a more reliable source of land cover information, particularly of crop cover. Hence, the current adjustments to cropland layers (e.g. those based on human population and LGP) would not be needed. Second, working with high resolution land cover maps brings to the fore the concept of scale. What is the range of scale at which livestock production systems can be meaningfully mapped? Is there a minimum mapping unit? Does this differ between production systems? And then, what are the practical implications for the mapping process?

As already discussed in the text, the gap between potential and actual systems is to be filled by integrating information on the distributions of different types of crop and livestock. A more discerning inclusion of crop data is needed if realistic mixed farming systems are to be mapped. Not all crops and not all cropping systems lend themselves to being integrated into a mixed-farming system, where the association between crops and livestock is not only spatial but functional. Ultimately, integrating information on livestock species and crop types allows us to move closer to the objective of better understanding global land use and livestock production systems. Such integration also implies the need for better harmonization between mapping livestock production systems and modelling of livestock distribution and abundance, which should address the suite of spatial data and methods used to map livestock production systems and livestock densities.

Understanding where intensification of livestock production is occurring now, and is likely to occur in the future, as demand for animal-source food in developing countries continues to grow, is important for many reasons. Three diverse methods were presented here to identify areas of intensive livestock production. However, further advancements are needed for more accurate mapping, especially because these are the areas where changes are occurring more rapidly. This would provide invaluable information for all studies on the relationships between intensifying systems and livelihoods and poverty, human and animal diseases, and environmental impacts of livestock production.

Finally, the outstanding issue of validation cannot be overlooked. As already observed by Rosegrant *et al.* (2009) only limited evaluation of the livestock production systems maps has been made. Some of the challenges in the validation of global maps are easy to picture, and include issues of definitions, data availability, resolution, statistical robustness and geographical coverage. We may still be a long way from a fully satisfactory validation of the global maps of livestock production systems. However, the slate is not blank and the available evidence is promising. A regional study summarized in this book, and covering six countries in Eastern Africa (Cecchi *et al.*, 2010) indicated that there is remarkable correspondence between global outputs based on proxy geospatial layers, and maps of pastoral, agropastoral and mixed farming systems independently derived from livelihood analysis. This regional study also highlights what should probably be a common feature of future validation efforts: to shed light on the relationship between environmental factors driving global mapping efforts, and socio-economic dimensions shaping the true nature of production systems on the ground. Meta-analyses and expert evaluation (e.g. through geo-wiki systems) might provide relatively easy and affordable solutions for global validation.

Sachs *et al.* (2010) call for a new global data collection and dissemination network to track the many impacts of different farming practices on the environment. There are considerable challenges ahead if the global population is to be fed sustainably and healthily in 2050. Classifying and mapping global agricultural production systems is not an end in itself, but is a necessity if we are to evaluate efficiently different technology and policy options, and to target effectively where they may be applicable.

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10 Appendices

These appendices provide regional views of the distribution of livestock production systems and detailed tables with numbers of rural poor livestock keepers. Appendix A lists the 2010 World Bank regions and related country income groupings that were used in the analysis (World Bank 2010).

Appendices B to G open with regional maps of livestock production systems. The livestock production systems used in the appendices are those from Version 5, described in Section 3 of this publication (see Table 3.1). For the purpose of this analysis of rural poor livestock keepers, the hyper-arid and arid production systems were aggregated into a single arid category. These appendices then provide detailed tables of the numbers of rural poor livestock keepers by country and by livestock production system. The spatial distribution of the rural population is derived from the GRUMP dataset (CIESIN, 2005), which was adjusted to match the 2010 UN rural and urban population totals for each country. The tables contain estimated numbers of rural poor livestock keepers using poverty rates based on three different poverty lines: 1) national, rural; 2) international US$1.25 (extreme poor); and 3) international US$2.00 (poor). Poverty rates were taken from World Bank (2011).