LAND DEGRADATION ASSESSMENT IN DRYLANDS

LADA

LADA PROJECT

MAPPING LAND USE SYSTEMS AT GLOBAL AND REGIONAL SCALES FOR LAND DEGRADATION ASSESSMENT ANALYSIS

Version 1.1

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2013

This work was originally published online by the
Food and Agriculture Organization of the United Nations in 2011.

ISBN 978-92-5-107568-5 (print)
E-ISBN 978-92-5-107569-2 (PDF)

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Acknowledgements

This report draws heavily on the earlier work of John Dixon, Hubert George and others who made considerable progress in improving the sub-national land use information in FAO and whose intellectual efforts in this field are herewith gratefully acknowledged. The work would have been impossible without the ongoing work in various sections of FAO that improved the individual databases used – in particular: John Latham (land cover and poverty); Tim Robinson and Gianluca Franceschini (livestock). Support, suggestions and comments received from Dominique Lantieri, Leslie Lipper and other members of the Stratification Task Force is also gratefully acknowledged. The report has benefited enormously from comments and suggestions received from the national LADA coordinators and their collaborators – in particular; Dirk Pretorius, Dethie Ndiaye, Jia Xiaoxia, Michael Laker, Andres Ravelo and Hedi Hamrouni, who are especially thanked for their constructive criticism of earlier versions.

Acronyms and abbreviations

CIESIN	Centre for International Earth Science Information Network
CRU	Climate Research Unit (of the University of East Anglia)
DPSIR	Drivers-Pressure-State-Impact-Response
FAO	Food and Agriculture Organization of the United Nations
GPCC	Global Precipitation Climatology Centre
GRUMP	Global Rural Urban Mapping Programme
IUCN	International Union for the Conservation of Nature
LADA	Land Degradation Assessment in Drylands
LGP	length of growing period
LUS	land use system
MDG	Millennium Development Goal
N-LUS	national-land use system
PET	potential evapotranspiration
SLM	sustainable land management
TLU	tropical livestock unit
UNEP	United Nations Environment Programme
UNESCO-MAP	United Nations Educational, Scientific and Cultural Organization – Man and the Biosphere Programme
WCMC	World Conservation Monitoring Centre
WOCAT	World Overview of Conservation Approaches and Technologies

CHAPTER 1

Introduction

1.1 Land Degradation Assessment in Drylands project and Land Use Systems

The objective of the Land Degradation Assessment in Drylands (LADA) project was to develop tools and methods to assess and quantify the nature, extent, severity and impacts of land degradation on dryland ecosystems, watersheds and river basins, carbon storage and biological diversity at a range of spatial and temporal scales. This builds the national, regional and international capacity to analyze, design, plan and implement interventions to mitigate land degradation and establish sustainable land use and management practices.

To achieve this objective, LADA has developed standardized and improved methods for dryland degradation assessment, with guidelines for their implementation at a range of spatial and / or temporal scales. The LADA methods enable users to assess the regional and global baseline land degradation situation with the view to highlighting the areas at greatest risk. These assessments were supplemented by detailed local assessments that focused on the root causes of land degradation and on local (traditional and adapted) technologies for the mitigation of land degradation. Areas where land degradation is well controlled were included in the analysis in order to develop 'best practice' guidelines and the results widely disseminated in various media. The project was intended to make an innovative generic contribution to methodologies and monitoring systems for land degradation, supplemented by empirically-derived lessons from the six main partner countries involved in Phase 1 of the project (Argentina, China, Cuba, Senegal, South Africa and Tunisia) for up-scaling to countries within their regional remit.

Land degradation can be defined as a long term loss of ecosystem functions over time, as perceived by the land users. The relationship between land degradation and land use is clear, as land use implicitly includes the way farmers and pastoralists use and manage the land, which can inherently change it for the better and / or the worse. Knowledge of local biophysical and socio-economic conditions is needed to explain and relate the land use to land degradation and vice versa. The methodology presented here describes the principles to map land use and inventory related ecosystems and more detailed crop or livestock information at a global scale. Refinements of this methodology are required when applied at more detailed (i.e. larger) scale, but the linkage with the overall global Land Use System can be maintained. This linkage allows a more reliable extrapolation of results from local to national and from national to global scale.

1.2 The ecosystem-Land Use System information base

Land use, defined as the sequence of operations carried-out with the purpose of obtaining goods and services from the land, can be characterized by the actual goods and services obtained as well as by the particular management interventions undertaken by the land users. Land use is generally determined by socio-economic market forces, also the biophysical constraints and potentials imposed by the ecosystems in which they occur. At the regional and global scale, information on land use can be indirectly derived from agricultural census data, land cover information and from maps of the biophysical resources. Few global databases are available that allow the characterization of the land management interventions themselves (e.g. information on mechanization or fertilizer use are often only available as national statistics): in fact only for irrigation, livestock presence and protected areas are consistent global databases available which allow refinement of the mapping and characterization of land use.

Land use is the single most important driver of land degradation as it focuses on interventions on the land which directly affect its status and impacts on goods and services. To characterize land use in a systematic and harmonized way allows the evaluation of the various aspects of land degradation, particularly when information on related ecosystem characteristics (on which land degradation has a major impact by affecting the good and services provided by each system) and socio-economic attributes of the area (which are often the indirect cause of land degradation) are associated with it.

Previous efforts to characterize land use globally were incomplete or fragmented. These include:

- The farming system maps produced by Dixon *et al*. (2001) covered the developing world only and were too generalized to be of practical use within countries. However, the farming system scheme developed appears to be a valid scheme to define global and regional land use classes;
- The Global Land Cover dataset (GLC-2000, JRC) and Globcover (2008), although providing global coverage at much higher resolution than the farming systems map (described above), recognizes only the land cover aspect and has not attempted to further characterize land use in terms of crops, goods and services or management interventions;
- Other efforts have attempted to distribute national agricultural statistics in a rational way based on bio-physical conditions and the actual land cover (IIASA, 2007; You and Wood, 2006; Monfreda *et al*., 2008);

- Global thematic databases at sub-national level exist for agricultural crops and livestock;
- Agro-MAPS (FAO/IFPRI/SAGE, 2006) provides sub-national statistics on crop production, area harvested and yields in a systematic way, but the information is fragmented in time and space, it is also limited to agricultural crops. A similar situation exists with livestock (ILRI global livestock production systems (Thornton *et al.*, 2002) and the FAO global per species livestock density database (Wint and Robinson, 2007);
- F-CAM (George and Petri, 2006) proposed a scheme that followed the principles applied by Dixon *et al.* (2001), but used a more systematic approach and consistent geo-referenced databases.

LADA adapted and applied a similar scheme at global and regional levels, putting emphasis on the role of ecosystems in land use systems and making a more clear distinction between what can be mapped (units) and what can be consulted and related to these units and their use as attributes.

The overall scheme to characterize land use systems is reproduced in Table 1. There is no single accepted nomenclature for land use. As there are links with the scheme from Dixon *et al.* (2001), it is tempting to use the word "farming systems", but this does not fit well with forest based activities, or with the non-agricultural uses of land. The term Land Production Systems has also been proposed but this over-emphasizes the productive functions of land as compared to the environmental services it may render. Therefore in the following discussion the more generic term "Land Use Systems" is used.

It is important to note that the database provided includes all individual characteristics aggregated to a 5 arc minutes grid. However, in order to graphically represent land use systems, certain groupings and simplifications are proposed here that are further documented in the sections that follow.

LAND USE SYSTEMS			Climatic ecosystem(s)	Land use	
				Attributes	
ID #	Ecosystem based on land cover	Major land use	Ecosystem[1] (including temperature regime class[2]	Livestock type	Dominant crop type or group
1	Forest	Virgin	✔		
2		Protected	✔		
3		with agricultural activities	✔		Crop type
4		with moderate or high livestock density	✔	Livestock type	
5		Agro forestry[5]	✔		Crop type
6		Plantations[5]	✔		Crop type
7	Grasslands	Unmanaged	✔		
8		Protected	✔		
9		Low livestock density	✔	Livestock type	
10		Moderate livestock density	✔	Livestock type	
11		High livestock density	✔	Livestock type	
12		Stable fed[5]	✔	Livestock type	
13	Shrubs	Unmanaged	✔		
14		Protected	✔		
15		Low livestock density	✔	Livestock type	
16		Moderate livestock density	✔	Livestock type	
17		High livestock density	✔	Livestock type	
18		Stable fed[5]	✔	Livestock type	
19	Agricultural land	Rainfed crops (Subsistence/Commercial)	✔	Livestock type	Crop type
20		Crops and mod. intensive livestock density	✔	Livestock type	Crop type
21		Crops and intensive livestock density	✔	Livestock type	Crop type
22		Crops with large scale irrigation and mod. intensive or higher livestock density	✔	Livestock type	Crop type
23		Large scale irrigation (>25% pixel size)	✔		Crop type
24		Protected	✔		

Land use		Biophysical				Socio economic	
Attributes		Attributes				Attributes	
Small scale irrigation	Crop management index	LGP class[3]	Dominant soil unit	Terrain class	Slope class	Population density	Poverty index
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
Yes/No	L-M-H[4]	✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
Yes/No	L-M-H	✔	✔	✔	✔	✔	✔
	L-M-H	✔	✔	✔	✔	✔	✔
	L-M-H	✔	✔	✔	✔	✔	✔

LAND USE SYSTEMS			Climatic ecosystem(s)	Land use	
				Attributes	
ID #	Ecosystem based on land cover	Major land use	Ecosystem[1] (including temperature regime class[2]	Livestock type	Dominant crop type or group
25	**Urban land**		✔	Livestock type	
26	**Wetlands**	Not used / not managed	✔		
27		Protected	✔		
28		Mangrove	✔		
29		with agricultural activities	✔	Livestock type	Crop type
30	**Sparsely vegetated areas**	Unmanaged	✔		
31		Protected	✔		
32		Low livestock density	✔	Livestock type	
33		with mod. or higher livestock density	✔	Livestock type	
34	**Bare areas**	Unmanaged	✔		
35		Protected	✔		
36		Low livestock density	✔	Livestock type	
37		with mod. livestock density	✔	Livestock type	
38	**Open water**	Unmanaged	✔		
39		Protected	✔		
40		Inland fisheries	✔		

[1] Warm tropics; Cool tropics; Subtropics; Mediterranean; Temperate; Boreal; Polar; Deserts, Drylands, Sub-humid, Humid, Per-humid, Mountainous
[2] See column 3 in Table 2
[3] Hyperarid, Arid, Dry semi arid, Moist semi arid, Sub-humid, Humid and Per-humid
[4] L=low; M= Medium; H= High
[5] Not available

In the context of LADA, the land use system approach to land degradation assessment has as a guiding principle that land use is the major driving force of land degradation. Mapping of land use systems was therefore a major activity within the project at global and national level, where land use units are considered the basic units in which land degradation and land improvements are mapped (FAO-WOCAT, 2011). Land degradation status, causes and impacts are further modified by the ecosystem and socio-economic factors in which land use takes place. These factors are therefore associated with the land use system as a whole.

Land use		Biophysical				Socio economic	
Attributes		Attributes				Attributes	
Small scale irrigation	Crop management index	LGP class[3]	Dominant soil unit	Terrain class	Slope class	Population density	Poverty index
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
	L-M-H	✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔
		✔	✔	✔	✔	✔	✔

The accuracy of the mapping of land use systems and their associated characteristics depends on the scale and the resolution of the available information, which varies from global to regional to national. The methodology outlined here refers to the first two levels only (global, regional) but with emphasis on the global principles. Preliminary results of applying these global principles by South Africa (Pretorius, 2009), Tunisia (Direction Générale de l'Aménagement et la Conservation des Terres Agricoles, 2008), China (LADA team, 2008), Argentina (Ravelo, 2010) and Senegal (CSE, 2008) indicate that at the national level, refinements of these global principles are certainly possible. However, a good balance is required between the level of detail and the practical purpose of the exercise which remains to serve as units in which land degradation and land improvements is to be assessed.

As explained by George and Petri (2006), the descriptions of the farming systems as given by Dixon *et al*. (2001) were first taken as a guideline to define land use systems. However, this approach proved to be too complex and did not result in readily recognizable land use units within countries, nor did certain major subdivisions have either a direct or indirect link with land degradation. Therefore a much simpler scheme is proposed at the global unit level, which allows for accessing the characterization of the land use and ecosystem attributes on-line and in GIS format. In this way, as all layers are present in the database and are connected to the final units obtained, no information is lost. It also allows the user to include some of these factors at national level and refine them to create more detailed national land use information systems at higher resolution / larger scale.

Dixon *et al*. (ibid.) recognized different land use systems and correlations with the resource base in the different regions in the world. The same principle was applied in LADA and regional rules were used to reflect the cultural and historical differences in land use in various areas of the world, particularly concerning livestock.

1.3 Base data and data quality

Data quality was and remains a major concern. Putting together global data layers of variable quality and different resolutions / scales by simple overlay is a risky exercise, which is bound to result in some erroneous conclusions being drawn on the land use systems practiced. Major problems with the individual databases used are well known (FAO, 2005); the main ones are discussed below.

GLC-2000: the global land cover dataset is an essential layer which distinguishes, at the highest level, if land use systems are forest, crop or grassland based. Any error here will result in errors in the end-product. Based on a limited number of tests in LADA countries, the accuracy of GLC-2000 is variable as Senegal and South Africa found it lacking in several areas, while China considered it a good base product.

Agro-Maps: crop dominance and cropping patterns are derived from this database (a joint product prepared by FAO, IFPRI and Sage), which provides sub-national statistics on areas, yields and production of specific crops. Although not fully comprehensive, it is the best global product available. In general, perennial crop information is very scarce in this database. Moreover, as administrative areas are used as the geographical units, the level of detail of the results information is variable (compare, for example, Ethiopia, which has a large number of very small sub administrative units, with many other countries in Africa where districts are often large).

Livestock data: the livestock data are available at a relatively high resolution (3 arc minutes grid) but much of it has been obtained by modelling rather than actual inventories. The reliability of the modelling exercise and its variation is unknown, but was found to have a reasonable level of accuracy in some LADA pilot countries, notably China and South Africa.

The Ecosystem and Biophysical resource base: although the individual resource base layers are relatively uniform in scale, some of the underlying data were obtained from less detailed databases (e.g. climate data), while others (e.g. terrain) were difficult to use to distinguish land use systems. Given the smaller scale and the different national traditions used to classify "climatic ecosystems", it was determined that these and other resource base information should be used as attributes of the land use system, rather than using their boundaries to delineate LUS.

Socio economic attributes: worldwide and even within countries, socio-economic data are the most scarcely available datasets. Population data are by far the most comprehensive but typically only re-surveyed every 10 years, while others such as poverty are scarce globally and often sensitive nationally.

1.4 From a global to a national Land Use Systems map

Regardless of the certain unreliability and low resolution of global datasets, a reasonable estimate of the prevailing national land use systems can be prepared, as is illustrated in the following sections. However verification of each database layer has been undertaken by the LADA countries to eliminate gross errors or to fill major gaps at the same scale / resolution of the global LUS map. This will probably result in changes in the boundaries and further refining of the information contained in each pixel.

LADA countries have created national land use system maps at a larger scale. This enabled the creation of sub-systems of land use within the different classes, also the introduction of land use factors that cannot be distinguished at global scale because of lack of data or because they can only be detected / mapped at larger scale. In particular, this concerns factors such as:

- **Land tenure and size of farms:** large areas in a country may be reserved for commercial large farms, which are quite distinct from other areas which are mostly used for small-holder farming.
- **Forest management and exploitation:** little can be done at global scale to characterize forest management, because most data are only available at the country level. Countries which have the geo-referenced information available at the sub-national level may be able to distinguish different forms of forest exploitation (e.g. firewood gathering).
- **Water resources and irrigation:** apart from the irrigation map (see Figure 1.2 in Annex 1), little is known about other sources of water; their availability and use at the global level (*inter alia* rivers, underground water reservoirs). It may be possible at sub-national scale to delineate areas which make use of this resource.
- **Fertilizer use, mechanization and other inputs:** although some more detailed information on fertilizer use by crop gathered by FAO for several countries (FAO, 2004) is available, the country coverage is incomplete. If data are available, the LUS units can be subdivided for these factors at the national scale.
- **The climatic system, socio-economic and resource base factors:** information is available as attribute information. Uniform land use systems may show different degradation features as a function of the soil and terrain in which they occur. If one is able to map these factors, they may be used to subdivide major LUS units in the national LUS map.

It is advisable to keep in mind the legibility of the maps produced from this type of overlay exercise and carefully consider that when a factor characterizing a specific land use system is added, the complexity of the map produced is exponentially increased. The national land use systems map provides the core units for the evaluation and mapping of land degradation and land improvements, therefore increasing the number of units results in a heavier workload for completing the QM questionnaire (CDE *et al.*, 2011).

2

CHAPTER

Global Ecosystems and Land Use Systems

An ecosystem is a complete community of living organisms and the non-living materials of their surroundings. Thus, its components include plants, animals and micro-organisms; also soil, rocks and minerals; as well as the surrounding water sources and the local atmosphere. The size of ecosystems varies tremendously. An ecosystem could be an entire rain forest, covering a geographical area larger than many nations, or it could be a puddle or a backyard garden. The components of an ecosystem are therefore soil resources, water resources, vegetative and other biological resources, also climatic resources. Although there is a general agreement what an ecosystem is, there is little consensus on how to map these consistently at a global scale. Those that show least variability at a global scale and for which consistent data are available are the vegetation (land cover) and the climatic resources. In the present approach, vegetation and climatic resources have been distinguished and a number of (partly overlapping) climatically determined ecosystems defined (*inter alia* deserts, drylands, mountains and the tropics). As far as land degradation and land use are concerned, it is obvious that these climatic conditions provide a biophysical context, however this is not sufficient to explain land use and land degradation. This is the reason why they are considered here as attributes rather than as factors which inherently delimit land use systems.

On the other hand, land cover -based ecosystems such as forests, grasslands or urban lands have much closer links to actual land use, as this is the highest category wherein land management takes place and has therefore been used as a delineation of the land use system.

Within these land cover-based ecosystems, one can distinguish a limited number of sub-divisions which directly reflect land use practices or the purpose for which the land is used. Listed in order of increasing intensity of use, one can distinguish:

No use/unmanaged: Pristine natural systems which are untouched or barely influenced by human interventions. These lands can be further subdivided according to their major land cover class.

Protected use: where legal provisions severely limit the use that can be made of the land, this is often the case where eco- or cultural tourism is promoted, such as in national parks or heritage sites.

Pastoralism: the rearing of livestock for meat, milk and hides often occurs in grasslands but can also be practiced together with crop production (crops-grazing) in agricultural lands and in some cases in forested areas. The intensity of the usage can be deduced from the livestock density within an ecosystem, but varies from region to region.

Rainfed croplands: this is the major agricultural system worldwide.

Irrigated crop lands: this is the agricultural system that assures a large part of crop production worldwide. Given the resolution of imagery used, only large-scale irrigation schemes can be consistently mapped at the global level. Small-scale irrigation, when present, is used as an attribute for the land use system units concerned.

Plantations: these are often associated with fruit crops or forest plantations, but are difficult to map at a global level due to the lack of a consistent comprehensive database, although some crops such as olives, grapes, coffee and fruit trees etc., are generally grown in plantations. At the national level, plantations are easier to distinguish and should be included (e.g. South Africa and Tunisia).

To guarantee homogeneity between layers, all maps are re-sampled on a uniform 5 arc minute basis.

2.1 Land cover

The Global Land Cover 2000 (GLC-2000) map, prepared by the Joint Research Centre (Joint Research Centre, 2005; FAO, 2005), was simplified to 8 classes by reclassification of the 16 original classes (Table 2). The resulting map is presented in Figure 1.1 of Annex 1.

2.2 Irrigation

A global irrigation map was produced by the University of Frankfurt in cooperation with FAO (Siebert *et al.*, 2007). This shows the global importance of irrigated agricultural land, which comprises less than one-fifth of the total cropped area of the world but produces about two-fifths of the world's food. At the same time, irrigation accounts for about 70 % of the global water withdrawals and for about 90% of the global consumptive water use. In order to analyze irrigated crop production and the related irrigation water requirements at the global scale, a digital global map of irrigated areas has been developed, which indicates the areas that were equipped for irrigation (not actually irrigated) in the year 2000.

The first global map of irrigated areas was developed at the Centre for Environmental Systems Research, University of Kassel in 1999. The map described the fraction of each 0.5 degree cell area that was equipped for irrigation

TABLE 2 **Reclassification of GLC 2000 classes into classes used for global land use**

Reclassified classes based on land cover 2000	Original class in GLC-2000
Forests	*Tree cover, broadleaved, deciduous, closed and open.* *Tree cover, needle leaved, evergreen, needle-leaved deciduous.* *Tree cover, mixed leaf type.* *Mosaic tree cover / other natural vegetation.* *Tree cover, ….*
Grasslands	*Herbaceous cover open and closed.*
Shrubs	*Shrub cover, closed-open, evergreen.* *Shrub cover, closed-open, deciduous.*
Cropland and mosaic cropland	*Cultivated and managed areas.* *Mosaic cropland/tree cover / other natural vegetation.* *Mosaic cropland/shrub/grassland.*
Wetlands	*Tree cover, regularly flooded, fresh water.* *Tree cover, regular flooded, saline water.* *Regularly flooded shrub and/or herbaceous cover.*
Sparse shrub and sparse herbaceous	*Sparse shrub and sparse herbaceous.*
Bare areas	*Sparse bush or sparse herbaceous cover. Bare areas, snow and ice, artificial surfaces and associated areas.*
Open water	*Water bodies.*

around 1995. The currently available global map of irrigated areas (version 4.0.1, February 2007) is a version of the above map which has been updated in cooperation with the Land and Water Development Division of the Food and Agriculture Organization of the United Nations (FAO) for all countries worldwide by using a new mapping methodology and also improved source data. The map shows the area within each 5 min cell (area 9.25 km by 9.25 km at the equator) that was equipped for irrigation around year 2000 (see Figure 1.2 in Annex 1).

The information aggregated at 5 arc minutes gives a vital indicator for actual land use systems. The map presents the information on the proportion (%) of areas within each cell which are equipped for irrigation and also of the hectares equipped. The map of percentages has been used by LADA. In evaluating the cell as "low intensity irrigated agriculture", a threshold value had to be chosen (from 5 to 25%). All areas equipped for irrigation above 25% were defined "large-scale irrigated agriculture". Those with an area extent between 5 and 25 % were flagged as having this as an attribute.

2.3 Urban areas

The urban-rural population coverage was created by using a mass-conserving algorithm called GRUMP (Global Rural Urban Mapping Programme), developed by the Centre for International Earth Science Information Network (CIESIN), that reallocates population statistics into urban areas, within each administrative unit. In particular the data inputs are the administrative polygons, containing the total population for each administrative unit and the populated urban extents. The reallocation process works iteratively, so that the output urban and rural proportions match, as closely as possible, the UN ones.

The input data for the GRUMP is a database based on administrative population data and a global database of cities and towns (points). Based on the data available and applying UN growth rates, population was estimated for the year 1990, 1995 and 2000.

The GRUMP urban mask represents an attempt to delineate extents associated with human settlements globally. All the sources of urban extent (the Night-time Lights dataset for the period 1994–1995, the DCW Populated Places polygons and Tactical Pilotage Charts) were combined in order to obtain the maximum possible urban extents for each country.

The initial beta version at 30 arc seconds resolution of the map of urban population was simplified to a single class map (mask of urban areas) and later re-sampled to 5 arc minutes (see Figure 1.3 in Annex 1).

Urban areas, although occupying relatively small proportions of land (each pixel is about 80-100 km^2) are a specific land use that is vital to be recognized. The implication of urban areas for land degradation issues (sealing) is obvious. However, only major and extensive cities are mapped due to the scale of map used.

2.4 Protected areas

The World Conservation Monitoring Centre (WCMC) and UNEP have prepared a coverage of protected areas worldwide that includes national sites with known boundary, national sites without IUCN category, sites within other International Conventions and Agreements with known boundary, wetlands of international importance (Ramsar Sites), World Heritage Sites and UNESCO-MAB Biosphere Reserves. The data where originally published at the scale 1: 1 000 000.

Although the type of land use in these protected areas may vary widely and the level of protection is also not uniform, it was thought important to distinguish these areas from other land uses. Particularly in Africa where large wildlife reserves are present, the distinction is useful in terms of land use and land degradation implications. The locations of protected areas of the world are show in Figure 1.4 of Annex 1, sub-divided into those with extents less than or greater than 10 000 ha.

2.5 Presence of livestock in the Land Use Systems

The procedure uses the tropical livestock unit (TLU) density as an indicator of the intensity of livestock husbandry within a land use unit. Digital geo-referenced data on the presence of cattle and small ruminant livestock species were used to derive the TLU.

To establish appropriate thresholds within the livestock data, a comparison with the map of "Global livestock production systems" (Thornton *et al.*, 2002) has been undertaken.

Data and data sources used were the following:

- Cattle density and small ruminants (sheep + goats) from Wint and Robinson, 2007: (lat/long, WGS84, 3 arc minutes);
- Global livestock production systems by Thornton *et al.*, 2002: (lat/long, WGS84, 3 arc minutes);

- Global land cover 2000 (JRC, 2005) : (lat/long, WGS84, 30 arc seconds).

A detailed explanation of how to obtain classes of livestock density is provided in Annex 2. Figure 1.5 in Annex 1 illustrates livestock densities worldwide.

2.6 Forest use in the Land Use Systems

The assessment of uses in forested areas is based on population (GRUMP, CIESIN 2004) and livestock presence. The detailed method for livestock areas definition is available in Annex 2. Different typologies of use in forest are defined as reported in the following table:

TABLE 3 **Typologies of use in forests**

Forest class	Factors
Protected forests	Protected areas
Managed forest	Population above 0
Grazing forest	Moderate of higher livestock presence
No use	All other forest areas

2.7 Technical procedure to obtain the major Land Use Systems

In order to transform the GLC-2000 land cover classes into major land use systems, a number of steps were required that make use of the additional layers (coverages) of information, notably the urban information coverage, the global irrigation coverage and the livestock density coverage. The various land use systems are identified using a stepwise approach, as illustrated below.

Step 1: Simplify the land classes of GLC-2000 to 8 basic classes (forests, grasslands, shrubs, crops and crop mosaics (agricultural land), wetlands, spare shrubs & herbaceous, bare areas and open water. In addition, use the urban layer to overlay and overrule the existing land cover and identify an urban land use system. These are the nine major subdivisions of the Land Use System classification system (Table 4).

TABLE 4 **Main LUS classes and total areal extents**

Main LUS Class	Area (km^2)	%
Forestry	40 441 370	30,4
Grasslands	12 320 680	9,3
Shrubs	13 116 080	9,9
Agriculture	23 221 183	17,5
Urban	3 502 900	2,6
Wetlands	4 067 544	3,1
Sparsely vegetated areas	10 502 493	7,9
Bare areas	22 723 230	17,1
Water	3 120 192	2,3

Step 2: Overlay the remaining areas with the irrigated area database and classify any pixel in which irrigation occupies more than 25 % of the pixel as irrigated agricultural land (a subclass of agricultural land).

Step 3: Overlay the remaining land with the protected area layer and classify all land within the protected areas as a protected land cover (e.g. protected forest or grassland).

Step 4: Calculate the livestock intensity of each pixel using the procedure explained in Annex 2.

Step 5: For the 4 classes of grassland, shrubs, sparse shrub & herbaceous and bare areas follow the procedure below:

1. High livestock density → intensive livestock rearing
2. Moderate livestock density → moderately intensive pastoral system
3. Low livestock density → extensive grazing
4. No livestock → unmanaged grassland / shrubs / sparse shrubs & herbaceous / bare areas

Step 6: For wetlands and agricultural land if the overlay with livestock indicates a moderate or high livestock density consider the land use system as a combination of forestry (or wetlands) and livestock rearing or crops mixed with grazing alternatively.

Step 7: For forests, sub-divisions are introduced due to livestock and agricultural activities presence (the latest approximated using population presence).

Step 8: For forests, the remaining sub-divisions are virgin forests, agroforestry and plantations (no distinction can be made at a world level). For grassland and shrub the presence of stable fed cannot be mapped at a global level. For agriculture, the remaining subclass is rainfed agriculture. For wetlands, there remain two possibilities: mangroves and unmanaged.

Step 9: Classify all open water areas as inland fisheries.

The final result is the LADA Global Map of Land Use Systems (see Figure 1.6 in Annex 1). The Land Use Systems are then further characterized by a number of biophysical and socio-economic attributes that are attached to the LUS units.

CHAPTER 3

The Major Ecosystems

Apart from land cover, ecosystems are mainly characterized by climate, terrain and by type of soil. These attributes are classified in a systematic manner in the LUS approach.

3.1 Global base maps used

- The Global Agro-Ecological Zoning (GAEZ, (FAO / IIASA, 2010) study provides maps of thermal regimes and the length of the available growing period (LGP), also of slopes and terrain. These can be combined to indicate major, climatically determined ecosystems.
- Based on altitude and slope (derived from digital elevation model), an arbitrary difference can be made between mountainous (between 800 and 1500 m having slopes >5 %, between 1500 and 2500 m having slopes >2 % and above 1500 m) and non-mountainous areas.
- The latest Harmonized World Soil Database (HWSD, FAO *et al*. 2008) provides information on soil types and soil characteristics. This can be used to further characterize the ecosystem.

3.2 Procedure

Step 1: Determine the temperature regime of the ecosystem

Based on actual temperature distribution throughout the year, seven major classes of temperature regimes are characterized: warm tropics, cool tropics, subtropics, Mediterranean (also based on moisture concentration in winter), temperate, boreal and polar (Table 5).

Step 2: Determine the moisture regime of the ecosystem

The map of the total length (number of days) of the growing period (LGP) was prepared by FAO / IIASA (2010 and Fischer, 2009), using averages from the database of the Climate Research Unit of the University of East Anglia (CRU) plus average precipitation from the Global Precipitation Climatology Centre (GPCC).

Under rainfed conditions, the beginning of the LGP is linked to the start of the rainy season when mean temperatures are above 5°C. For establishing crops, 0.4 – 0.5 times the level of reference evapo-transpiration is considered sufficient to meet water requirements of dryland crops (FAO 1978-81, 1992).

Table 6 recognizes five moisture regimes: deserts (hyper arid), drylands, sub-humid, humid and per-humid.

TABLE 5 **Temperature regime classification**

Thermal regime	Temperature and rainfall regime
Tropics All months with monthly mean level above 18°C	**Warm Tropical** *All months have mean temperature over 20°C* **Cool Tropical** *One or more months with mean temperature less thanr 20°C*
Subtropics One or more months with monthly mean temperatures, below 18°C but above 5°C and 8-12 months above 10°C	**Subtropics** Northern hemisphere: P/PET in April-September ≥ P/PET in October-March. Southern hemisphere: P/PET in October-March ≥ P/PET in April-September **Mediterranean** Northern hemisphere: P/PET in October-March ≥ P/PET in April-September. Southern hemisphere: P/PET in April-September ≥ P/PET in October-March
Temperate At least one month with monthly mean temperatures, below 5°C, four or more months above 10°C and 4-7 months above 10°C	**Temperate** *No subdivisions (could be done on the basis of continentality)*
Boreal At least one month with monthly mean temperatures, below 5°C and 1-3 months above 10°C	**Boreal** *No subdivision (could be done on the basis of continentality)*
Polar All months with monthly mean temperatures, below 10°C	**Polar**

Table 6 **Reclassification of length of growing period (LGP) days (FAO/IIASA, 2010)**

Definition	Number of LGP days
Deserts	< 60
Drylands	60 – 180
Sub humid	180 – 270
Humid	270 - 330
Per-humid	> 330

(see LGP map in Figure 1.8 of Annex 1)

Step 3: Split ecosystems in drylands areas and humid areas

Determine if a dryland or a humid ecosystem occurs. Ecosystems are defined as follows:
1/ Polar ecosystems are undifferentiated;
2/ All Boreal areas are defined as drylands;
3/ Areas with LGP less than 60 days are defined as deserts;
4/ Temperate, Mediterranean and Subtropical areas are defined as either Drylands or Humid;
5/ Drylands are defined as occurring in areas with LGP below 180 days. All remaining areas are classified as Humid;
6/ Cool tropics are undifferentiated;
7/ Warm tropics are sub-classified by all LGP classes defined in Table 6.

Maps of the individual layers are available on-line and the information is displayed in the attribute table of the Land Use Systems map (Figure 1.6 in Annex1).

A map defining the major climatic ecosystems, which combines the simplified temperature and moisture regimes is available in Figure 1.7 Annex 1. The distribution worldwide is tabulated below.

Table 7 **Ecosystem classes**

Ecosystem class	Area (km²)	%
Polar	9 966 060	7,4
Boreal drylands	20 742 000	15,4
Temperature humid	7 485 630	5,6
Temperate drylands	15 959 100	11,9
Mediterranean humid	1 729 900	1,3
Mediterranean drylands	1 858 630	1,4
Subtopical humid	2 881 990	2,1
Subtropical drylands	3 958 410	2,9
Cool Tropic mixed	3 709 310	2,8
Warm Tropics perhumid	5 516 010	4,1
Warm Tropics humid	8 167 770	6,1
Warm Tropics sub-humid	13 243 900	9,9
Warm Tropics drylands	10 658 900	7,9
Deserts	28 415 300	21,2

Step 4: Include the major soil unit and its associated soil properties

Soils are a main component of the ecosystem and their effect on its functions and the goods and processes on-going in the system should not be underestimated. The Harmonized World Soil Database (HWSD) readily provides at a global level and with high resolution (30 arc seconds or approximately 1km by 1km) information on soil type and 15 soil properties in top- and subsoil (Figure 1.9 in Annex 1). The HWSD (FAO / IIASA / ISRIC / JRC and C-AS - 2008) can be readily queried for any parameter and exported in GIS format. Given the many combinations possible (29 soil units, 14 texture classes, a number of soil fertility classes etc....), only the base map with the main soil type is provided as an attribute and it is up to the user to select one or more of the soil properties associated with it in HWSD to further characterize the ecosystem at more detailed scales.

4

CHAPTER

The Land Use attributes

Four different types of information on land use and land use practices are provided in the attribute table:

- dominant livestock type;
- dominant crop type(s);
- presence of small scale irrigation;
- a crop management index.

Databases and a summary of the procedure followed are given below.

4.1 Dominant livestock types

The same database used for the livestock density calculation is used (see section 2.5). A differentiation is made between cattle, small ruminants (goats and sheep), pigs and poultry. The methodology to obtain these is explained in Annex 2.

4.2 Dominant crop types

Dominant crops are defined on the basis of their harvested areas within the administrative unit in the Agro-MAPS database (FAO, 2006). The dominant crops are the crops with the greatest extent of harvested area; these are summed until 70% of the total harvested area is reached. If the number of crops needed to reach 70% is more than 3, then the crop combination in the administrative unit is defined as “MIXED”.

This procedure is automated in the online version of Agro-MAPS' program and has been used to determine the dominant crop and crop groups in all administrative districts for which data were available in Agro-MAPS.

Note that crop combinations "wheat-tomatoes" and "tomatoes-wheat", both showing the same crops as dominant, are listed alphabetically in the same single dominant crop combination ("tomatoes-wheat").

The same procedure is used for determining the dominant crop-group combinations, using FAO crop groups as listed in Annex 3.

Where no data are present in Agro-MAPS, the crop considered is the one with the highest production within the 5 minute pixel in the Beta version of the IFPRI database (Wood and You, 2006). The procedure used is explained in detail in Annex 3.

The maps are presented in Figure 1.11 of Annex 1.

4.3 Small-scale irrigation

Where irrigation is present in an area occupying 5 to 25 % of the pixel as indicated in the irrigation database (section 2.2), this is flagged as small-scale irrigation in the attribute database.

4.4 Crop management index

Intensity of agriculture (cropped) land use systems can be deduced using the crop statistics present in FAOSTAT (IIASA, 2009). The management index is estimated by comparison of down-scaled year 2000 yields (international price weights of 2000/2001) with potential low input yields. Ratios of less than 1.0 represent areas where current yield levels are below its potential at low level input and management circumstances. High management factor ratios represent a higher intensity of agricultural activities and therefore a pollution risk.

5

CHAPTER

Biophysical attributes of ecosystems

A number of biophysical attributes can be displayed, which provide more information on the local conditions in each land use system. These are a refinement of the climatic ecosystem classes as defined in section 3.

5.1 Temperature regime class

The actual temperature distribution and characteristics as given in Table 5 can be displayed as an attribute.

5.2 Length of growing period class

The precise length of the growing period (LGP) in 30 day classes is indicated basing on data from FAO / IIASA 2010. A corresponding moisture class as given in Table 6 is attached to the information (see Figure 1.8 of Annex 1).

5.3 Dominant soil unit

The dominant soil unit is derived from the Harmonized World Soil Database (FAO/IIASA/ISRIC/JRC and C-AS, 2008) and links potentially to 15 soil properties when used in combination with the land use system map. The map is presented in Figure 1.9 of Annex 1.

5.4 Terrain information

The input map for the combining procedure is based on the elevation and on the median slope class produced within FAO / IIASA / ISRIC / JRC and C-AS (2008) under "Terrain data". The median elevation and slope class of 30-arcsec pixels was calculated from slopes at 3-sec SRTM data. For latitudes north of 60° N and south of 60° S, slope classes are determined as before from GTOPO30 data. Data were originally in 30" resolution and were re-sampled at 5'.

In the slope dataset, data were originally group in the following classes: Unclassified, 0-0,5%, 0,5-2%, 2-5%, 5-8%, 8-16%, 16-30%, 30-45%, > 45%. A simplified map is presented in Figure 1.10 of Annex1.

Based on altitude and slope, a further attribute was implemented. An arbitrary difference is made between mountainous (between 800 and 1500 m having slopes >5 %, between 1500 and 2500 m having slopes >2 % and above 1500 meters) and non-mountainous areas. All other areas are considered plains or plateaus.

6

CHAPTER

Socio-economic attributes of Land Use Systems

At a global and regional level, it is necessary to generalize to a great extent as sub-national socio-economic factors are seldom available or mapped. For the purposes of LADA, two socio-economic factors were retained that were considered to have a direct influence on the actual land use. It was realized that in national and local studies these are the factors that will have to be refined considerably (land tenure, market access etc.).

6.1 Population density

The urban-rural population grid was created by using a mass-conserving algorithm called GRUMP (Global Rural Urban Mapping Programme), developed by CIESIN (Centre for International Earth Science Information Network), that reallocates population statistics into urban areas, within each administrative unit. In particular, the data inputs are the administrative polygons, containing the total population for each admin. unit and the populated urban extents. The reallocation process works iteratively in order that the output urban and rural proportions match, when possible, the UN ones. (See section 2.3 for detailed explanation.)

Young *et al*. (2000) found a very close correlation between the extent of and the severity of land degradation as mapped in GLASOD and the population density in most countries. This contradicts some case studies (e.g. Machakos, Kenya in Tiffen and Mortimore, 1992), which have shown positive effects of higher population density on land degradation. An example of the GRUMP map for sub-Saharan Africa is presented in Annex1, Figure 1.12.

6.2 Poverty

As with population density, the poverty level is not directly used in the land use characterization, but as it is thought to be a very important driver of land degradation it is included as an attribute of the land use system to be investigated at a later date. Information on sub national poverty levels is scarce and needless to say politically sensitive. The database used here is the Global Subnational Infant Mortality Rates for the year 2000 (CIESIN, 2005), defined as the number of children who die before their first birthday for every 1000 live births. Data are distributed in a gridded version with the resolution of 2.5 arc minutes (approximately 4.5 by 4.5 km at the equator). The map is presented in Figure 1.13 in Annex 1.

1

ANNEX

Input and output maps in Land Use Systems method

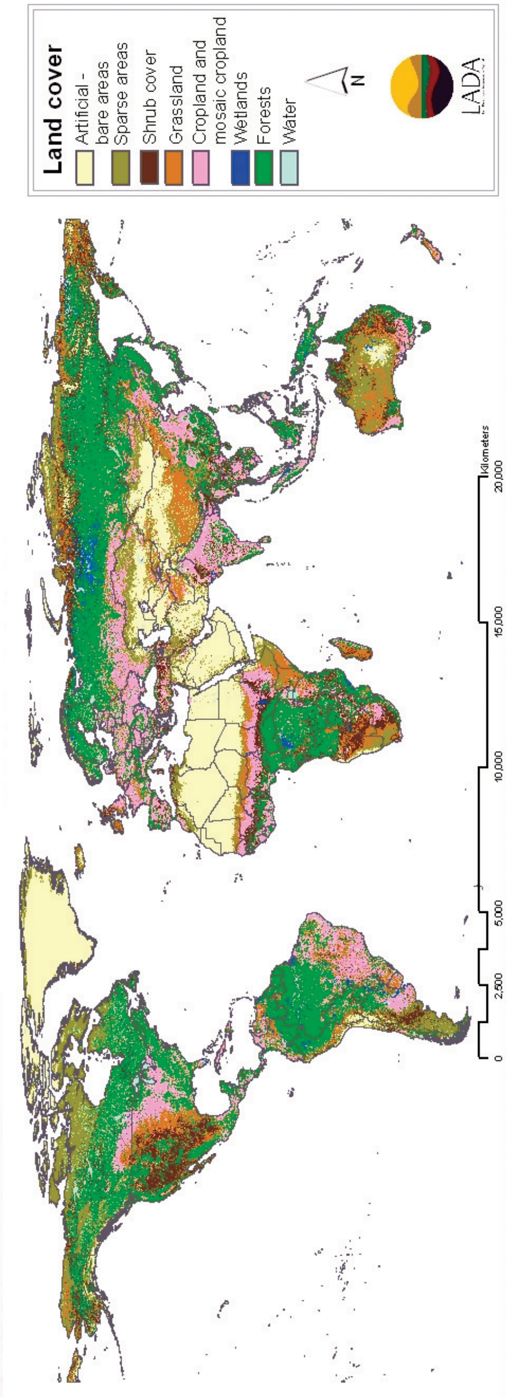

FIGURE A1.1 **Reclassified Global Land Cover (GLC-2000)**

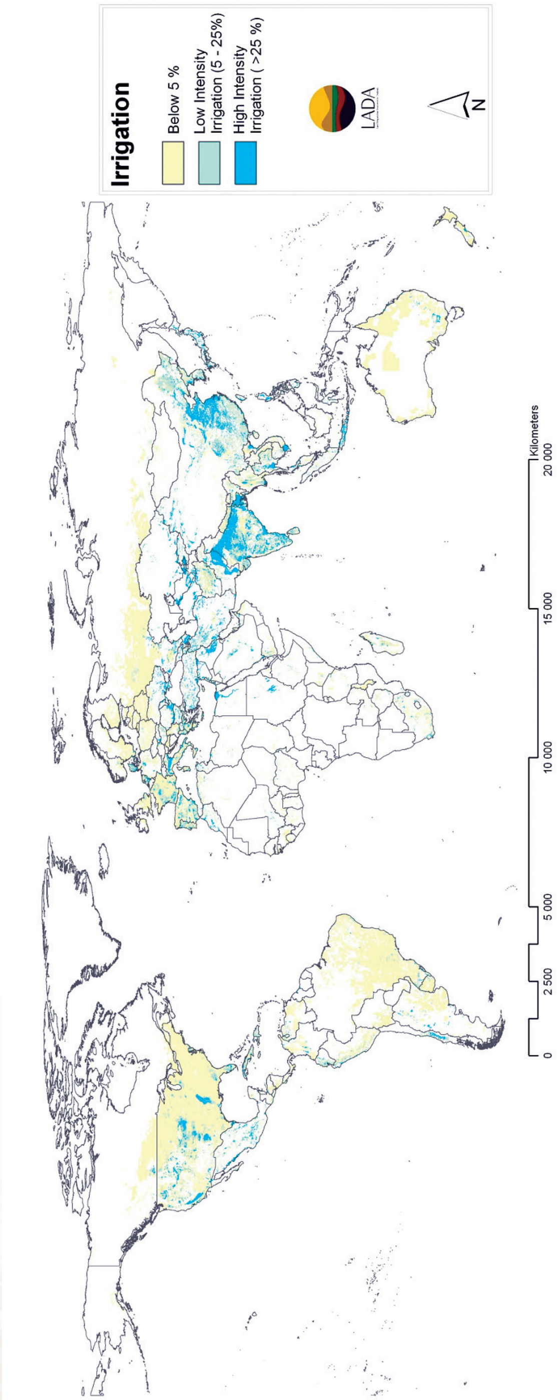

FIGURE A1.2 **Reclassified Global map of Irrigated Areas** (University of Frankfurt in cooperation with FAO)

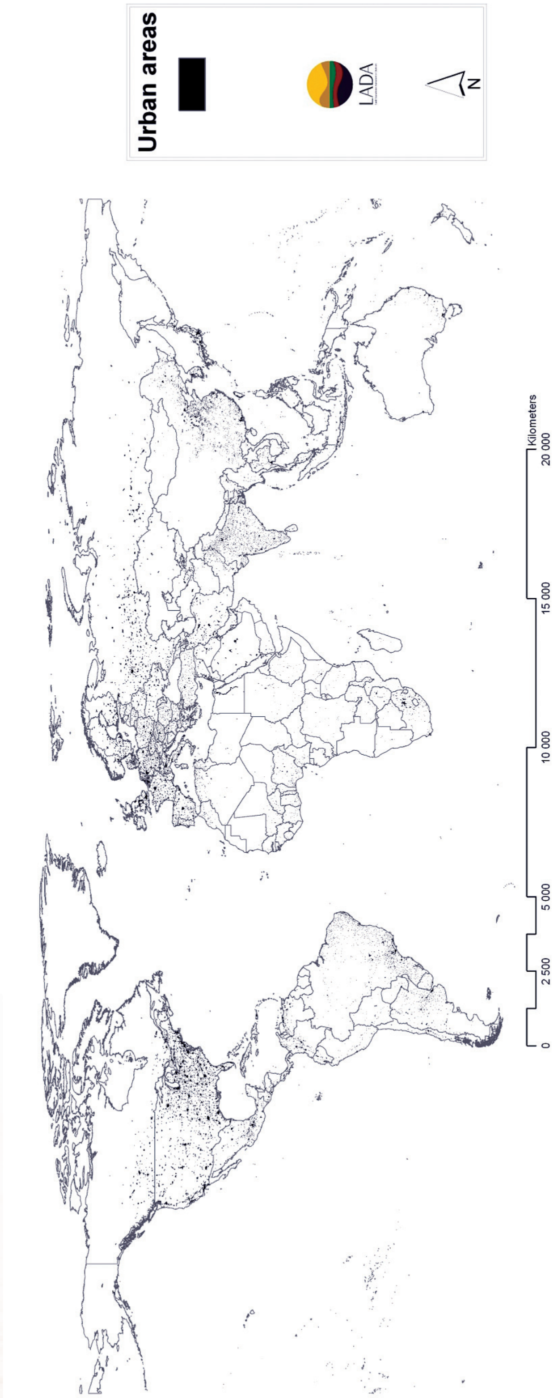

FIGURE A1.3 **Urban Areas** (GRUMP database)

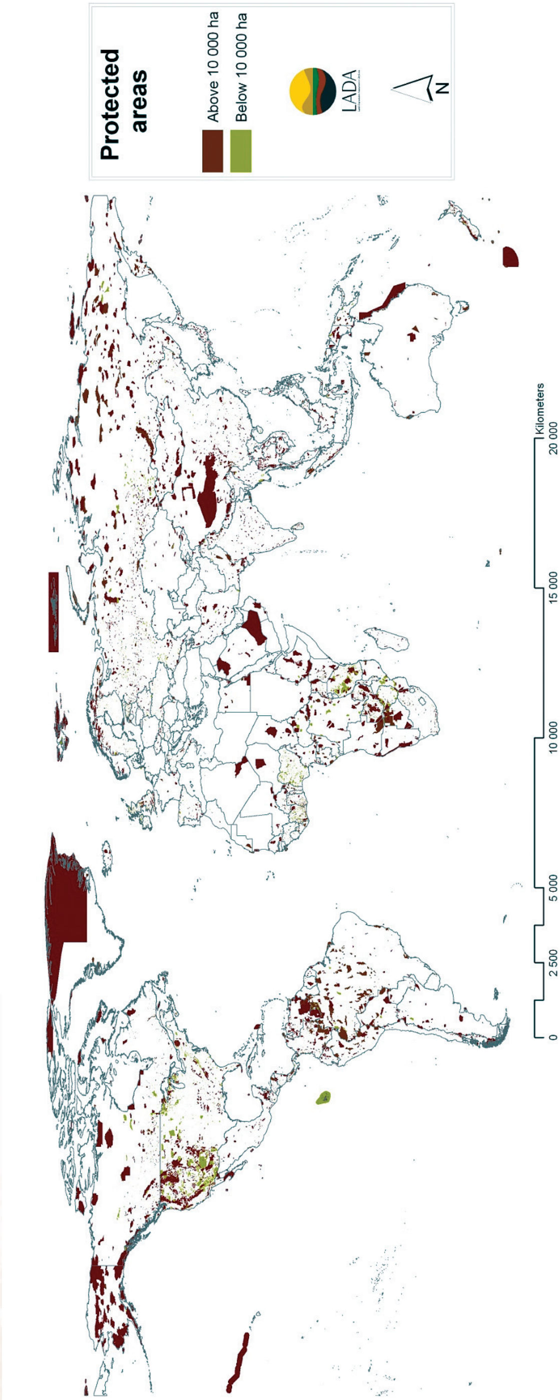

FIGURE A1.4 **Protected Areas** (over 10 000 ha in area – source: World database on protected areas, 2007)

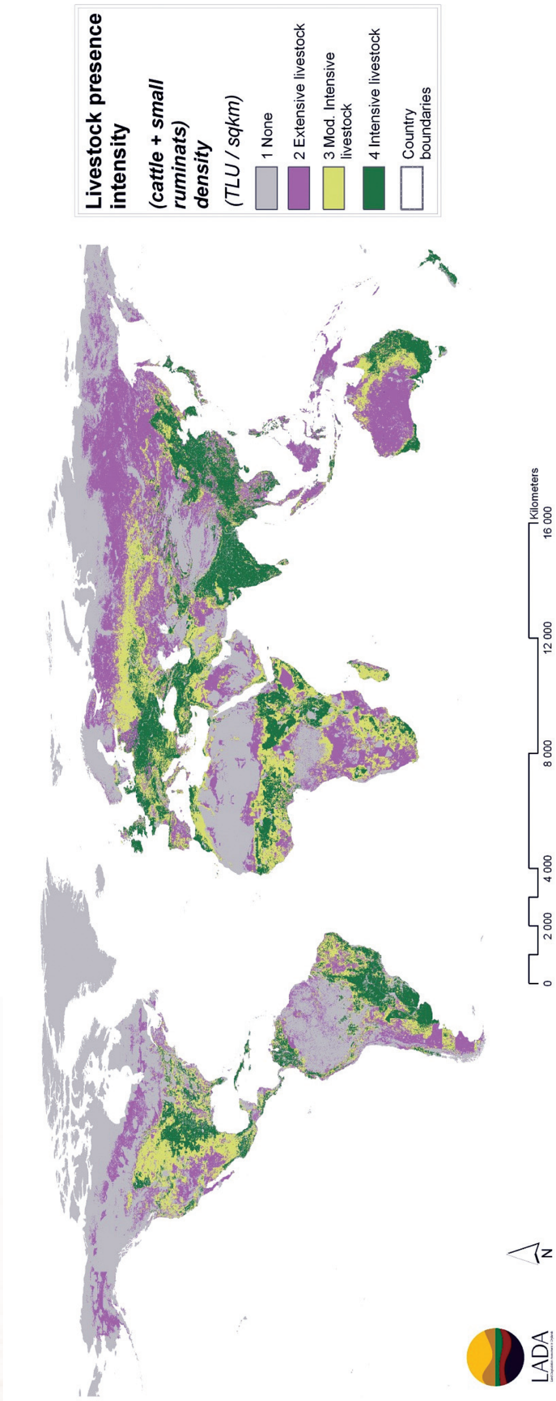

FIGURE A1.5 **Livestock Densities** (cattle plus small ruminants TLU)

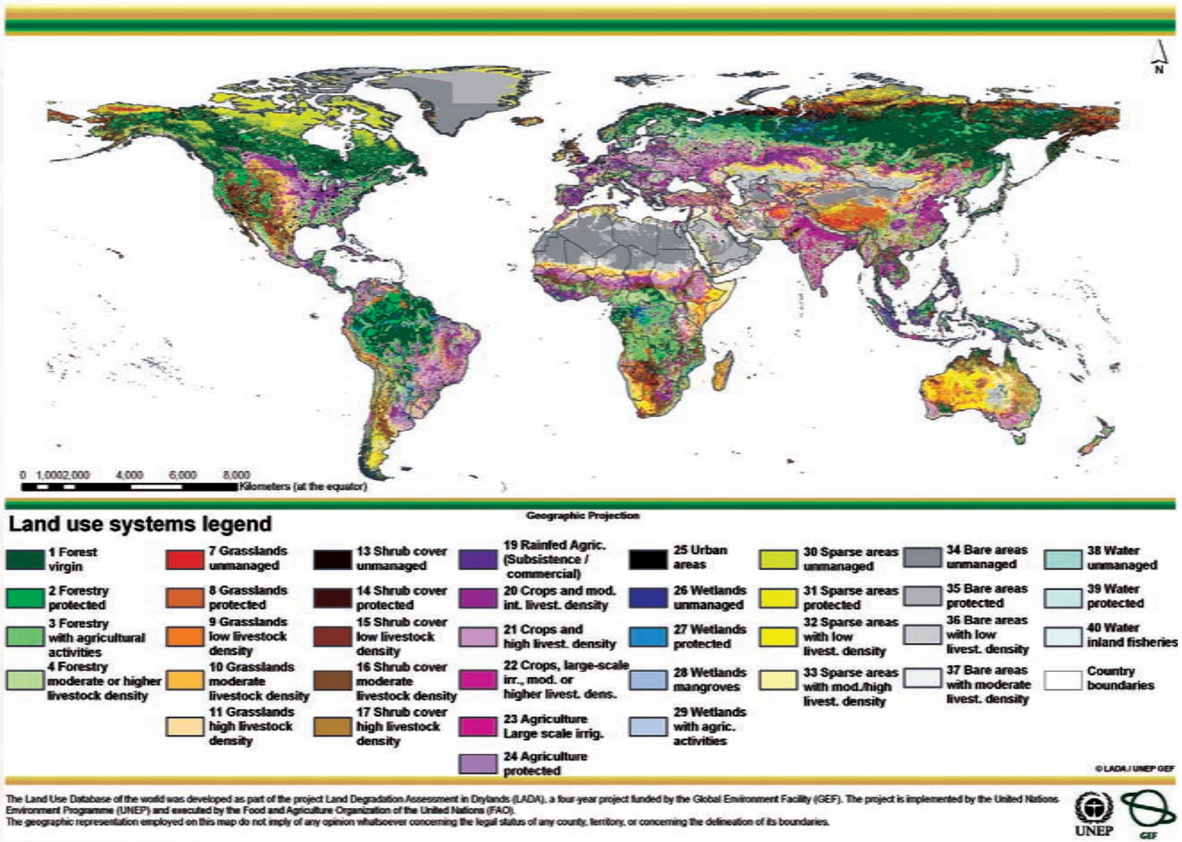

FIGURE A1.6 **LADA Global Map of Land Use Systems**

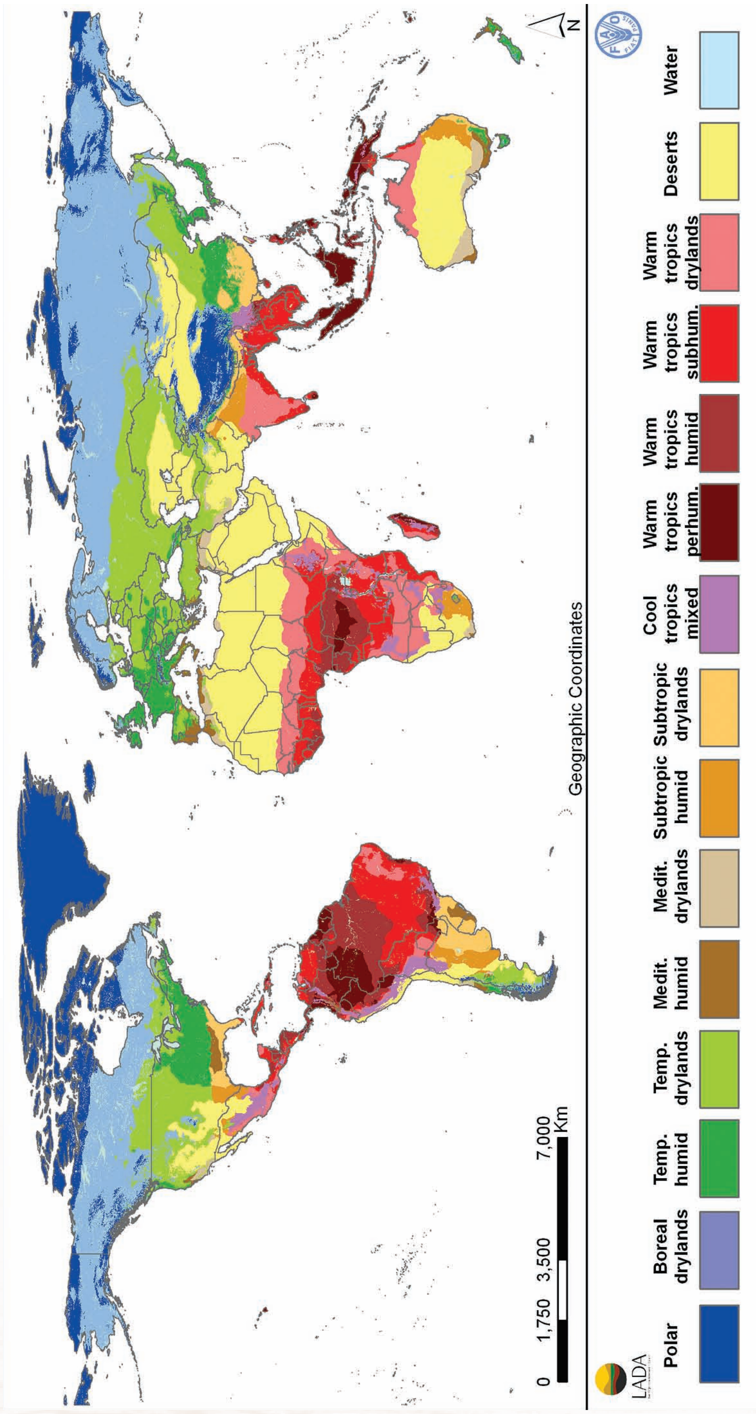

FIGURE A1.7 **Climatic Ecosystems** (derived from FAO/IIASA GAEZ, 2010)

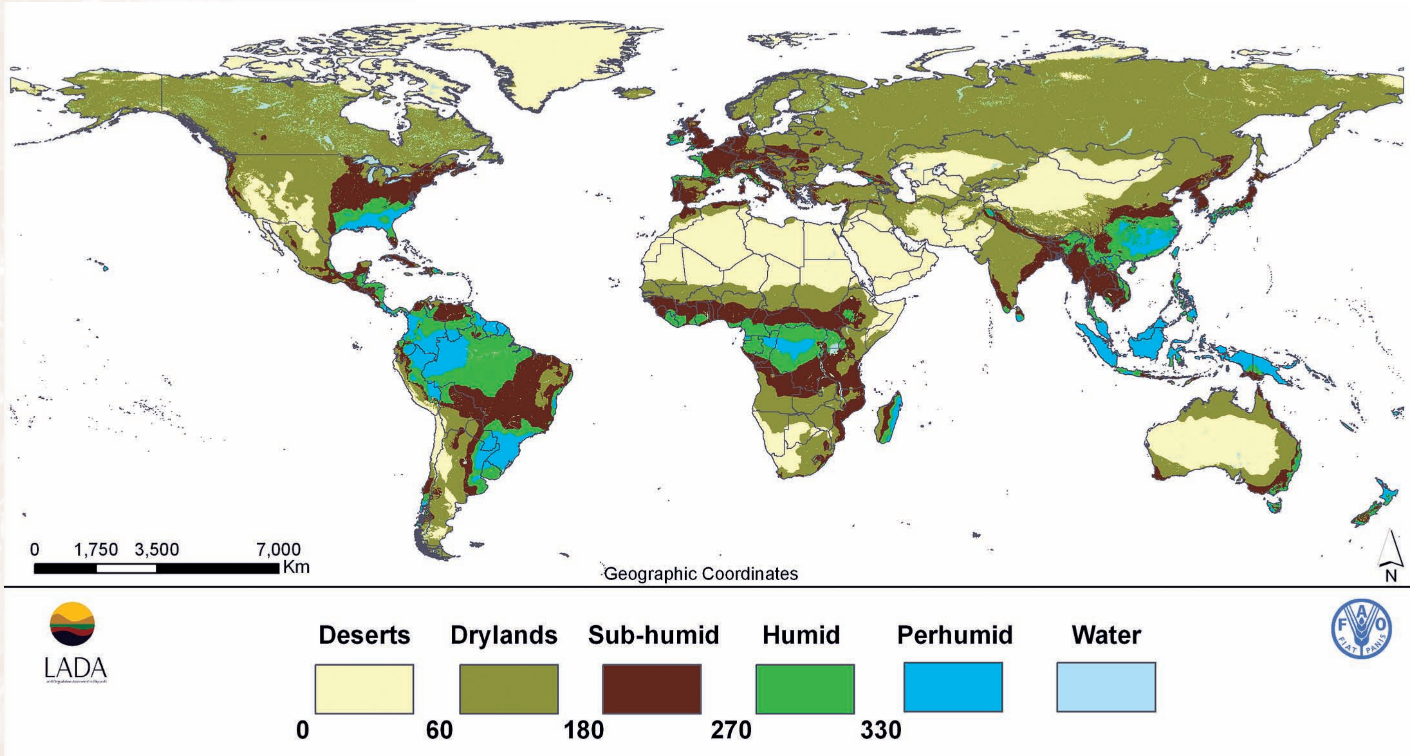

FIGURE A1.8 **Reclassified Length of Growing Period** (FAO/IIASA GAEZ, 2010)

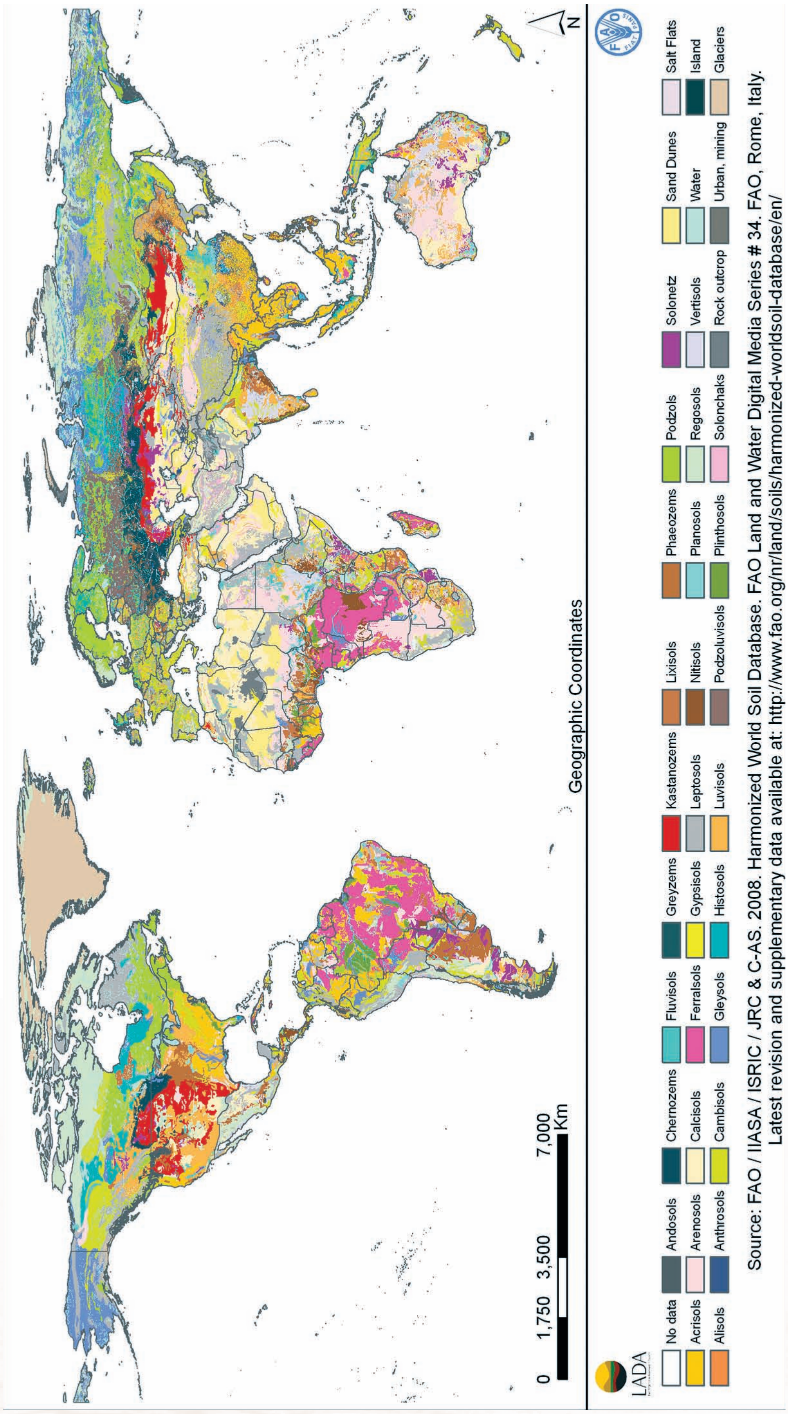

FIGURE A1.9 **Soils** (HWSD 2010)

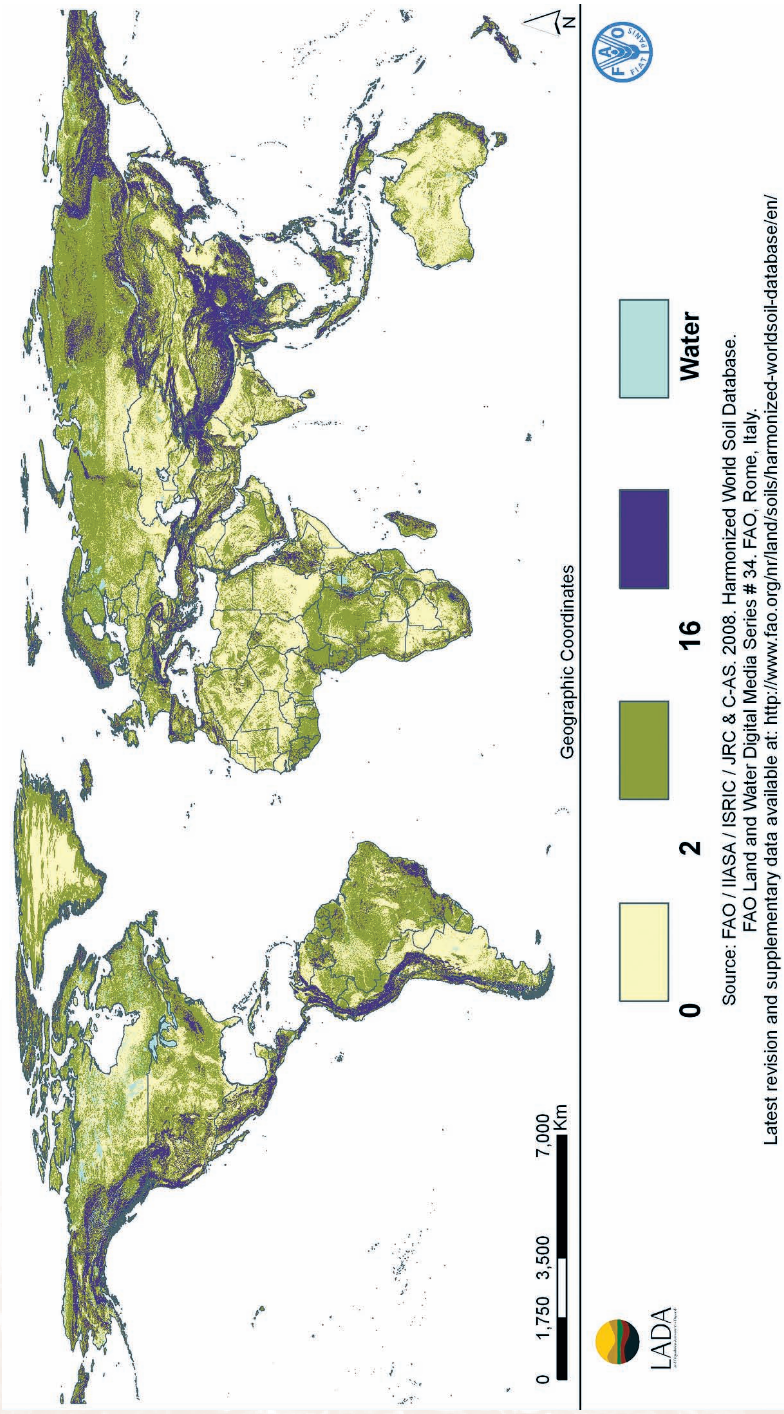

FIGURE A1.10 **Reclassification of Terrain** (FAO/IIASA GAEZ, 2007)

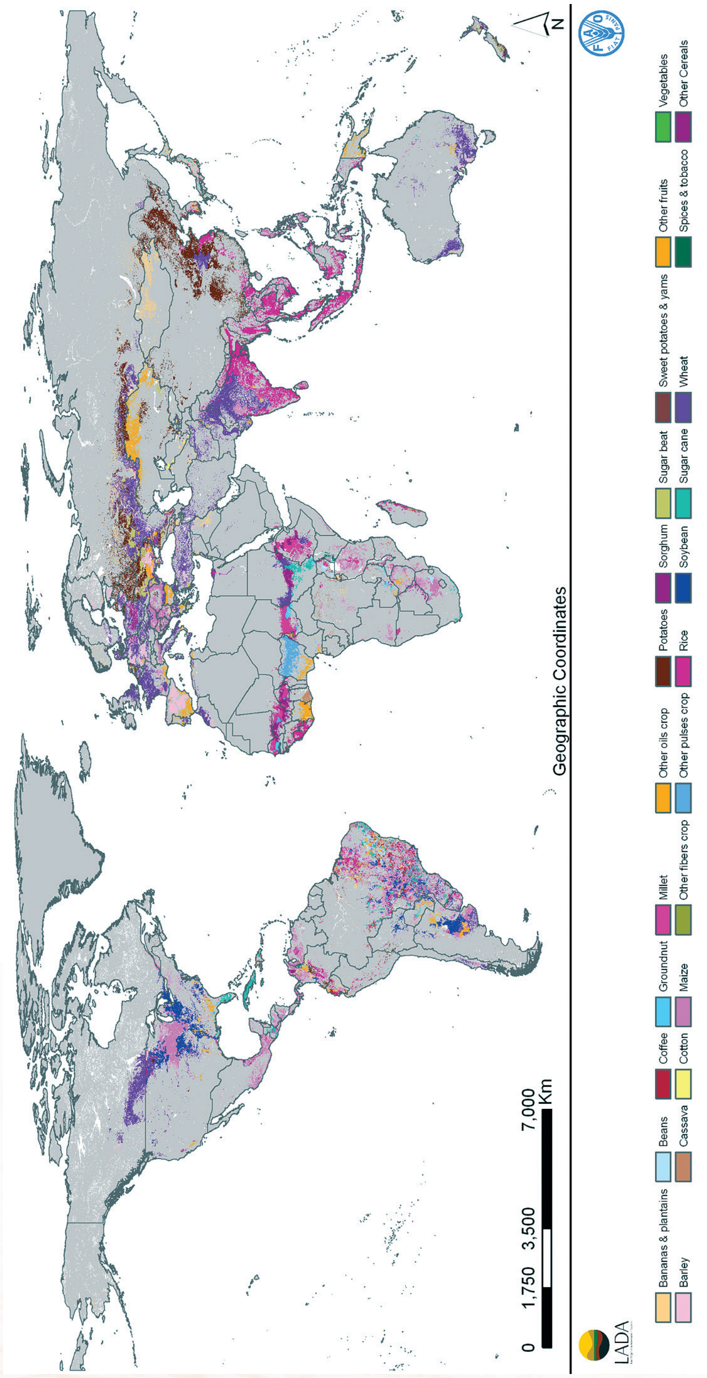

FIGURE A1.11 **Dominant Crops** (source: Agro-MAPS and beta IFPRI data)

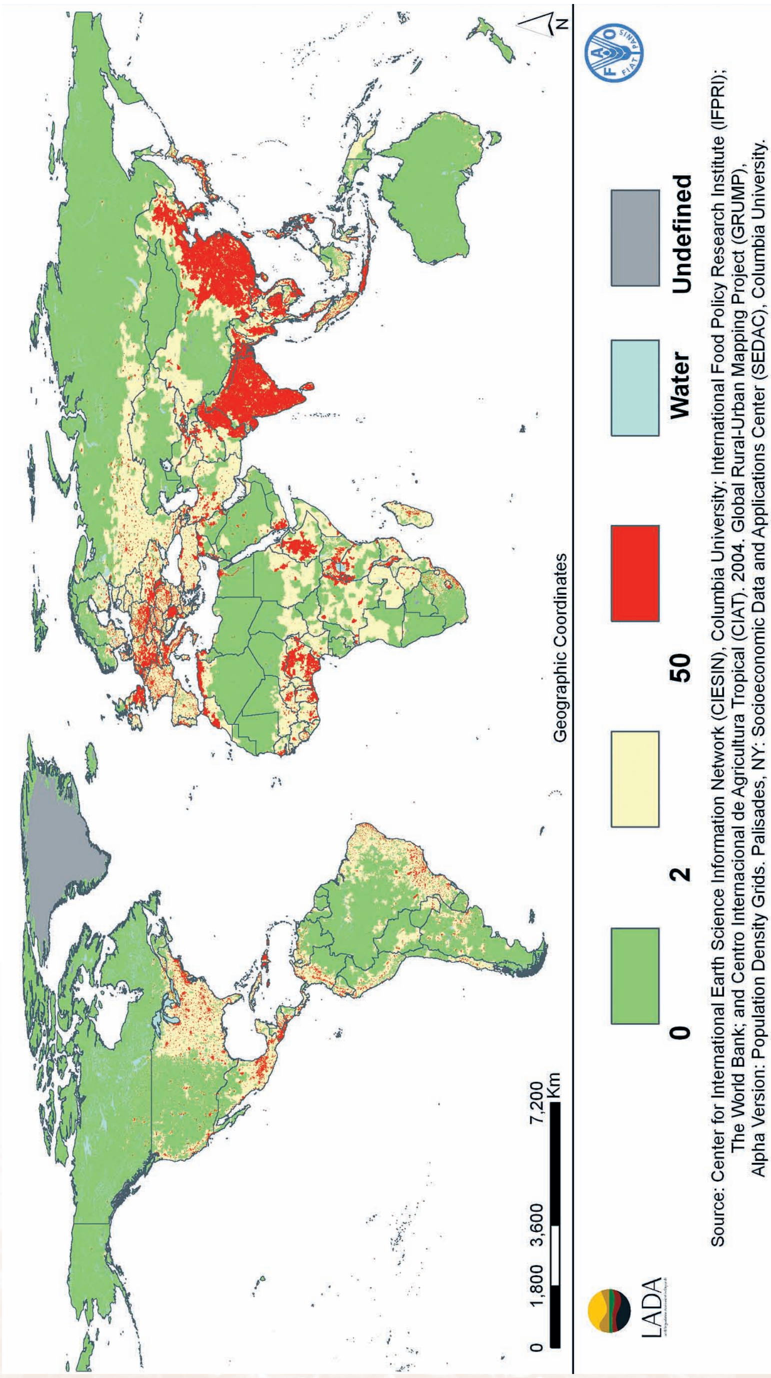

FIGURE A1.12 **Reclassification of Population density** (source: GRUMP database)

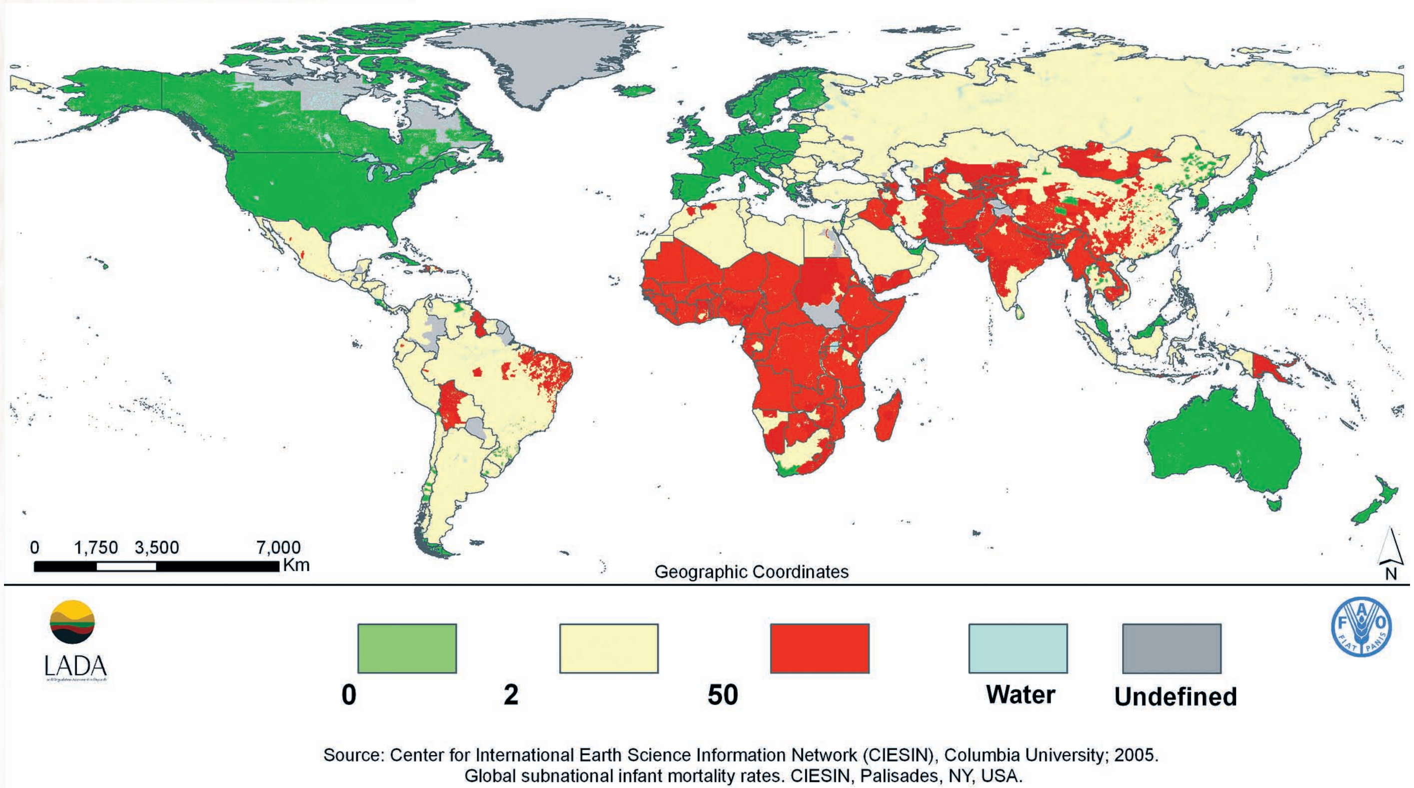

FIGURE A1.13 **Reclassification of Infant Mortality Rate** (source: CIESIN)

2

ANNEX

Livestock presence in Land Use Systems

The procedure uses the Tropical Livestock Unit (TLU) density as an indicator of the intensity of livestock husbandry within a land use unit. Digital geo-referenced data on the presence of cattle and small ruminant livestock species (sheep & goats) were used to derive the TLU.

To establish appropriate thresholds within the livestock data, a comparison with the map of "Global livestock production systems" (Thornton *et al*., 2002) was undertaken.

Data and data sources used were the following:

- Cattle and small ruminants (sheep & goats) density from Wint and Robinson, 2007: (lat/long, WGS84, 3 arc minutes, data is multiplied by 10), Figure 2.1a in Annex 2;
- Global livestock production systems by Thornton *et al*., 2002: (lat/long, WGS84, 3 arc minutes, qualitative data description), Figure 2.1b in Annex 2;
- Area file: (lat/long, WGS84, 3 arc minutes, data in sq km), used in statistics.

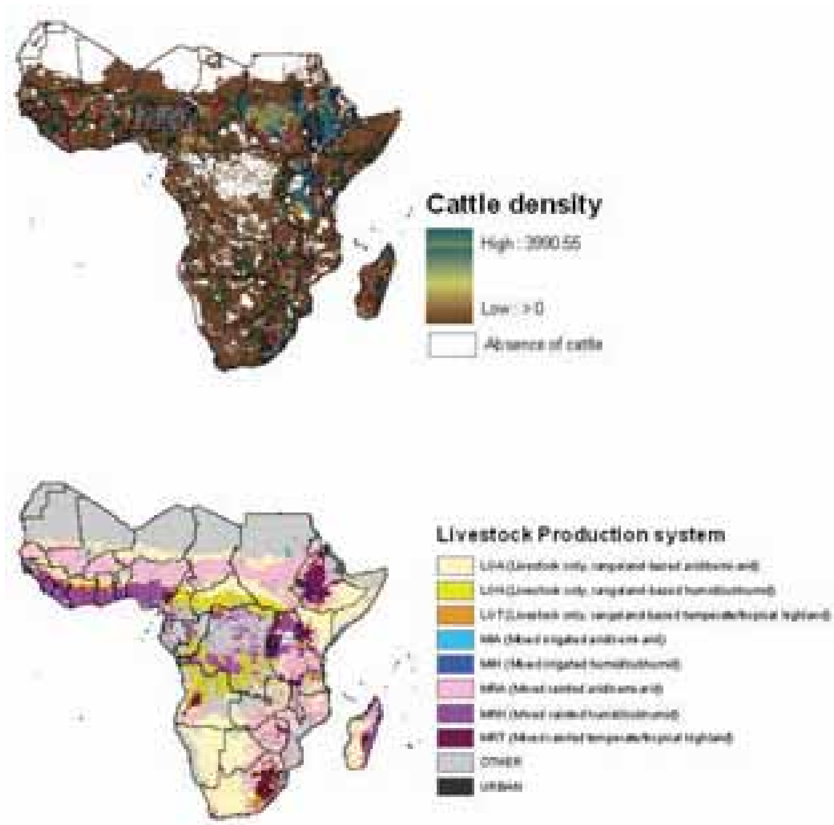

FIGURE A2.1 **Input data used for livestock classification. a) Cattle density in Sub Saharan Africa** (Wint and Robinson, 2007); **b) Global livestock production systems** (Thornton *et al.*, 2002)

An example for Sub-Saharan Africa, with the steps used to obtain the TLU in each unit are illustrated in Figure 2.2 in this Annex.

In detail, the following GIS steps were undertaken for each region:
Step 1 – cattle density, sheep density and goat density from the gridded livestock database were used as input data;

Step 2 – density maps have been converted to numbers of animals, using the formula suggested in the data manual (number of animal = [density file / 10] * area file);

Step 3 – to work with a unique unity of measurements for all livestock, the number of animals was expressed in tropical livestock units (TLU). In this procedure, the cattle numbers are converted to TLU by multiplying by 0.7, while sheep and goats numbers are multiplied by 0.1;

Step 4 – "cattle + small ruminants TLU density" is then calculated (TLU / area);

Step 5 – the mean "cattle + small ruminants TLU density" per livestock production system was computed. Results are shown in this Annex (2) Figures 2.3a (Sub-Saharan Africa), Figure

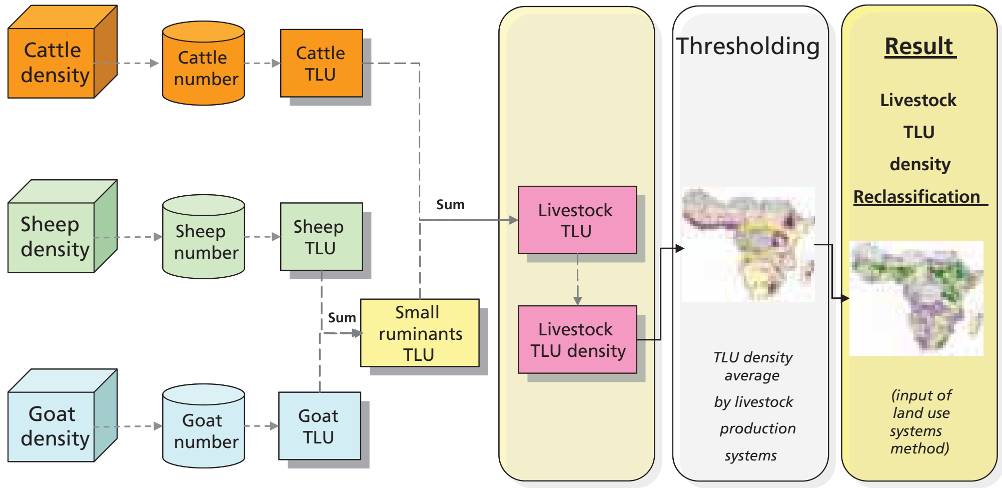

FIGURE A2.2 **Procedure used to obtain TLU in each 3 arc minutes pixel**

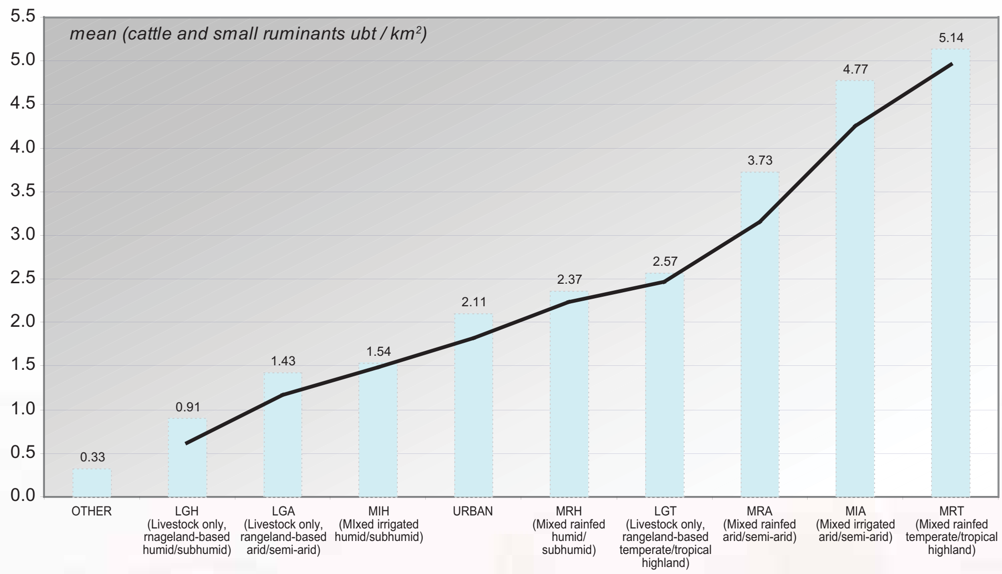

FIGURE A2.3a **Mean TLU/km² in the main livestock production systems in Sub Saharan Africa**

2.3b (South and Central America) and Figure 2.3c (East Asia and Pacific), Figure 2.3d (North Africa and the Near East) and Figure 2.3e (South Asia). Class thresholds for the TLU densities were consequently based on the class limits from the main livestock production systems and reclassified in 4 or 5 classes (Table 2.1 in Annex 2).

Step 6 – where the global livestock production systems was not available, statistics and thresholding was undertake basing on the Global Land Cover 2000 (JRC, 2005) reclassified with the same method used in LUS mapping. Areas computed based on the different inputs are mapped in Figure 2.4. The mean "cattle + small ruminants TLU density" per land use are shown in Figure 2.5a (Australia and New Zealand), Figure 2.5b (Eastern Europe and Central Asia), Figure 2.5c (North America), Figure 2.5d (Europe). Class thresholds are listed in Table 2.2.

The map of livestock densities is presented in Annex 1 Figure 1.5.

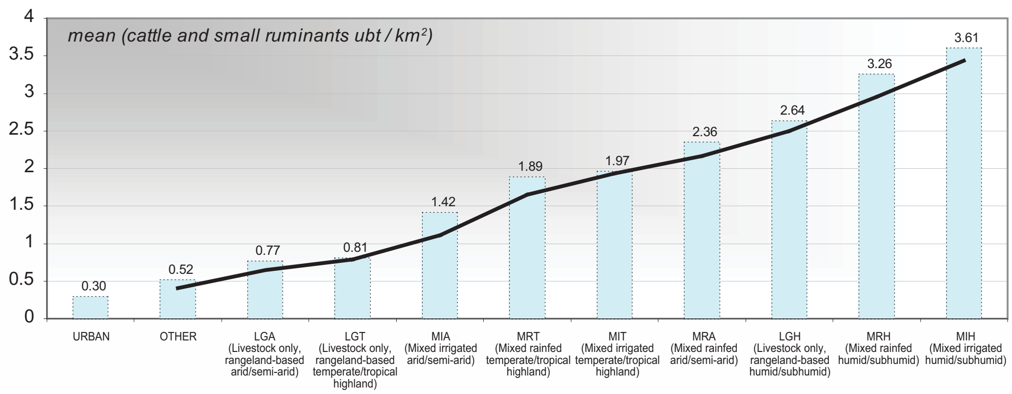

FIGURE A2.3b **Mean TLU/km² of "cattle + small ruminants" in the main livestock production systems in South and Central America**

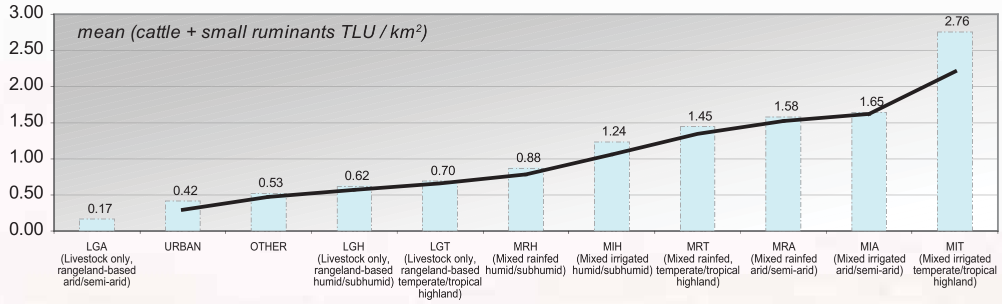

FIGURE A2.3c **Mean TLU/km² of "cattle + small ruminants" in the main livestock production systems in East Asia and Pacific**

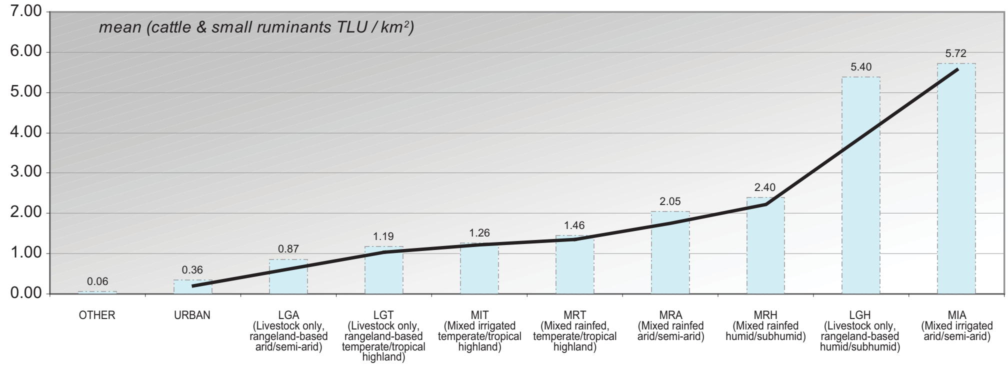

FIGURE A2.3d **Mean TLU/km² of "cattle + small ruminants" in the main livestock production systems in North Africa and Near East**

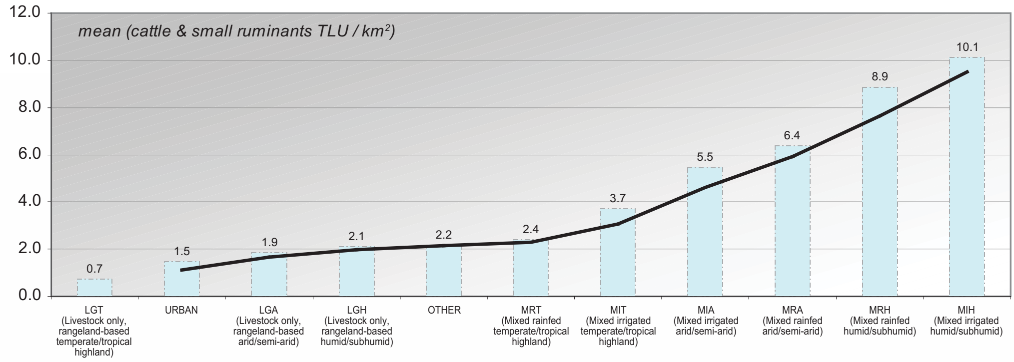

FIGURE A2.3e **Mean TLU/km² of "cattle + small ruminants" in the main livestock production systems in South Asia**

TABLE A2.1 **TLU and its interpretation for the Land Use System for each region, based on Global Livestock Systems**

Livestock presence description	**LUS description**	**Sub-Saharan Africa** (TLU/km²)	**South and Central America** (TLU/km²)	**East Asia and Pacific** (TLU/km²)	**North Africa and Near East** (TLU/km²)	**South Asia** (TLU/km²)
Absence	Non pastoral area	0	0	0	0	0
Very low	Extensive pastoralism	0 – 0.33	0 – 0.52	0 – 0.52	0 – 0.06	0 – 0.70
Low	Mod. extensive pastoralism	0.33 – 2.57	0.52 – 1.89	0.52 – 0.87	0.06 – 1.19	0.70 – 2.40
High	Intensive pastoralism	2.57 – 3.73	1.89 – 2.64	0.87 – 1.65	1.19 – 1.46	> 2.4
Very high	Intensive pastoralism	> 3.73	> 2.64	> 1.65	> 1.46	– –

FIGURE A2.4 **Baseline data used to compute livestock statistics and elaborate TLU density thresholding**

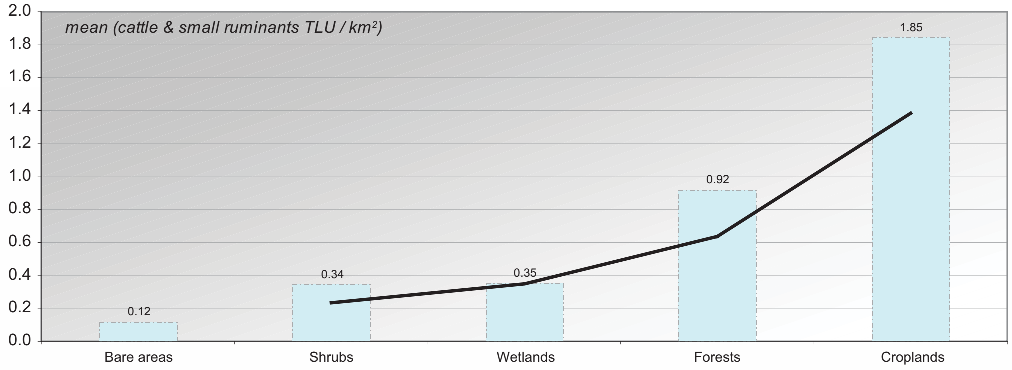

FIGURE A2.5a **Mean TLU/km² in the reclassified land cover in Australia and New Zealand**

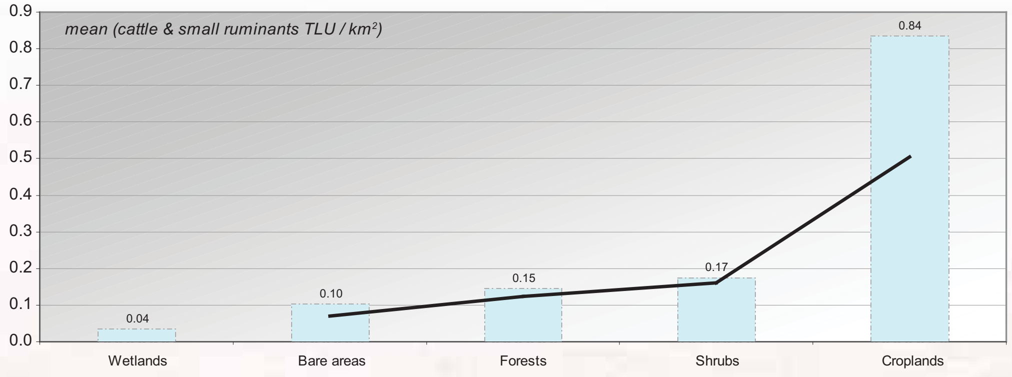

FIGURE A2.5b **Mean TLU/km² in the reclassified land cover in Eastern Europe and Central Asia**

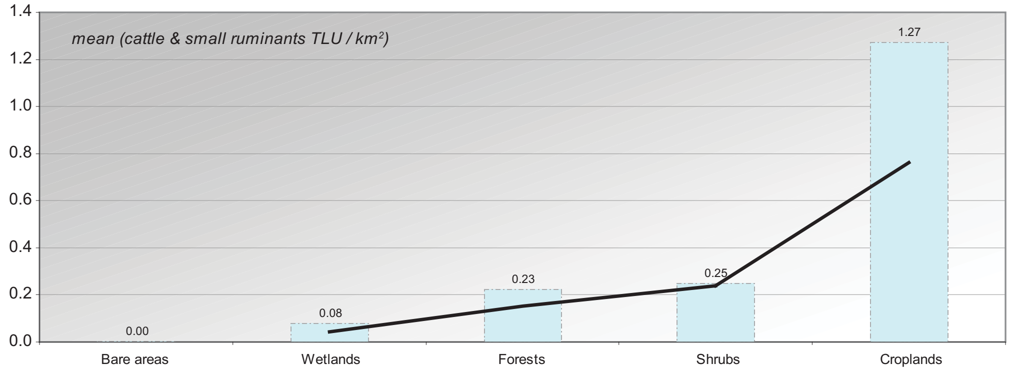

FIGURE A2.5c **Mean TLU/km² in the reclassified land cover in North America**

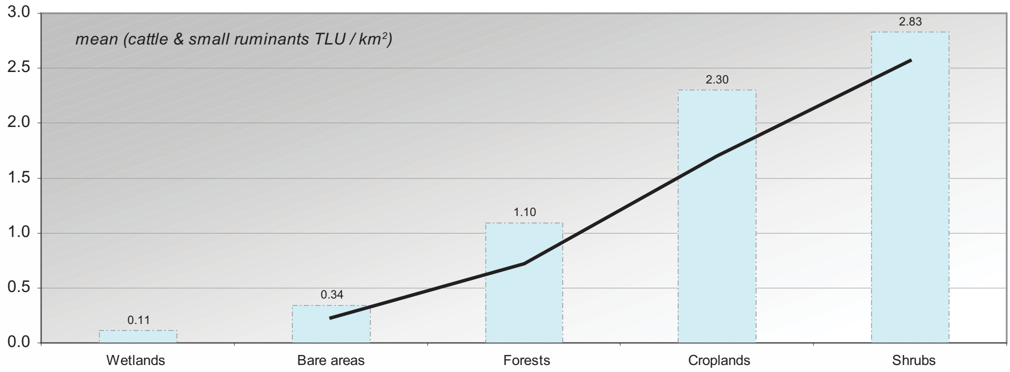

FIGURE A2.5d **Mean TLU/km² in the reclassified land cover in Europe**

TABLE A2.2 **TLU and its interpretation for the land use system for each region, based on Global Land Cover**

Livestock presence description	**LUS description**	**Australia** (TLU/km²)	**Europe** (TLU/km²)	**North America** (TLU/km²)	**Eastern Europe and Central Asia** (TLU/km²)
Absence	Non pastoral area	0	0 – 0.34	0 – 0.004	0
Very low	Extensive pastoralism	0 – 0.12	0.34 – 1.1	0.004 – 0.25	0 – 0.17
Low	Mod. intensive pastoralism	0.12 – 0.35	1.1 – 2.83	0.25 – 1.27	0.17 – 0.83
High	Intensive pastoralism	0.35 – 0.92	> 2.83	> 1.27	> 0.83
Very high	Intensive pastoralism	> 0.92	> 2.83	> 1.27	> 0.83

ANNEX 3

Dominant crop type in Land Use Systems

Cropland areas

Agricultural land use systems can be characterized by identifying the dominant crop or dominant crop group occurring in them.

Dominants crops are defined on the basis of their harvested areas within the administrative unit in the Agro-MAPS database (FAO, 2006). The dominant crops are the crops with the greatest extent of harvested area; these are summed until 70% of the total harvested area is reached. If the number crops needed to reach 70% is more than 3, then the crop combination in the administrative unit is defined as "MIXED".

This procedure is automated in Agro-MAPS' program and has been used to determine the dominant crop and crop group in all administrative districts for which data were available in Agro-MAPS.

Note that crop combinations "wheat-tomatoes" and "tomatoes-wheat", both showing the same crops as dominant, are alphabetically listed in the same single dominant crop combination ("tomatoes-wheat").

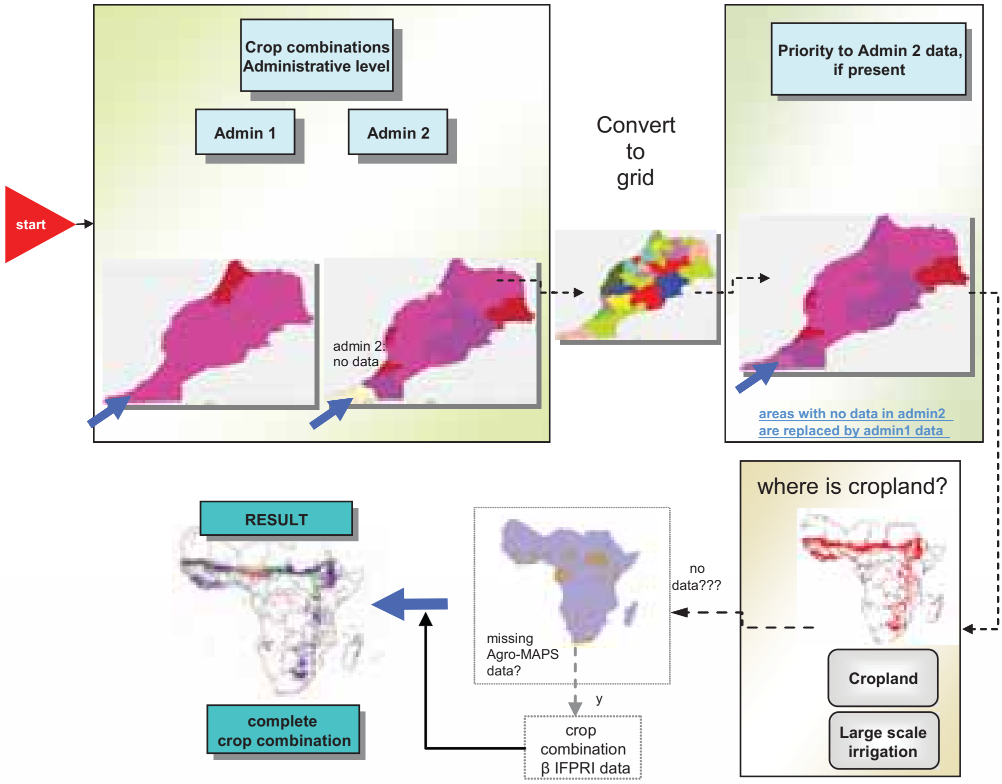

FIGURE A3.1 **Procedure used to obtain crop combination per pixel by using Agro-MAPS data and substituting NO DATA with IFPRI data**

A synthesis of the GIS steps used in obtaining crop and crop groups maps to be used as attribute in LUS mapping is schematically reported below and in Figure 3.1 of this Annex (3):

Step 1 – Vector files (shape) of crops and crop groups combinations at administrative levels 1 and 2 are automatically downloaded from beta version of Agro-MAPS.

Step 2 – Vector files are converted to GRID and a single map is created, giving priorities to the administrative level 2, where present. In some selected cases, where administrative level 2 seems to not closely correspond to reality (missing crops, low extent of known relevant crops), the administrative level 1 is used even if the 2 is present.

Step 3 – Where no data is present, or if data are strongly unrealistic, those are replaced by crop combination or crop group combinations obtained from other data.

Step 4 – beta IFPRI data of production (megatons per pixel[1]), available for 20 crops and crop groups, are extracted only for NO DATA areas.

1 (1 000 000 000 kg)

Step 5 – The single crop with the highest production for each pixel is selected and chosen as attribute for the pixel.

The same procedure is used for determining the dominant crop-group combinations, using FAO crop groups as listed in Table 3.1. Areas with no data are not replaced in this case.

The methodology, though straightforward, suffers from the unknown and uneven quality of the Agro-MAPS database. Where no data were available for sub-national entities, dummies have been used by accessing the beta version of the IFPRI database. What could not be captured is where crop data are available for the country as a whole but a single important crop in the country has not been inventoried in the Agro-MAPS database. For instance, the absence of sugarcane data in the Cuba was glaring and could be corrected; the absence of maize data in Nigeria was less obvious and has not been corrected yet. National LADA studies refine and correct this aspect of the database.

A map of the (single) dominant crop (using Agro-MAPS and beta IFPRI data) is available in Annex 1 Figure 1.11. Note the map of a single dominant crop is shown, not the tree crops result, used only as LUS attribute.

Tree crops and plantations

Areas where tree crops could be present have been selected by using Agro-MAPS and the beta IFPRI data for cropland and forestry areas.

When a tree crop is present in a forestry area, it is considered to be plantation.

A synthesis of the GIS steps used to obtain maps of tree crop groups is schematically reported below:

Step 1 – Dominant tree crops have been exported from Agro=MAPS (using the same procedure and data set as that followed for non-tree crops).

Step 2 – beta IFPRI data provided two world-scale 5 arc minute maps of tree crops, for coffee and "bananas and plantains". Areas where production of those two crops is present are considered as areas with "possible presence of tree crops" only if they are in forestry or cropland zones.

Step 3 – Agro-MAPS dominant tree crops have been grouped following the FAOSTAT groups (see http://faostat.fao.org/default.aspx).

Step 4 – Areas where tree crops were present were considered as areas with "possible presence of tree crops" only if they are in forestry or cropland zones.

An explanation of naming differences for tree crops and plantations is available in Annex 4.

TABLE A3.1 **Crops and Crop Groups as used in the Land Use system**

Crops	Crop Groups											
	f0	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11
Almonds					X							
Apples								X				
Apricots								X				
Bambara Beans				X								
Bananas								X				
Barley	X											
Beans, Dry				X								
Beans, Green							X					
Broad Beans, Dry				X								
Cabbages							X					
Cantaloupes&oth Melons							X					
Carrots							X					
Cassava		X										
Chick-Peas				X								
Chillies&Peppers, Green							X					
Cocoa Beans											X	
Coffee, Green											X	
Cow Peas, Dry				X								
Cucumbers and Gherkins							X					
Dates								X				
Figs								X				
Fonio	X											
Garlic							X					
Ginger										X		
Grapes								X				
Groundnuts in Shell						X						
Lentils				X								
Lettuce							X					
Maize	X											
Millet	X											
Oats	X											
Oil Palm Fruit						X						
Okra							X					
Olives						X						
Onions+Shallots, Green							X					
Onions, Dry							X					
Oranges								X				
Peaches and Nectarines								X				

TABLE A3.1 **Crops and Crop Groups as used in the Land Use system** *(continued)*

Crops	Crop Groups											
	f0	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11
Pears								X				
Peas, Dry				X								
Peas, Green							X					
Pepper,White/Long/Black										X		
Pigeon Peas				X								
Pimento, Allspice										X		
Pineapples								X				
Pistachios					X							
Plantains								X				
Potatoes		X										
Pumpkins, Squash, Gourds							X					
Rice, Paddy	X											
Seed Cotton						X						
Sesame Seed						X						
Sisal									X			
Sorghum	X											
Soybeans						X						
Sugar Beets			X									
Sugar Cane			X									
Sunflower Seed						X						
Sweet Potatoes		X										
Taro Coco Yam		X										
Tea											X	
Tobacco Leaves												X
Tomatoes							X					
Watermelons							X					
Wheat	X											
Yams		X										
Yautia Cocoyam		X										

FAO Groups
f0 – CEREALS AND CEREAL PRODUCTS
f1 – ROOTS, TUBERS AND DERIVED PRODUCTS
f2 – SUGAR CROPS AND SWEETENERS AND DERIVED PRODUCTS
f3 – PULSES AND DERIVED PRODUCTS
f4 – NUTS AND DERIVED PRODUCTS
f5 – OIL-BEARING CROPS AND DERIVED PRODUCTS
f6 – VEGETABLES AND DERIVED PRODUCTS
f7 – FRUITS AND DERIVED PRODUCTS
f8 – FIBRES OF VEGETAL AND ANIMAL ORIGIN
f9 – SPICES
f10 – STIMULANT CROPS AND DERIVED PRODUCTS
f11 – TOBACCO, RUBBER AND OTHER CROPS

ANNEX 4

Technical specifications

This annex describes the Land Use Systems database structure as available in the LADA web page http://www.fao.org/nr/lada/index.php?option=com_content&view=article&id=154&Itemid=184&lang=en.

In FAO Geonetwork (http://www.fao.org/geonetwork/) one can go to this map by typing the strings "*Lus*" or "*Land use systems*" in the search function.

GeoNetwork open-source is a standards-based geospatial catalogue application which allows data providers to organize and publish geospatial data on the web. The Land Use Systems map of the world and its metadata, images, downloadable data, interactive maps, and Google Earth files (kml format) are directly available from this source.

Metadata

The Land Use Systems map metadata are in ISO/DIS 19115 standard format, the FAO standards for metadata information. Data distribution applications such as GeoNetwork implement its metadata according to the scheme and specifications provided by this document.

Resolution, projection and naming

The database is produced in geographic coordinates and WGS84 datum at a 5 arc minutes resolution. Each pixel corresponds approximately to 9 kilometres by 9 kilometres at the equator. To be consistent, the regional databases extracts are also in Geographic Coordinates, and have not been projected in equal areas projections. Eight-digit, alphanumeric, not-case- sensitive file-names have been used. The naming of the database attributes does not follow any particular standard.

Formats

This section lists the formats used to make the data available to the public. Data are produced in ESRI GRID and also in "Band interlaced by line" (.tiff) formats. Database attributes in ESRI GRID are stored the GRID .VAT table while the BIL format is connectable to a database in Access format.

Both formats are furnished in two different versions: a detailed one, storing attribute tables with records referring to row and column number; and a simplified one, with attribute tables referring only to each single combination of attributes. The two versions show the same dataset without any difference, but the second one has approximately one quarter of the rows of the first one and therefore computer performance is enhanced considerably. On the other hand, the first version, which considers each single pixel as a unique element of the GRID, facilitates the use of the dataset for detailed studies (e.g. for scientific use such as modelling) or, in general, when a comparison within the Land Use Systems and a different dataset is undertaken.

<u>ESRI GRID format</u>

Data are produced and provided in ESRI GRID format. GRID is a raster data storage format native to ESRI. There are two types of grids: integer and floating point. The use of integer GRIDs is common in representing raster data. Attributes for an integer grid are stored in a value attribute table (.VAT). A VAT has one record for each unique value in the grid. The record stores the unique value (VALUE is an integer that represents a particular class or grouping of cells) and the number of cells (COUNT) in the grid represented by that value. A raster attribute table is generated with three default fields created in the table: OID, VALUE, and COUNT. The ObjectID (OID) is a unique, system-defined, object identifier number for each row in the table. VALUE is a list of each unique cell value in the raster datasets. COUNT represents the number of cells in the raster dataset with the cell value in the VALUE column.

<u>TIFF format</u>

Data are also distributed in TIFF (Tagged Image File Format), a format which is in widespread use in the desktop publishing world. It serves as an interface to several scanners and graphic arts packages. TIFF supports black-and-white, grey-scale, pseudo colour and true colour images, all of which can be stored in a compressed or decompressed format. GeoTIFF is a public domain metadata standard which allows geo-referencing information to be embedded within a TIFF file. Additional information that can be included are: map projection, coordinate systems, ellipsoids, datums and everything else necessary to establish the exact spatial reference for the file.

Table A4.1 **Description of LUS database attributes in GRID format**

Attribute description	Units of measurement	Coding	Source data	zip download	Notes
Land use systems descriptor	Land use systems	string	LADA	lus	
Major Ecosystems descriptor	Ecosystems	string	beta version of FAO / IIASA GAEZ, 2010 rearranged by LADA	clim	Combination of elevation, thermal regime and LGP
Livestock presence descriptor	List of 2 dominant livestock species (*alphabetical order*)	string	Gridded livestock of the world	lvstsp	
Crops (*from Agro-MAPS*)	List of 3 dominant crops (*alphabetical order*)	string	Agro-MAPS		
Crops (*from IFPRI*)	List of 3 dominant crop or group (*alphabetical order*)	string	beta version of IFPRI data	crops	Only in areas with NO DATA in Agro-MAPS
Crop Groups (*from Agro-MAPS*)	List of 3 dominant groups (*alphabetical order*)	string	Agro-MAPS		
Irrigation	% (see Report chapter 2.2)	string	Global map of irrigated areas	irri	
Thermal regime	Thermal regime	string	beta version of FAO / IIASA GAEZ, 2010	ther	
Length of growing period	Number of Days	string	beta version of FAO / IIASA GAEZ, 2010	lgp	
Soil	Soil name	string	beta version of Harmonized world soil database 2010	soil	
Slope	%	string	beta version of FAO / IIASA GAEZ, 2010	slp	
Population density	Inhabit./km^2	string	Grump database (CIESIN)	popd	
Infant mortality rate	Number of children who die before their first birthday for every 1000 live births	string	CIESIN, 2005	pov	

NOTE: In the case of the GRID storing attributes table with record referring to a unique identifier the attributes rows and columns are not present and the MAP_ID became the VALUE of the grid.

Table A4.2 **Description of LUS database attributes in TIFF image**

Attribute description	Units of measurement	Coding	Source data	zip download	Notes
Land use systems descriptor	Land use systems	code	LADA	lus	
Major Ecosystems descriptor	Ecosystems	code	beta version of FAO / IIASA GAEZ, 2010 rearranged by LADA	clim	Combination of thermal regime and LGP
Livestock presence descriptor	List of 2 dominant livestock species (*alphabetical order*)	code	Gridded livestock of the world	lvstsp	
Crops (*from Agro-MAPS*)	List of 3 dominant crops (*alphabetical order*)	code	Agro-MAPS	crops	
Crops (*from IFPRI*)	List of 3 dominant crop or group (*alphabetical order*)	code	beta version of IFPRI data		Only in areas with NO DATA in Agro-MAPS
Crop Groups (*from Agro-MAPS*)	List of 3 dominant groups (*alphabetical order*)	code	Agro-MAPS		
Irrigation	% (see Report chapter 2.2)	code	Global map of irrigated areas	irri	
Thermal regime	Thermal regime	code	beta version of FAO / IIASA GAEZ, 2010	ther	
Length of growing period	Number of days	code	beta version of FAO / IIASA GAEZ, 2010	lgp	
Soil	Soil name	code	beta version of Harmonized world soil database 2008	soil	
Slope	%	code	beta version of FAO / IIASA GAEZ, 2010	slp	
Population density	Inhabit./km^2	code	Grump database (CIESIN)	popd	
Infant mortality rate	Number of children who die before their first birthday for every 1000 live births	code	CIESIN, 2005	pov	

NOTE: In the case of the GRID storing attributes table with record referring to a unique identifier the attributes rows and columns are not present and the MAP_ID became the raster value.

Attributes of the database

Land use system data are provided as database in an interactive format, at the link: http://www.fao.org/nr/lada/index.php?option=com_content&view=article&id=154&Itemid=184&lang=en

The use of a standardized structure allows the user to link data of selected characteristics (*inter alia* land use systems, major ecosystems, livestock presence, crops and crop groups, irrigation, thermal regime, length of growing period, soil, slope, population density, infant mortality rate).

The attribute identifier, description, metadata, units of measurements and source data are listed in Table 4.1 in this Annex. The database is completely downloadable as separate layers both in GRID and TIFF format. In the TIFF case the attribute identifier, description, metadata, units of measurements and source data are listed in Table 4.2 in this Annex.

Legends

In ESRI GRID format, legend pallette are provided both in .lyr and in .avl format. .avl is the format used by ArcView 3.x. lyr palette is provided for the use in ArcGIS (version 9.0 or above). Furthermore, colormaps are applied to all GRIDs. Colormaps are a set of values that are associated with specific colors, commonly used to display a raster dataset consistently on many different platforms. Legends are provided for TIFF in .lyr format (for ArcGIS version 9.0 or above). Furthermore, colormap are applied to all layers. No legends are provided for crops and livestock species data, but data include tables (.VAT or .dbf depending on the format) with dataset details.

Single tables identifying attributes

This chapter describes the single indicators (attributes) present in the database as layers, including the numerical codes and the text (or symbol) description.

CODE	Land Use Systems
1	Forest – virgin
2	Forest – protected
3	Forest – with agricultural activities
4	Forest – with moderate or higher livestock density
7	Grasslands – unmanaged
8	Grasslands – protected
9	Grasslands – low livestock density
10	Grasslands – moderate livestock density
11	Grasslands – high livestock density
13	Shrubs – unmanaged
14	Shrubs – protected
15	Shrubs – low livestock density
16	Shrubs – moderate livestock density
17	Shrubs – high livestock density
19	Rainfed crops (Subsistence / Commercial)
20	Crops and mod. intensive livestock density
21	Crops and high livestock density
22	Crops, large-scale irrigation. mod. or higher livestock density
23	Agriculture – large scale Irrigation
24	Agriculture – protected
25	Urban land
26	Wetlands – unmanaged
27	Wetlands – protected
28	Wetlands – mangrove
29	Wetlands – with agricultural activities
30	Sparsely vegetated areas – unmanaged
31	Sparsely vegetated areas – protected
32	Sparsely vegetated areas – with low livestock density
33	Sparsely vegetated areas – mod. or high livestock density
34	Bare areas – unmanaged
35	Bare areas – protected
36	Bare areas – with low livestock density
37	Bare areas – with mod. livestock density
38	Open Water – unmanaged
39	Open Water – protected
40	Open Water – inland Fisheries
100	No data

Land Use Systems
The global land use system has 40 classes. The codes of the classes are not continuous because of some lack of data which did not allow the implementation of some classes (class 5-6 due to the lack of management level data on forestry and class 12 and 18 due to the lack of data on stable feed).

Climatic Ecosystems
The climatic ecosystems attribute has 14 classes listed in logical order. It is obtained by combining major classes of thermal regime with moisture regime.

CODE	Ecosystems
1	Polar
2	Boreal drylands
3	Temperate humid
4	Temperate drylands
5	Mediterranean humid
6	Mediterranean drylands
7	Subtopical humid
8	Subtropical drylands
9	Cool Tropic mixed
10	Warm Tropics perhumid
11	Warm Tropics humid
12	Warm Tropics sub-humid
13	Warm Tropics drylands
14	Deserts

Land Use Attributes – Livestock type
The data are organized in 16 classes listing two dominant livestock species and placed in alphabetical order. In one case (cattle – code 6) one species only is present and therefore dominant.

CODE	Livestock
-999	Not available
0	No Livestock
1	Buffaloes, Cattle
2	Buffaloes, Goats
3	Buffaloes, Pigs
4	Buffaloes, Poultry
5	Buffaloes, Sheep
6	Cattle
7	Cattle, Goats
8	Cattle, Pigs
9	Cattle, Poultry
10	Cattle, Sheep
11	Goats, Pigs
12	Goats, Poultry
13	Goats, Sheep
14	Pigs, Poultry
15	Pigs, Sheep
16	Poultry, Sheep

Land Use Attributes – Dominant crops (from Agro-MAPS)
The dominant crops are listed in 534 classes (obtained according to the procedure explained in Annex 3). All crops are labelled alphabetically from 1-516 and from 517-534.

Industrial crops are coded with numbers from 498 to 505 when they occur in agricultural areas. Those crops are listed as obtained from the procedure in Annex 3 extracted for the areas under croplands in GLC-2000.

Crops can also exits in forest land cover (classes 517-534). In this case the main Land Use System is considered to be "forest with agricultural activities".

CODE	Dominant Crops (*from AgroMAPS*)
-999	Not available
1	Almonds;Barley;Olives
2	Almonds;Olives
3	Apples;Maize;Potatoes
4	Apples;Olives
5	Apples;Sugar Cane
6	Areca Nuts;Citrus Fruit Nes;Rice Paddy
7	Areca Nuts;Fruit Tropical Fresh Nes;Rice Paddy
8	Avocados;Maize
9	Bananas (also in forestry plantations)
10	Bananas;Cassava
11	Bananas;Cassava;Groundnuts in Shell
12	Bananas;Cassava;Maize
13	Bananas;Cassava;Plantains
14	Bananas;Cocoa Beans
15	Bananas;Cocoa Beans;Coffee Green (also in forestry plantations)
16	Bananas;Coconuts;Coffee Green
17	Bananas;Coffee Green (also in forestry plantations)
18	Bananas;Coffee Green;Plantains
19	Bananas;Cucumbers and Gherkins
20	Bananas;Maize
21	Bananas;Maize;Potatoes
22	Bananas;Maize;Seed Cotton
23	Bananas;Maize;Sorghum
24	Bananas;Maize;Sugar Cane
25	Bananas;Onions Dry;Tomatoes
26	Bananas;Pigeon Peas
27	Bananas;Pineapples
28	Bananas;Pineapples;Plantains
29	Bananas;Plantains
30	Bananas;Potatoes
31	Bananas;Sorghum;Sweet Potatoes
32	Bananas;Sugar Cane
33	Bananas;Sweet Potatoes
34	Bananas;Taro (Coco Yam)
35	Bananas;Tomatoes
36	Barley
37	Barley;Beans Dry
38	Barley;Beans Dry;Maize
39	Barley;Beans Dry;Wheat
40	Barley;Broad Beans Dry;Olives
41	Barley;Carobs;Maize
42	Barley;Carobs;Potatoes
43	Barley;Carrots;Wheat
44	Barley;Chick-Peas;Wheat
45	Barley;Dates
46	Barley;Dates;Grapes
47	Barley;Dates;Wheat
48	Barley;Grapes
49	Barley;Grapes;Lettuce
50	Barley;Grapes;Olives
51	Barley;Grapes;Wheat
52	Barley;Lentils;Maize
53	Barley;Lentils;Potatoes
54	Barley;Lentils;Wheat
55	Barley;Lupins;Rapeseed
56	Barley;Maize
57	Barley;Maize;Millet
58	Barley;Maize;Millet
59	Barley;Maize;Oats
60	Barley;Maize;Potatoes
61	Barley;Maize;Sorghum
62	Barley;Maize;Soybeans
63	Barley;Maize;Wheat
64	Barley;Millet;Sorghum
65	Barley;Millet;Wheat
66	Barley;Oats
67	Barley;Oats;Potatoes
68	Barley;Oats;Wheat
69	Barley;Olives
70	Barley;Olives;Wheat
71	Barley;Potatoes
72	Barley;Potatoes;Rye
73	Barley;Potatoes;Sugar Cane
74	Barley;Potatoes;Wheat
75	Barley;Rapeseed
76	Barley;Rapeseed;Wheat
77	Barley;Rye;Wheat

CODE	Dominant Crops (*from AgroMAPS*)
78	Barley;Seed Cotton
79	Barley;Seed Cotton;Wheat
80	Barley;Sorghum;Wheat
81	Barley;Soybeans
82	Barley;Sugar Beets
83	Barley;Sugar Beets;Wheat
84	Barley;Sunflower Seed
85	Barley;Sunflower Seed;Wheat
86	Barley;Tomatoes
87	Barley;Wheat
88	Barley;Wheat;Olives
89	Beans Dry
90	Beans Dry;Cassava
91	Beans Dry;Cassava;Coffee Green
92	Beans Dry;Cassava;Groundnuts in Shell
93	Beans Dry;Cassava;Maize
94	Beans Dry;Cassava;Millet
95	Beans Dry;Cassava;Plantains
96	Beans Dry;Cassava;Potatoes
97	Beans Dry;Cassava;Rice Paddy
98	Beans Dry;Cassava;Sorghum
99	Beans Dry;Cassava;Soybeans
100	Beans Dry;Cassava;Sugar Cane
101	Beans Dry;Cassava;Sweet Potatoes
102	Beans Dry;Cocoa Beans
103	Beans Dry;Cocoa Beans;Maize
104	Beans Dry;Cocoa Beans;Sorghum
105	Beans Dry;Coffee Green
106	Beans Dry;Coffee Green;Maize
107	Beans Dry;Coffee Green;Plantains
108	Beans Dry;Coffee Green;Potatoes
109	Beans Dry;Coffee Green;Rice Paddy
110	Beans Dry;Coffee Green;Sorghum
111	Beans Dry;Coffee Green;Soybeans
112	Beans Dry;Coffee Green;Sugar Cane
113	Beans Dry;Groundnuts in Shell
114	Beans Dry;Groundnuts in Shell;Rice Paddy
115	Beans Dry;Maize

CODE	Dominant Crops (*from AgroMAPS*)
116	Beans Dry;Maize;Onions+Shallots Green
117	Beans Dry;Maize;Plantains
118	Beans Dry;Maize;Potatoes
119	Beans Dry;Maize;Pulses nes
120	Beans Dry;Maize;Rice Paddy
121	Beans Dry;Maize;Seed Cotton
122	Beans Dry;Maize;Sorghum
123	Beans Dry;Maize;Soybeans
124	Beans Dry;Maize;Sugar Beets
125	Beans Dry;Maize;Sugar Cane
126	Beans Dry;Maize;Sweet Potatoes
127	Beans Dry;Maize;Tomatoes
128	Beans Dry;Maize;Wheat
129	Beans Dry;Maize;Yams
130	Beans Dry;Millet
131	Beans Dry;Millet;Sweet Potatoes
132	Beans Dry;Oats
133	Beans Dry;Onions+Shallots Green;Rice Paddy
134	Beans Dry;Plantains
135	Beans Dry;Plantains;Potatoes
136	Beans Dry;Plantains;Sugar Cane
137	Beans Dry;Potatoes
138	Beans Dry;Potatoes;Sugar Cane
139	Beans Dry;Rice Paddy
140	Beans Dry;Rice Paddy;Sugar Cane
141	Beans Dry;Seed Cotton
142	Beans Dry;Sorghum
143	Beans Dry;Sorghum;Wheat
144	Beans Dry;Soybeans
145	Beans Dry;Soybeans;Wheat
146	Beans Dry;Sugar Beets;Wheat
147	Beans Dry;Sugar Cane
148	Beans Dry;Sweet Potatoes
149	Beans Dry;Tomatoes
150	Beans Dry;Wheat
151	Beans Green;Onions+Shallots Green
152	Beans Green;Wheat
153	Broad Beans Dry;Maize

CODE	Dominant Crops (*from AgroMAPS*)
154	Broad Beans Green;Maize;Rice Paddy
155	Broad Beans Green;Potatoes
156	Cabbages;Carrots;Onions+Shallot s Green
157	Cabbages;Citrus Fruit Nes;Rice Paddy
158	Cabbages;Eggplants
159	Cabbages;Eggplants;Onions+Shallo ts Green
160	Cabbages;Lettuce;Wheat
161	Cabbages;Okra;Onions+Shallots Green
162	Cabbages;Onions+Shallots Green
163	Cabbages;Onions+Shallots Green;Tobacco Leaves
164	Cabbages;Onions+Shallots Green;Tomatoes
165	Cantaloupes&oth Melons;Chillies&Peppers Green;Tomatoes
166	Cantaloupes&oth Melons;Onions+Shallots Green;Wheat
167	Carobs;Maize;Potatoes
168	Carobs;Potatoes;Sugar Cane
169	Carrots
170	Carrots;Eggplants
171	Carrots;Grapes;Lettuce
172	Cassava
173	Cassava;Coffee Green
174	Cassava;Coffee Green;Rice Paddy
175	Cassava;Coffee Green;Sweet Potatoes
176	Cassava;Fonio
177	Cassava;Maize
178	Cassava;Maize;Melonseed
179	Cassava;Maize;Taro (Coco Yam)
180	Cassava;Maize;Yams
181	Cassava;Rice Paddy
182	Chillies&Peppers Green;Eggplants;Tomatoes
183	Chillies&Peppers Green;Onions+Shallots Green;Tomatoes
184	Chillies&Peppers Green;Tomatoes
185	Citrus Fruit Nes;Rice Paddy
186	Cloves Whole+Stems;Olives;Wheat
187	Cocoa Beans (also in forestry plantations)
188	Cocoa Beans;Coffee Green (also in forestry plantations)
189	Cocoa Beans;Coffee Green;Maize
190	Cocoa Beans;Coffee Green;Plantains
191	Cocoa Beans;Coffee Green;Soybeans
192	Cocoa Beans;Coffee Green;Sugar Cane
193	Cocoa Beans;Maize
194	Cocoa Beans;Maize;Plantains
195	Cocoa Beans;Maize;Rice Paddy
196	Cocoa Beans;Plantains
197	Cocoa Beans;Plantains;Rice Paddy
198	Cocoa Beans;Rice Paddy
199	Cocoa Beans;Sugar Cane
200	Coconuts
201	Coconuts;Coffee Green
202	Coconuts;Oranges;Rice Paddy
203	Coconuts;Plantains
204	Coffee Green (also in forestry plantations)
205	Coffee Green;Groundnuts in Shell;Maize
206	Coffee Green;Maize
207	Coffee Green;Maize;Oats
208	Coffee Green;Maize;Plantains
209	Coffee Green;Maize;Potatoes
210	Coffee Green;Maize;Rice Paddy
211	Coffee Green;Maize;Soybeans
212	Coffee Green;Maize;Sugar Cane
213	Coffee Green;Maize;Tomatoes
214	Coffee Green;Onions+Shallots Green
215	Coffee Green;Onions+Shallots Green;Tomatoes
216	Coffee Green;Oranges
217	Coffee Green;Pineapples
218	Coffee Green;Plantains
219	Coffee Green;Plantains;Potatoes
220	Coffee Green;Plantains;Sugar Cane

CODE	Dominant Crops (*from AgroMAPS*)
221	Coffee Green;Potatoes
222	Coffee Green;Rice Paddy
223	Coffee Green;Rice Paddy;Vanilla
224	Coffee Green;Sorghum
225	Coffee Green;Soybeans
226	Coffee Green;Sugar Cane
227	Coffee Green;Sugar Cane;Tomatoes
228	Coffee Green;Tea
229	Cow Peas Dry
230	Cow Peas Dry;PepperWhite/Long/Black
231	Cow Peas Dry;Groundnuts in Shell;Maize
232	Cow Peas Dry;Groundnuts in Shell;Millet
233	Cow Peas Dry;Maize
234	Cow Peas Dry;Maize;Sorghum
235	Cow Peas Dry;Millet
236	Cow Peas Dry;Millet;Sorghum
237	Cow Peas Dry;Oil Palm Fruit
238	Cow Peas Dry;Rice Paddy
239	Cow Peas Dry;Sorghum
240	Cow Peas Dry;Soybeans
241	Cucumbers and Gherkins
242	Dates
243	Dates;Citrus Fruit nes;Wheat
244	Dates;Sorghum
245	Dates;Sorghum;Tomatoes
246	Dates;Wheat
247	Dates;Wheat;Sorghum
248	Eggplants;Onions+Shallots Green
249	Eggplants;Onions+Shallots Green;Tomatoes
250	Eggplants;Pumpkins Squash Gourds;Tomatoes
251	Eggplants;Tomatoes
252	Fonio;Groundnuts in Shell
253	Fonio;Groundnuts in Shell;Maize
254	Fonio;Groundnuts in Shell;Rice Paddy
255	Fonio;Maize
256	Fonio;Maize;Rice Paddy

CODE	Dominant Crops (*from AgroMAPS*)
257	Fonio;Maize;Sorghum
258	Fonio;Rice Paddy
259	Grapefruit and Pomelos
260	Grapefruit and Pomelos;Oranges
261	Grapes
262	Grapes;Lettuce
263	Grapes;Lettuce;Millet
264	Grapes;Maize
265	Grapes;Maize;Olives
266	Grapes;Maize;Potatoes
267	Grapes;Maize;Soybeans
268	Grapes;Maize;Wheat
269	Grapes;Olives
270	Grapes;Olives;Tomatoes
271	Grapes;Olives;Wheat
272	Grapes;Potatoes
273	Grapes;Potatoes;Wheat
274	Grapes;Sorghum;Wheat
275	Grapes;Wheat
276	Groundnuts in Shell
277	Groundnuts in Shell;Maize
278	Groundnuts in Shell;Maize;Millet
279	Groundnuts in Shell;Maize;Pulses nes
280	Groundnuts in Shell;Maize;Rice Paddy
281	Groundnuts in Shell;Maize;Seed Cotton
282	Groundnuts in Shell;Maize;Sorghum
283	Groundnuts in Shell;Maize;Taro (Coco Yam)
284	Groundnuts in Shell;Maize;Tobacco Leaves
285	Groundnuts in Shell;Maize;Tomatoes
286	Groundnuts in Shell;Millet
287	Groundnuts in Shell;Millet;Rice Paddy
288	Groundnuts in Shell;Millet;Sesame Seed
289	Groundnuts in Shell;Millet;Sorghum
290	Groundnuts in Shell;Millet;Yams
291	Groundnuts in Shell;Oilseeds nes
292	Groundnuts in Shell;Oilseeds nes;Rice Paddy

CODE	Dominant Crops (*from AgroMAPS*)
293	Groundnuts in Shell;Pistachios;Plantains
294	Groundnuts in Shell;Plantains;Taro (Coco Yam)
295	Groundnuts in Shell;Rice Paddy
296	Groundnuts in Shell;Rice Paddy;Sorghum
297	Groundnuts in Shell;Seed Cotton
298	Groundnuts in Shell;Seed Cotton;Soybeans
299	Groundnuts in Shell;Seed Cotton;Sunflower Seed
300	Groundnuts in Shell;Seed Cotton;Wheat
301	Groundnuts in Shell;Sorghum
302	Groundnuts in Shell;Sorghum;Sugar Cane
303	Groundnuts in Shell;Sorghum;Wheat
304	Groundnuts in Shell;Soybeans
305	Groundnuts in Shell;Soybeans;Wheat
306	Groundnuts in Shell;Sunflower Seed
307	Groundnuts in Shell;Sweet Potatoes
308	Groundnuts in Shell;Wheat
309	Lemons and Limes;Maize
310	Lemons and Limes;Maize;Rice Paddy
311	Lemons and Limes;Oranges
312	Lentils;Maize;Potatoes
313	Lentils;Oats
314	Lettuce;Onions+Shallots Green
315	Lupins;Wheat
316	Maize
317	Maize;Groundnuts in Shell
318	Maize;Groundnuts in Shell;Sorghum
319	Maize;Millet
320	Maize;Millet;Rice Paddy
321	Maize;Millet;Sorghum
322	Maize;Millet;Wheat
323	Maize;Oats
324	Maize;Oats;Potatoes
325	Maize;Oats;Soybeans
326	Maize;Oats;Wheat
327	Maize;Oil Palm Fruit

CODE	Dominant Crops (*from AgroMAPS*)
328	Maize;Olives
329	Maize;Onions Dry;Tomatoes
330	Maize;Onions+Shallots Green
331	Maize;Onions+Shallots Green;Potatoes
332	Maize;Onions+Shallots Green;Rice Paddy
333	Maize;Onions+Shallots Green;Sugar Cane
334	Maize;Oranges
335	Maize;Oranges;Plantains
336	Maize;Oranges;Wheat
337	Maize;Pigeon Peas
338	Maize;Pistachios
339	Maize;Plantains
340	Maize;Plantains;Potatoes
341	Maize;Plantains;Rice Paddy
342	Maize;Plantains;Soybeans
343	Maize;Plantains;Sugar Cane
344	Maize;Potatoes
345	Maize;Potatoes;Rice Paddy
346	Maize;Potatoes;Soybeans
347	Maize;Potatoes;Sugar Cane
348	Maize;Potatoes;Taro (Coco Yam)
349	Maize;Potatoes;Wheat
350	Maize;Pulses nes
351	Maize;Pulses nes;Sweet Potatoes
352	Maize;Pulses nes;Tobacco Leaves
353	Maize;Rice Paddy
354	Maize;Rice Paddy;Seed Cotton
355	Maize;Rice Paddy;Sorghum
356	Maize;Rice Paddy;Soybeans
357	Maize;Rice Paddy;Sugar Cane
358	Maize;Rice Paddy;Tomatoes
359	Maize;Rice Paddy;Wheat
360	Maize;Rye
361	Maize;Seed Cotton
362	Maize;Seed Cotton;Sorghum
363	Maize;Seed Cotton;Soybeans
364	Maize;Seed Cotton;Sugar Cane
365	Maize;Seed Cotton;Wheat

CODE	Dominant Crops (*from AgroMAPS*)
366	Maize;Sesame Seed
367	Maize;Sesame Seed;Wheat
368	Maize;Sorghum
369	Maize;Sorghum;Soybeans
370	Maize;Sorghum;Sugar Cane
371	Maize;Sorghum;Wheat
372	Maize;Sorghum;Yams
373	Maize;Soybeans
374	Maize;Soybeans;Sugar Cane
375	Maize;Soybeans;Sunflower Seed
376	Maize;Soybeans;Tomatoes
377	Maize;Soybeans;Wheat
378	Maize;Sugar Beets;Wheat
379	Maize;Sugar Cane
380	Maize;Sugar Cane;Tomatoes
381	Maize;Sugar Cane;Wheat
382	Maize;Sunflower Seed
383	Maize;Sunflower Seed;Wheat
384	Maize;Sweet Potatoes
385	Maize;Sweet Potatoes;Taro (Coco Yam)
386	Maize;Sweet Potatoes;Tomatoes
387	Maize;Taro (Coco Yam)
388	Maize;Tobacco Leaves
389	Maize;Tobacco Leaves;Wheat
390	Maize;Tomatoes
391	Maize;Tomatoes;Wheat
392	Maize;Wheat
393	Maize;Yams
394	Mangoes;Pineapples;Rice Paddy
395	Millet
396	Millet;Peas Dry
397	Millet;Peas Dry;Sorghum
398	Millet;Pigeon Peas
399	Millet;Pumpkins Squash Gourds
400	Millet;Rice Paddy
401	Millet;Rice Paddy;Sorghum
402	Millet;Seed Cotton;Sorghum
403	Millet;Seed Cotton;Wheat
404	Millet;Sesame Seed;Sorghum
405	Millet;Sorghum
406	Millet;Sorghum;Wheat
407	Millet;Soybeans;Wheat
408	Millet;Wheat
409	MIXED
410	Natural Rubber
411	Oats
412	Oats;Potatoes
413	Oats;Soybeans
414	Oats;Soybeans;Wheat
415	Oats;Wheat
416	Oil Palm Fruit
417	Oilseeds nes;Rice Paddy
418	Oilseeds nes;Rice Paddy;Wheat
419	Oilseeds nes;Wheat
420	Okra;Potatoes;Tomatoes
421	Olives
422	Olives;Seed Cotton;Wheat
423	Olives;Tomatoes
424	Olives;Watermelons;Wheat
425	Olives;Wheat
426	Onions Dry;Potatoes
427	Onions+Shallots Green
428	Onions+Shallots Green;Potatoes
429	Onions+Shallots Green;Rice Paddy
430	Onions+Shallots Green;Sugar Cane
431	Onions+Shallots Green;Tobacco Leaves
432	Onions+Shallots Green;Tomatoes
433	Onions+Shallots Green;Tomatoes;Eggplants
434	Oranges
435	Oranges;Plantains
436	Oranges;Wheat
437	Peas Dry;Sorghum
438	Peas Green
439	PepperWhite/Long/Black
440	Pigeon Peas
441	Pineapples
442	Pistachios;Plantains;Taro (Coco Yam)
443	Plantains

CODE	Dominant Crops (*from AgroMAPS*)
444	Plantains;Potatoes
445	Plantains;Rice Paddy
446	Plantains;Sugar Cane
447	Plantains;Tomatoes
448	Potatoes
449	Potatoes;Rice Paddy
450	Potatoes;Rice Paddy;Sweet Potatoes
451	Potatoes;Rye
452	Potatoes;Rye;Wheat
453	Potatoes;Sorghum;Wheat
454	Potatoes;Sugar Beets
455	Potatoes;Sugar Beets;Wheat
456	Potatoes;Sugar Cane
457	Potatoes;Sunflower Seed
458	Potatoes;Sunflower Seed;Wheat
459	Potatoes;Tobacco Leaves
460	Potatoes;Tobacco Leaves;Wheat
461	Potatoes;Tomatoes
462	Potatoes;Wheat
463	Pumpkins Squash Gourds
464	Rapeseed;Wheat
465	Rice Paddy
466	Rice Paddy;Seed Cotton;Sorghum
467	Rice Paddy;Seed Cotton;Soybeans
468	Rice Paddy;Seed Cotton;Wheat
469	Rice Paddy;Sorghum
470	Rice Paddy;Soybeans
471	Rice Paddy;Soybeans;Sugar Cane
472	Rice Paddy;Soybeans;Wheat
473	Rice Paddy;Sugar Beets;Wheat
474	Rice Paddy;Sugar Cane
475	Rice Paddy;Sweet Potatoes
476	Rice Paddy;Wheat
477	Rye
478	Rye;Sorghum;Wheat
479	Rye;Wheat
480	Seed Cotton
481	Seed Cotton;Sesame Seed;Sorghum
482	Seed Cotton;Sorghum
483	Seed Cotton;Sorghum;Wheat

CODE	Dominant Crops (*from AgroMAPS*)
484	Seed Cotton;Soybeans
485	Seed Cotton;Soybeans;Sunflower Seed
486	Seed Cotton;Soybeans;Wheat
487	Seed Cotton;Sugar Cane
488	Seed Cotton;Sunflower Seed
489	Seed Cotton;Tobacco Leaves;Wheat
490	Seed Cotton;Wheat
491	Sesame Seed;Wheat
492	Sorghum
493	Sorghum;Soybeans
494	Sorghum;Soybeans;Sugar Cane
495	Sorghum;Soybeans;Wheat
496	Sorghum;Sugar Cane
497	Sorghum;Sugar Cane;Wheat
498	Sorghum;Sunflower Seed;Wheat
499	Sorghum;Wheat
500	Soybeans
501	Soybeans;Sugar Cane
502	Soybeans;Sugar Cane;Wheat
503	Soybeans;Sunflower Seed;Wheat
504	Soybeans;Wheat
505	Sugar Beets
506	Sugar Beets;Sunflower Seed;Wheat
507	Sugar Beets;Wheat
508	Sugar Cane
509	Sugar Cane;Wheat
510	Sunflower Seed
511	Sunflower Seed;Wheat
512	Sweet Potatoes
513	Tobacco Leaves
514	Tobacco Leaves;Wheat
515	Tomatoes
516	Wheat
517	Bananas;Cocoa (forestry plantations only)
518	Bananas;Coffee;Fruit tree (forestry plantations only)
519	Bananas;Coffee;Oil tree crops (forestry plantations only)

CODE	Dominant Crops (*from AgroMAPS*)
520	Bananas;Coffee;Spices (forestry plantations only)
521	Bananas;Fruit tree (forestry plantations only)
522	Bananas;Fruit tree;Oil tree crops (forestry plantations only)
523	Bananas;Oil tree crops (forestry plantations only)
524	Bananas;Rubber & other crops (forestry plantations only)
525	Bananas;Spices (forestry plantations only)
526	Coffee;Fruit tree (forestry plantations only)
527	Coffee;Oil tree crops (forestry plantations only)
528	Coffee;Rubber & other crops (forestry plantations only)
529	Coffee;Spices (forestry plantations only)
530	Fruit tree (forestry plantations only)
531	Fruit tree;Oil tree crops (forestry plantations only)
532	Oil tree crops (forestry plantations only)
533	Rubber & other crops (forestry plantations only)
534	Spices (forestry plantations only)

Land Use Attributes – Dominant crops (from IFPRI)
In the case of IFPRI data, the dominant crop is a single one and is listed in 20 classes in alphabetical order. This attribute is present only where Agro-MAPS has NO DATA.

CODE	Dominant Crops (*from IFPRI*)
-999	None
1	Bananas & plantains
2	Barley
3	Beans
4	Cassava
5	Coffee
6	Cotton
7	Groundnut
8	Maize
9	Millet
10	Other fibers crop
11	Other oils crop
12	Other pulse crops
13	Potatoes
14	Rice
15	Sorghum
16	Soybean
17	Sugar beat
18	Sugar cane
19	Sweet potatoes & yams
20	Wheat

Land Use Attributes – Dominant crop groups (from AgroMAPS)
The dominant crops are listed in 90 classes in alphabetical order. This attribute shows crop groups in cropland areas only.

CODE	Crop groups
-999	Not available
1	Cereals and cereal products
2	Cereals and cereal products;Fruits
3	Cereals and cereal products;Fruits;Oil-bearing crops
4	Cereals and cereal products;Fruits;Pulses
5	Cereals and cereal products;Fruits;Roots tubers

CODE	Crop groups
6	Cereals and cereal products;Fruits;Stimulant crops
7	Cereals and cereal products;Fruits;Sugar crops and sweeteners
8	Cereals and cereal products;Fruits;Vegetables
9	Cereals and cereal products;Nuts
10	Cereals and cereal products;Oil-bearing crops
11	Cereals and cereal products;Oil-bearing crops;Fruits
12	Cereals and cereal products;Oil-bearing crops;Pulses
13	Cereals and cereal products;Oil-bearing crops;Roots tubers
14	Cereals and cereal products;Oil-bearing crops;Stimulant crops
15	Cereals and cereal products;Oil-bearing crops;Sugar crops and sweeteners
16	Cereals and cereal products;Oil-bearing crops;Vegetables
17	Cereals and cereal products;Pulses
18	Cereals and cereal products;Pulses;Roots tubers
19	Cereals and cereal products;Pulses;Stimulant crops
20	Cereals and cereal products;Pulses;Sugar crops and sweeteners
21	Cereals and cereal products;Pulses;Vegetables
22	Cereals and cereal products;Roots tubers
23	Cereals and cereal products;Roots tubers;Stimulant crops
24	Cereals and cereal products;Roots tubers;Sugar crops and sweeteners
25	Cereals and cereal products;Roots tubers;Tobacco rubber and other crops
26	Cereals and cereal products;Roots tubers;Vegetables
27	Cereals and cereal products;Stimulant crops

CODE	Crop groups
28	Cereals and cereal products;Stimulant crops;Sugar crops and sweeteners
29	Cereals and cereal products;Stimulant crops;Vegetables
30	Cereals and cereal products;Sugar crops and sweeteners
31	Cereals and cereal products;Sugar crops and sweeteners;Vegetables
32	Cereals and cereal products;Tobacco rubber and other crops
33	Cereals and cereal products;Vegetables
34	Fruits
35	Fruits;cereals and cereal products
36	Fruits;Nuts;Roots tubers
37	Fruits;Oil-bearing crops
38	Fruits;Oil-bearing crops;Roots tubers
39	Fruits;Pulses
40	Fruits;Pulses;Roots tubers
41	Fruits;Pulses;Stimulant crops
42	Fruits;Pulses;Sugar crops and sweeteners
43	Fruits;Roots tubers
44	Fruits;Roots tubers;Stimulant crops
45	Fruits;Roots tubers;Sugar crops and sweeteners
46	Fruits;Roots tubers;Vegetables
47	Fruits;Stimulant crops
48	Fruits;Stimulant crops;Sugar crops and sweeteners
49	Fruits;Sugar crops and sweeteners
50	Fruits;Vegetables
51	Mixed
52	Nuts;Oil-bearing crops
53	Oil-bearing crops
54	Oil-bearing crops;cereals and cereal products
55	Oil-bearing crops;Fruits
56	Oil-bearing crops;Fruits;cereals and cereal products
57	Oil-bearing crops;Pulses
58	Oil-bearing crops;Pulses
59	Oil-bearing crops;Roots tubers

CODE	Crop groups
60	Oil-bearing crops;Stimulant crops
61	Oil-bearing crops;Sugar crops and sweeteners
62	Oil-bearing crops;Vegetables
63	Pulses
64	Pulses;Roots tubers
65	Pulses;Roots tubers;Stimulant crops
66	Pulses;Roots tubers;Sugar crops and sweeteners
67	Pulses;Roots tubers;Vegetables
68	Pulses;spices
69	Pulses;Stimulant crops
70	Pulses;Stimulant crops;Sugar crops and sweeteners
71	Pulses;Sugar crops and sweeteners
72	Pulses;Vegetables
73	Roots tubers
74	Roots tubers;Fruits;cereals and cereal products
75	Roots tubers;Stimulant crops
76	Roots tubers;Stimulant crops;Sugar crops and sweeteners
77	Roots tubers;Sugar crops and sweeteners
78	Roots tubers;Sugar crops and sweeteners;Tobacco rubber and other crops
79	Roots tubers;Tobacco rubber and other crops
80	Roots tubers;Vegetables
81	Spices
82	Stimulant crops
83	Stimulant crops;Sugar crops and sweeteners
84	Stimulant crops;Sugar crops and sweeteners;Vegetables
85	Stimulant crops;Vegetables
86	Sugar crops and sweeteners
87	Sugar crops and sweeteners;Vegetables
88	Tobacco rubber and other crops
89	Vegetables
90	Vegetables;cereals and cereal products

Land Use Attributes – Dominant crop groups
(from AgroMAPS)
Irrigation has been reclassified in only 2 classes, low (i.e. small-scale) or large-scale irrigation. Low-scale irrigation may be present in all LUS classes while large-scale irrigation is a subclass associated with the agricultural or agro-pastoral classes.

CODE	Irrigation
-999	None
1	Low-scale irrigation
2	Large-scale irrigation

Land Use Attributes – Agricultural management index
The management index has been reclassified in 6 classes and is present, when available, in agricultural areas and in forested areas with agricultural activities.

CODE	Management
0	Not available
1	Very poor managed
2	Relatively poor managed
3	Well managed
4	Very well managed
5	Relatively over managed
6	Over managed
7	No data

Biophysical Attributes – Length of Growing Period (LGP) classes
The LGP is subdivided in 14 classes from the driest to the more humid class, with the unit of measurement being number of 30 days (month) periods.

CODE	LGP
1	0
2	1 to 29
3	30 to 59
4	60 to 89
5	90 to 119
6	120 to 149
7	150 to 179
8	180 to 209
9	210 to 239
10	240 to 269
11	270 to 299
12	300 to 329
13	330 to 359
14	above 360

Biophysical Attributes of the Ecosystem: dominant soils

The soils are extrapolated from the Harmonized World Soil Database and are subdivided in 35classes. In the case of ESRI GRID version the soil symbol is not used. The "not defined" class may depend from differences between coastlines of different LUS dataset (note that water has also been inserted in this class). The "no data" class is derived from the original HWSD.

CODE	SOIL	SYMBOL
-999	Not Defined	NI
1	Acrisols	AC
2	Alisols	AL
3	Andosols	AN
4	Arenosols	AR
5	Anthrosols	AT
6	Chernozems	CH
7	Calcisols	CL
8	Cambisols	CM
9	Fluvisols	FL
10	Ferralsols	FR

CODE	SOIL	SYMBOL
11	Gleysols	GL
12	Greyzems	GR
13	Gypsisols	GY
14	Histosols	HS
15	Kastanozems	KS
16	Leptosols	LP
17	Luvisols	LV
18	Lixisols	LX
19	Nitisols	NT
20	Podzoluvisols	PD
21	Phaeozems	PH
22	Planosols	PL
23	Plinthosols	PT
24	Podzols	PZ
25	Regosols	RG
26	Solonchaks	SC
27	Solonetz	SN
28	Vertisols	VR
29	Rock Outcrop	RK
30	Sand Dunes	DS
32	Urban, mining	UR
31		
33	Salt Flats	ST
34	No data	NI
35	Glaciers	GG
36	Island	IS

Biophysical Attributes – Slope classes

The slope percentage was derived from SRTM and is subdivided in 10 classes, where 0 indicates areas that are "undefined" in the source data. In other cases, the Land Use System map may have a different coastline than the slope map (derived from SRTM Shuttle mission). In those cases the code -999 is used and the label is "not available".

CODE	Slope
-999	Not available
0	Undefined
1	0 to 0.5
2	0.5 to 2
3	2 to 5
4	5 to 8
5	8 to 16
6	16 to 30
7	30 to 45
8	above 45

CODE	Poverty
-999	Undefined
1	below 2
2	2 to 5
3	5 to 10
4	10 to 20
5	20 to 30
6	30 to 40
7	40 to 50
8	50 to 75
9	75 to 100
10	above 100

Socio-Economic Attributes – Population density
The population density, measured in inhabitants per square kilometres, is classified into 7 classes, where -999 defines areas with no data.

CODE	Population density
-999	Undefined
1	0
2	0 to 2
3	2 to 10
4	10 to 50
5	50 to 250
6	above 250

Socio-Economic Attributes – Infant mortality rate
The infant mortality rate (the number of children out of every 1000 born alive that die before they reach the age of one year) is classified in 11 classes, where -999 defines areas with no data.

Quality of the database
Data quality was and remains a major concern. Putting together global data layers of variable quality and different resolutions / scales by simple overlay is a risky exercise, which is bound to result in some erroneous conclusions being drawn on the land use systems practiced. Major problems with the individual databases used are well known (FAO, 2005) and are discussed in this Manual (section 1.3).

This section aims to describe some of the methods used to reduce this problem.

Position accuracy
Most databases used came from FAO internal sources, which had already been corrected for positional accuracy.

In other cases, some correction needs to be done. For example, the FAO/IIASA GAEZ data (i.e. LGP, thermal climate and slope (the SRTM corrected data was resampled by IIASA)), the boundaries were buffered in order that a simple clipping was realistic. The soil map (from the beta version of the Harmonized World Soil Database) was corrected to match with GAUL by IIASA.

Expansion of outer boundaries and clipping was performed using a reference layer at a 5 arc minutes resolution. Data were in all cases first re-classified, secondly resampled and finally compared to the reference layer. Subsequently, the re-sampling technique was applied with a snap to the reference grid.

The datasets where major problems were encountered were the population density and livestock maps.

Completeness

The work previously described allowed to create a quite consistent database in term of completeness. Less than 150 pixels (of over more than 2 million) in islands or far northern areas have most of the attribute missing.

The incompleteness of the Agro-Maps database has been highlighted within this Manual (section 4.2), but missing data have been consistently substituted (as a separate attribute) by IFPRI data. Nevertheless there are a few areas were neither of the datasets held information.

Correctness

The correctness of this database is linked to the correctness of each single input layer.

Timeliness

Integrating this amount of different data creates issues of time precision which must be borne in mind when using the outputs. Data sources were from the nineties (Agro-MAPS) to 2007 in the case of Global Map of Irrigated areas. In case of IFPRI beta version, the year of data collection is unknown.

References

Bai, Z.G. & Dent D.L. 2007. *Assessment of Land Degradation and Improvement in South Africa*. LADA Project, internal document.

Bai, Z.G., Dent, D.L., Olson. L. & Schaepman, M. 2008. *Global land degradation assessment*. (in preparation).

CDE/WOCAT, FAO/LADA, ISRIC. 2011. *Questionnaire for Mapping Land Degradation and Sustainable Land Management v2*. WOCAT, Berne, Switzerland.

Centre for International Earth Science Information Network (CIESIN), Columbia University. 2005. *Global subnational infant mortality rates*. CIESIN, Palisades, NY, USA. Available from: http://www.ciesin.columbia.edu/povmap/ds_global.html [Accessed 18 November 2007].

Centre de Suivi Ecologique (CSE). 2007a. *Préparation du guide pour la stratification*, Rapport intérimaire 1. LADA Project Senegal country report. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=53&Itemid=165&lang=en.

Centre de Suivi Ecologique (CSE). 2007b. *Préparation du guide pour la stratification*, Rapport intérimaire 2. LADA Project Senegal country report.

Centre de Suivi Ecologique (CSE). 2008. *Préparation du guide pour la stratification*, Rapport intérimaire 3. LADA Project Senegal country report.

China LADA team. 2008. *Land use system map of China*. LADA project China country report. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=763&Itemid=165&lang=en.

Direction Générale de l'Aménagement et la Conservation des Terres Agricoles. 2008. *Réalisation d'une carte d'utilisation des terres à l'échelle 1/500 000 en se basant sur des données nationales disponibles et en suivant les directives LADA pour la starification et la cartographie LUS*. LADA Project Tunisia country report.

Dixon, J, Gulliver, Gibbon, D. 2001. *Farming Systems and Poverty - Improving farmers' livelihoods in a changing world*. FAO and World Bank, Rome and Washington DC. 412p.

European Space Agency (ESA) GlobCover Project. 2008. *GlobCover Land Cover v2 2008 database*, led by MEDIAS-France. Available from: http://ionia1.esrin.esa.int/index.asp [Accessed 22 July 2011].

FAO. 1978-1981. *Report on the agro-ecological zones project*. Vol 1 Methodology and Results for Africa. Vol. 2 - Results for Southwest Asia. Vol 3. South America. Vol 4 Southeast Asia. World Soil Resources Reports No 48. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 1992. *Agro-Ecological Zoning Guidelines*. FAO Soils Bulletin 73. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2005. *An inventory and comparison of globally consistent geospatial databases and libraries*. Environmental and Natural Resources Working Paper 19. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2005. *Reports of the series of Global Land Cover Network Training Workshops*, Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO/IFPRI/SAGE. 2006. *Agro-MAPS*. FAO Land and Water Digital media series # 32. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2007. *Consultant Report on Global LADA Stratification Data for China*. LADA Project, internal document. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO/IIASA/ISRIC/JRC & C-AS. 2008. *Harmonized World Soil Database*. FAO Land and Water Digital Media Series # 34. Food and Agriculture Organization of the United Nations, Rome, Italy. Latest revision available at: http://www.fao.org/nr/land/soils/harmonized-world-soil-database/en/ [Accessed 23 July 2011].

FAO/IIASA, 2010. *Global Agro-ecological Zoning*. FAO Land and Water Digital Media series # 35. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.gaez.iiasa.ac.at/w/ctrl?_flow=Vwr&_view=Welcome&idAS=0&idFS=0&fieldmain=main_&idPS=0 [Accessed 22 July 2011].

FAO-WOCAT. 2011. *Questionnaire for Mapping Land Degradation and Sustainable Land Management (QM) v2*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Fischer, G., van Velthuizen, Shah, M. & Nachtergaele, F. 2002. *Global agro-ecological assessment for agriculture in the 21st century*. IIASA/FAO. 119p.

Fischer, G. 2009. *Personal communication*.

George, H. & Petri, M. 2006. *The rapid characterization and mapping of agricultural land-use: A methodological framework approach for the LADA project*. LADA Project technical report 1. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=11&Itemid=165&lang=en [Accessed 22 July 2011].

JRC. 2005. *GLC 2000, a New Approach to Global Land Cover Mapping from Earth Observation Data*. Intern. Journal of Remote Sensing Volume 26, Number 9, pp.1959-1977(19). Available from: http://www.ingentaconnect.com/content/tandf/tres/2005/00000026/00000009/art00012 [Accessed 22 July 2011].

FAO-WOCAT. 2011. Questionnaire for Mapping Land Degradation and Sustainable

IIASA. 2009. *Compilation of selected global indicator of land degradation*. LADA technical report 14. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=331&Itemid=165&lang=en.

Monfreda, C., Ramankutty, N. & Foley, J.A. 2008. *Farming the Planet. 2: The Geographic Distribution of Crop Areas and Yields in the Year 2000*, Glob. Biogeochem. Cycles, submitted.

Ravelo, A. *et al.* 2010. *Unpublished LADA land use system report of Argentina*.

Ravelo, A.C., Planchuelo, A.M., Kindgard, A. & Castellanos, M. 2010. *Protocolo de validacion de LUS* (proyecto LADA / FAO). LADA Project Argentina country report.

Siebert, S., Döll, P., Feick, S., Hoogeveen, J. & Frenken, K. 2007. *Global Map of Irrigation Areas version 4.0.1*. Johann Wolfgang Goethe University, Frankfurt am Main, Germany / Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.fao.org/nr/water/aquastat/irrigationmap/index.stm [Accessed 22 July 2011]

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A.N. & Ndegwa, T. 2002. *Mapping poverty and livestock in the developing world*. ILRI (International Livestock Research Institute),Nairobi, Kenya.124 pp. Available from: http://www.ilri.org/InfoServ/Webpub/fulldocs/mappingPLDW/index.htm

Tiffen, M. & Mortimore, M. 1992. *Environment, Population Growth and Productivity in Kenya: A Case Study of Machakos District*. Development Policy Review, Vol. 10, No 1: 359-387.

Wint, G.R.W. & Robinson, T.P. 2007. *Gridded Livestock of the World, 2007*. Rome: Food and Agriculture. Organization of the United Nations, Animal Production and Health Division. Available from: http://www.fao.org/ag/againfo/resources/en/glw/default.html [Accessed 22 July 2011]

World Conservation Union and UNEP-World Conservation Monitoring Centre. 2007. *World Database on Protected Areas*, WCMC, Cambridge, UK, 2007.

You, L. & Wood, S. 2006. *An entropy approach to spatial disaggregation of agricultural production*. Agricultural Systems 90(1-3): 329-347. Available from: http://rustmapper.ctl1.com/YouWood_AgSystem2006.pdf [Accessed 22 July 2011]

Young, A., Bot, A. & Nachtergaele, F. 2000. *Land resource potential and constraints at regional and country levels*. World Soil Resources Reports no 90. FAO, Rome.

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ISBN 978-92-5-107568-5

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I3242/1/03.13