Manual of the Basic Set of Environment Statistics of the FDES 2013

Land Cover and Land Use Statistics

(Topics 1.2.1 Land Cover and 2.3.1 Land Use of the Basic Set of Environment Statistics of the FDES 2013)

Elaborated by the Environment Statistics Section
of the United Nations Statistics Division,
in collaboration with the
Expert Group on Environment Statistics

Version 1.0
31 January 2018

Methodology sheet of the Basic Set of Environment Statistics of the FDES:
https://unstats.un.org/unsd/envstats/fdes/manual_bses.cshtml
https://unstats.un.org/unsd/envstats/fdes.cshtml

Contents

1. Statistics in Topics 1.2.1 Land Cover and 2.3.1 Land Use

Component 1: Environmental Conditions and Quality				
Sub-component 1.2: Land Cover, Ecosystems and Biodiversity				
Topic 1.2.1: Land cover				
	Statistics and Related Information (**Bold Text - Core Set/Tier 1**; Regular Text - Tier 2; *Italicized Text - Tier 3*)	**Category of Measurement**	**Potential Aggregations and Scales**	**Methodological Guidance**
a.	**Area under land cover categories**	Area	▪ By location ▪ By type of land cover (e.g., artificial surfaces including urban and associated areas; herbaceous crops; woody crops; multiple or layered crops; grassland; tree-covered areas; mangroves; shrub-covered areas; shrubs and/or herbaceous vegetation, aquatic or regularly flooded; sparsely natural vegetated areas; terrestrial barren land; permanent snow and glaciers; inland water bodies; and coastal water bodies and inter-tidal areas)[(a)] ▪ National ▪ Sub-national	▪ FAO Land Cover Classification System ▪ System of Environmental-Economic Accounting (SEEA) Central Framework (2012) land cover categories ▪ European Environment Agency (EEA)

(a) SEEA land cover categories, based on FAO Land Cover Classification System (http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf)

Component 2: Environmental Resources and their Use				
Sub-component 2.3: Land				
Topic 2.3.1: Land use				
Statistics and Related Information (**Bold Text - Core Set/Tier 1**; Regular Text - Tier 2; *Italicized Text - Tier 3*)		**Category of Measurement**	**Potential Aggregations and Scales**	**Methodological Guidance**
a.	**Area under land use categories**	Area	▪ By type of land use (e.g., agriculture; forestry; land used for aquaculture; use of built-up and related areas; land used for maintenance and restoration of environmental functions; other uses of land not elsewhere classified; land not in use; inland waters used for aquaculture or holding facilities; inland waters used for maintenance and restoration of environmental functions; other uses of inland waters not elsewhere classified; inland water not in use; coastal waters (including area of coral reefs and mangroves); Exclusive Economic Zone (EEZ)) ▪ National ▪ Sub-national	▪ FAO ▪ UNECE Standard Classification of Land Use (1989) ▪ SEEA Central Framework (2012) Annex 1
b.	Other aspects of land use		▪ National ▪ Sub-national	
	1. *Area of land under organic farming*	Area		▪ FAO Inter-departmental Working Group on Organic Agriculture
	2. Area of land under irrigation	Area		
	3. Area of land under sustainable forest management	Area		▪ Forest Stewardship Council
	4. *Area of land under agroforestry*	Area		
c.	Land ownership	Area	▪ By ownership category ▪ National ▪ Sub-national	▪ FAO

2. Introduction/Relevance

Land is a unique resource that delineates the space in which economic activities and environmental processes take place and within which environmental resources and economic assets are located. Land use determines food, material and energy supply. Land is finite, and is under pressure to serve the growing demand for human needs, which often requires land use change characterized by the expansion of urban areas and infrastructure at the expense of agricultural land, and by the expansion of agricultural land at the expense of grasslands, savannahs and forests. These pressures result in land use change which can be associated with a profound alteration of land cover, a deprivation of natural capital such as shrinking extension of natural ecosystems and degraded soil functions, including fertility.[1]

The two primary aspects of land, land cover and land use, are separate but related concepts. Land cover describes the biophysical aspects of land, e.g., lakes, wetlands, forests, impervious surfaces; while land use refers to the socio-economic or functional aspects of land, e.g., timber, fuelwood, commercial, recreation, housing.

Land is also of critical importance to climate change and land use and land cover change is essential in understanding emissions and carbon sequestration. For example, forests contain a large part of the carbon stored on land; also, fossil fuel burning and land use change can lead to additions of carbon to the atmosphere. Similarly, cropland ecosystems both stock carbon in below-ground organic matter and soil, and releases carbon in agricultural production and associated waste materials. Ecosystem conservation may also influence carbon sinks. Many forests, savannas, and wetlands, if managed as nature reserves or/and recreation areas, can preserve significant stocks of carbon, although these stocks might be affected negatively by climate change. Some wetlands and old-growth forests exhibit particularly high carbon densities; other semi-natural ecosystems (e.g., savannas) may conserve carbon simply because of their large areal extent. The different levels of emissions from various land uses and the sequestration potential of land cover types requires monitoring of land use and land cover change.

Security of tenure is also an important consideration as land and water use rights which can protect the environment are often based on local traditions. Security of tenure, including that which allows access to forests, communal grazing and common property, is important in the face of pressures on land from growing populations, increased levels of urbanization etc. Secure tenure rights allow for protection of common property and motivate farmers to adopt sustainable practices.

Land use and land cover statistics are important for policy formulation and planning, namely for natural resources and the environment (agriculture, agro-industries, forestry, minerals, water, fisheries, etc.); human resources (e.g. education, health services and infrastructure); prevention and mitigation of natural disasters and military conflicts; crime prevention, and biofuel production.

---

[1] UN Environment (2014) *Assessing Global Land Use: Balancing Consumption with Sustainable Supply*, UN Environment: Nairobi, http://wedocs.unep.org/handle/20.500.11822/9546 (accessed 19 December 2017)

Statistics on land use or land cover refer to a point in time or to a short period of time. Generally, the total area of a country will remain unchanged from one period to the next. However, land use or land cover can change over time and changes in the stocks of land will comprise changes within and between stocks in different classes of land cover and land use (land restructuring).[2] Statistics on land use/land cover should therefore include the land use/land cover changes taking place during defined periods of time.

This methodology sheet covers Topic 1.2.1 Land Cover and Topic 2.3.1 Land Use. In addition to identifying areas as defined by land use/land cover classifications, these topics highlight aspects of land use for agriculture and forestry, and the issue of land tenure (termed ownership) which are important for the environment.

[2] United Nations Statistics Division (2017) *Framework for the Development of Environment Statistics (FDES 2013)*, https://unstats.un.org/unsd/environment/fdes/FDES-2015-supporting-tools/FDES.pdf (accessed 17 December 2017)

3. Definitions and description of the statistics

The concepts and definitions are provided by the standards and guidelines established by lead agencies in the field, such as FAO, UNFCCC, etc., to ensure conformity with established international best practices. The references can be found with the respective definitions and classifications.

Land cover is the observed (bio)physical cover on the earth's surface, including water surfaces. When considering land cover in a strict sense, it should be confined to the description of vegetation and man-made features. However, in practice it also includes the areas of bare rock or bare soil (which describe land itself rather than land cover) and water surfaces. The latter is the more common use of the term.[3]

Water surfaces include inland water (e.g., rivers, lakes and ponds), coastal water bodies and inter-tidal areas but not marine water. Certain types of land use analyses may include coastal waters (internal waters) or even Exclusive Economic Zones (EEZs).[4]

Land use is the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment.[5]

Land cover or land use change indicates the changes occurring to the land cover or land use over time. These may be natural successional changes, natural events or due to climate change or human intervention.[6]

It should be noted that an important element of land use and land cover statistics is the classification used which is discussed in Section 4.

3A. Land cover (Topic 1.2.1)

Area under land cover categories (FDES 1.2.1.a)

The area of land cover is the area under each land cover category of the classification used. Land cover change is an equally important statistic and indicates the changes occurring to the land cover over time.

---

[3] FAO (2000) *Land Cover Classification System (LCCS): Classification Concepts and User Manual*, FAO: Rome, http://www.fao.org/docrep/003/x0596e/X0596e00.htm#P-1_0 (accessed 17 December 2017)
[4] United Nations Statistics Division (2017) *Framework for the Development of Environment Statistics (FDES 2013)*, https://unstats.un.org/unsd/environment/fdes/FDES-2015-supporting-tools/FDES.pdf (accessed 17 December 2017)
[5] FAO (2000) *Land Cover Classification System (LCCS): Classification Concepts and User Manual*, FAO: Rome, http://www.fao.org/docrep/003/x0596e/X0596e00.htm#P-1_0 (accessed 17 December 2017)
[6] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017]

3B. Land use (Topic 2.3.1)

Area under land use categories (FDES 2.3.1.a)

The area of land use is the area under each land use category of the classification used. Land use change is an equally important statistic and indicates the changes occurring to the land use over time.

3C. Other aspects of land use

Area of land under organic farming (FDES 2.3.1.b.1)

Organic agriculture (farming) is a specific and precise standard of production which aims at achieving optimal agro-ecosystems that are socially, ecologically and economically sustainable. Although no unique standards have yet been defined for organic agriculture, two widely used standards developed at international level are those provided within the CODEX Alimentarius (FAO/WHO) and those developed by the International Federation of Organic Agricultural Movements (IFOAM).[7]

The definition used in the CODEX Alimentarius is that "organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system."[8]

The area of land under organic farming is defined as the area certified organic or in conversion to certified organic. The area certified organic is the area dedicated to products certified as "organic" by a certification body. Certification can be through an accredited third-party certification body or authority, or through Participatory Guarantee Systems. The area in conversion to certified organic is that area undergoing a conversion process to area certified organic. Products can be marketed as in-conversion. There is usually a set period for conversion, from initiation to completion of the process.[9]

Remark:

- This definition has been aligned to that of FDES statistic 2.5.3.a.4 Amount of organic production, in the methodology sheet on Crops and Livestock Statistics.

[7] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)
[8] FAO and WHO (1999) *FAO/WHO Codex Alimentarius Commission* website, http://www.fao.org/fao-who-codexalimentarius/en/ (accessed 17 December 2017)
[9] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)

Area of land under irrigation (FDES 2.3.1.b.2)

The area of land under irrigation refers to land area equipped for irrigation or land area actually irrigated.[10] The former is the land area equipped with irrigation infrastructure and equipment to provide water to crops, which are in working order. The equipment does not have to be used during the reference year. The area equipped for irrigation covers areas equipped for fully controlled irrigation by any of the methods of surface, sprinkler or localized irrigation. It also includes areas under partially controlled irrigation methods of spate irrigation (controlling flood waters to water crops), equipped wetlands and inland valley bottoms and equipped flood recession. It excludes manual watering of plants using buckets, watering cans or other devices.[11]

Land area actually irrigated is the land area equipped for irrigation that is actually irrigated in the reference year. It covers both fully controlled and partially controlled irrigation. It refers to the physical area of land irrigated. Therefore, even if the same area is irrigated more than once a year, it should only be counted once.[12] It includes manual watering of plants. Uncontrolled land flooding by overflowing of rivers and streams is not considered irrigation.[13]

Remark:

- Irrigation may be seasonal and therefore the area of land under irrigation should be identified over a reference period such as a calendar or agricultural year.

Area of land under sustainable forest management (FDES 2.3.1.b.3)

Sustainable forest management (SFM) is "*[a] dynamic and evolving concept [that] aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations.*"[14]

In line with the Sustainable Development Goals the area of land under sustainable forest management is defined as forest area with a stable or positive net change; stable or increasing above-ground biomass stock in forest; under legally established protected areas; under a long-term forest management plan; and under an independently verified forest management certification scheme.[15]

Area of land under agroforestry (FDES 2.3.1.b.4)

Agro-forestry is the collective term for land-use systems and technologies in which woody perennials (e.g., trees, shrubs, palms or bamboos) and agricultural crops or animals are used deliberately on the same parcel of land in some form of spatial and temporal arrangement. It can also be defined as a dynamic, ecologically based natural resource management system that, through the integration of trees on farms and in agricultural landscapes or through the

[10] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)
[11] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)
[12] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)
[13] FAO (2015) *World Programme for the Census of Agriculture 2020.* FAO Statistical Development Series 15, FAO: Rome, http://www.fao.org/3/a-i4913e.pdf (accessed 17 December 2017)
[14] United Nations (2008) *A/RES/62/98 Resolution adopted by the General Assembly: 62/98 Non-legally binding instrument on all types of forests*, http://www.fao.org/forestry/14717-03d86aa8c1a7426cf69bf9e2f5023bb12.pdf (accessed 17 December 2017)
[15] United Nations Statistics Division (December 2017) *SDG Metadata for Indicator 15.2.1 Progress towards sustainable forest management*, December 2017, https://unstats.un.org/sdgs/metadata/files/Metadata-15-02-01.pdf (accessed 17 December 2017)

production of agricultural products in forests, diversifies and sustains production for increased economic, social and environmental benefits for land users.[16]

In general, to be termed agro-forestry, the forestry practices should be deliberate and some examples of the purposes of agro-forestry activities include improving soil fertility, reducing soil erosion, improving watershed management, or providing shade and food for livestock.[17]

Remark:

- Countries need to develop their own procedures to collect data on agroforestry systems. Some may wish to collect data on specific agroforestry activities.[18]

Land ownership (FDES 2.3.1.c)

The statistic should be interpreted to cover not only areas under formal ownership but more broadly a range of land tenure rights. Land tenure rights are the rights to land that are, in everyday language, associated with the ability to use, control, transfer, or otherwise enjoy a land parcel as long as those activities are allowed by law.[19] Tenure rights can vary from limited use to full ownership, and can be assigned to a variety of parties, such as rights which are private, communal, open access or assigned to the state. This also includes customary tenure rights and informal tenure.[20]

Remark:

- Countries generally report land tenure or ownership categories that are most appropriate to their circumstances but which allow identification of the broad land tenure categories, "Legal ownership or legal owner-like possession" and "Non-legal ownership or non-legal owner-like possession."[21]

[16] FAO (2015) web page on the Sustainable Forest Management (SFM) Toolbox, http://www.fao.org/sustainable-forest-management/toolbox/modules/agroforestry/basic-knowledge/en/ (accessed 17 December 2017)
[17] FAO (2015) *World Programme for the Census of Agriculture 2020.* FAO Statistical Development Series 15, FAO: Rome, http://www.fao.org/3/a-i4913e.pdf (accessed 17 December 2017)
[18] FAO (2015) *World Programme for the Census of Agriculture 2020.* FAO Statistical Development Series 15, FAO: Rome, http://www.fao.org/3/a-i4913e.pdf (accessed 17 December 2017)
[19] FAO (2012) *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security*, Rome: FAO, http://www.fao.org/docrep/016/i2801e/i2801e.pdf (accessed 17 December 2017)
[20] FAO (2012) *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security*, Rome: FAO, http://www.fao.org/docrep/016/i2801e/i2801e.pdf (accessed 17 December 2017)
[21] FAO (2015) *World Programme for the Census of Agriculture 2020.* FAO Statistical Development Series 15, FAO: Rome, http://www.fao.org/3/a-i4913e.pdf (accessed 17 December 2017)

4. International sources and recommendations

4A. Classifications and groupings

When discussing land use and land cover classifications it is important to distinguish between the classification and the legend. The classification is the arrangement of objects into groups or sets according to specific rules of classifications. It is thus scale independent, meaning that all levels of classes are applicable no matter what scale or level of detail is used in identifying the classes; and it is source independent, that is independent of the source data used, e.g., remotely sensed images, aerial photographs.[22]

A legend is the application of a classification in a specific area using a defined mapping scale and specific data set. Therefore, a legend may contain only a proportion, or sub-set, of all possible classes of the classification. Thus, a legend is scale and cartographic representation dependent (e.g., a mixture of map scales are used if individual elements cannot be individually identified at a smaller scale); and data and mapping methodology dependent (e.g., an aerial photograph shows different features compared to a satellite false colour composite image).[23]

It should be noted that the definitions of the classes should always be consulted, as the same category titles for different classifications do not necessarily incorporate the same land cover or land uses. Further information on mappings between classifications is presented in Section 4B.

Since there is generally no natural or best classification of a set of objects as such, the elaboration of a classification requires either formal criteria of goodness of fit or, if a classification is required for a purpose, a precise statement of that purpose.[24] Given the diversity of purposes for land cover and land use statistics, countries often use a national classification and it is encouraged that this can be mapped to applicable international classifications.

A mapping among the classifications covered here, namely 4A5. FAO Land Use Classification, 4A2. and 4A3. System of Environmental Economic Accounting Central Framework Land Cover Classification and Land Use Classification, 4A4. World Census of Agriculture Land Use Classification and 4A6. Intergovernmental Panel on Climate Change Land Cover Groupings can be found in the FAO Land Use, Irrigation and Agricultural Practices Questionnaire 2017.[25]

---

[22] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[23] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[24] Duhamel, C. (unknown) *Necessary paths for developing harmonized global land use classification systems*, Landsis: Luxembourg
[25] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)

4A1. Classification systems: FAO Land Cover Classification System v.3[26]

The Land Cover Classification System (LCCS) v.3 developed by FAO is a classification system used to develop classifications, using standard diagnostic attributes (classifiers) which are used as building blocks to develop a list of classes. These can be combined to create classifications detailing different land cover patterns.[27] These blocks are described using the Land Cover Meta Language (LCML), which provides a general framework of rules from which more exclusive conditions can be derived to create specific land cover legends or nomenclatures. The LCML consists of:

- "Basic elements" divided into biotic and abiotic elements, which relate to the basic objects of land cover, e.g., trees, shrubs, herbaceous vegetation, snow, ice; and
- "Element properties" which define the characteristics of these basic objects, e.g., type and size of tree, and properties, e.g., natural grass.

Each element has associated properties, e.g., natural vegetation height, cover, leaf type and leaf phenology. Characteristics can also be associated to an element and are user defined, e.g., vegetation seeding time, grazing, vegetation management practices.

The land cover classes created are mapped by its producers to the elements which together define the class. For example, a class "tree and shrub savannah" could be formed of the elements, herbaceous vegetation with 50 to 100% cover; trees with cover from 4 to 15% and shrubs with open cover of 4 to 15%.[28]

The basic building blocks allow for the mapping of classifications from different sources, thus allowing for standard interpretation of class labels. This also assists in mapping national classifications to international classifications. For example, the SEEA Land Cover and Land Use classifications having been derived from the basic definitions of the LCCS can easily be linked to specific classifiers.[29]

4A2. System of Environmental-Economic Accounting, Central Framework: Land Cover Classification

The 14 classes of the System of Environmental-Economic Accounting, Central Framework (SEEA-CF) Land Cover Classification constitute a comprehensive set of land cover types with clear boundaries derived from the building blocks of the LCCS that are mutually exclusive and unambiguous. This land cover classification can be used at all scales, independently of the method of observation, thus allowing cross-referencing of local and regional maps with continental and global maps without loss of information.[30]

---

[26] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[27] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[28] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[29] FAO (2017) FAOSTAT webpage data on land use metadata, http://www.fao.org/faostat/en/#data/RL (accessed 17 December 2017)
[30] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*.

Figure 4A2 System of Environmental-Economic Accounting-Central Framework Land Cover Classification (interim)[31]

Category	Basic rule (for translation of national data sets)
Artificial surfaces (including urban and associated areas)	The category is composed of any type of artificial surfaces.
Herbaceous crops	The category is composed of a main layer of cultivated herbaceous plants.
Woody crops	The category is composed of a main layer of cultivated tree or shrub plants.
Multiple or layered crops	The category is composed of at least two layers of cultivated woody and herbaceous plants or different layers of cultivated plants combined with natural vegetation.
Grassland	The category is composed of a main layer of natural herbaceous vegetation with a cover from 10 to 100 per cent.
Tree-covered areas	The category is composed of a main layer of natural trees with a cover from 10 to 100 per cent.
Mangroves	The category is composed of natural trees with a cover from 10 to 100 per cent in aquatic or regularly flooded areas in salt and brackish water.
Shrub-covered areas	The category is composed of a main layer of natural shrubs with a cover from 10 to 100 per cent.
Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	The category is composed of natural shrubs or herbs with a cover from 10 to 100 per cent in aquatic or regularly flooded areas with water persistence from 2 to 12 months per year.
Sparsely natural vegetated areas	The category is composed of any type of natural vegetation (all growth forms) with a cover from 2 to 10 per cent.
Terrestrial barren land	The category is composed of abiotic natural surfaces.
Permanent snow and glaciers	The category is composed of any type of glacier and perennial snow with persistence of 12 months per year.
Inland water bodies	The category is composed of any type of inland water body with a water persistence of 12 months per year.
Coastal water bodies and intertidal areas	The category is composed on the basis of geographical features in relation to the sea (lagoons and estuaries) and abiotic surfaces subject to water persistence (intertidal variations).

Studies in Methods, Series F, No. 109. Sales No. E.12.XVII.12. https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed 17 December 2017)

[31] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*. Studies in Methods, Series F, No. 109. Sales No. E.12.XVII.12. https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed 17 December 2017)

4A3. System of Environmental-Economic Accounting, Central Framework: Land Use Classification

Presented below are the first and second levels of the SEEA Land Use Classification. More detailed classes are presented in the third and fourth levels of the classification.

Figure 4A3: SEEA Land Use Classification[32]

Land use classification	
1	**Land**
1.1	Agriculture
1.2	Forestry
1.3	Land used for aquaculture
1.4	Use of built-up and related areas
1.5	Land used for maintenance and restoration of environmental functions
1.6	Other uses of land n.e.c.
1.7	Land not in use
2	**Inland waters**
2.1	Inland waters used for aquaculture or holding facilities
2.2	Inland waters used for maintenance and restoration of environmental functions
2.3	Other uses of inland waters n.e.c.
2.4	Inland waters not in use

4A4. World Census of Agriculture Land Use Classification

Other classifications for specific uses are also available, for example, the Land Use Classification for the Agricultural Census of the World Census of Agriculture.[33]

[32] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*. Studies in Methods, Series F, No. 109. Sales No. E.12.XVII.12. https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed 17 December 2017)

[33] FAO (2015) *World Programme for the Census of Agriculture 2020.* FAO Statistical Development Series 15, FAO: Rome, http://www.fao.org/3/a-i4913e.pdf (accessed 17 December 2017)

Figure 4A4: World Census of Agriculture Classification of land use for the agricultural census

Figure 1 - Classification of land use (LU) for the agricultural census

Basic land use classes	Aggregate land use classes			
LU1. Land under temporary crops	LU1-3 Arable land	LU1-4 Cropland	LU1-5 Agricultural land	LU1-6 Land used for agriculture
LU2. Land under temporary meadows and pastures				
LU3. Land temporarily fallow				
LU4. Land under permanent crops				
LU5. Land under permanent meadows and pastures				
LU6. Land under farm buildings and farmyards				
LU7. Forest and other wooded land				
LU8. Area used for aquaculture (including inland and coastal waters if part of the holding)				
LU9. Other area not elsewhere classified				

4A5. FAO Land Use Classification[34]

The FAO Land Use Classification is that used to collect data on land use for the FAOSTAT database.

Figure 4A5. FAO Land Use Classification

CATEGORIES
Country area
Land area
Agriculture
Agricultural land
Cropland
Arable land
Land under temporary crops
Land under temporary meadows and pastures
Land with temporary fallow
Land under permanent crops
Land under permanent meadows and pastures
Permanent meadows and pastures - Cultivated
Permanent meadows and pastures - Naturally growing
Land under protective cover
Forestry
Forest land
Other wooded land
Other land
Inland waters
Coastal waters
Exclusive Economic Zone (EEZ)

[34] FAO (2015) *Land use, Irrigation and Agricultural Practices Questionnaire 2017*, http://www.fao.org/economic/ess/ess-home/questionnaires/en/ (accessed 17 December 2017)

4A6. Intergovernmental Panel on Climate Change (IPCC) Land Cover Groupings[35]

The IPCC while not a classification per se, provides high level groupings related to the monitoring of greenhouse gas emissions. These groupings combine land use and land cover. The groupings are forest land, cropland, grassland, wetlands, settlements and other land. For each of these further sub-groupings are provided which are characterized by their contribution to CO_2 emission and removals. Categories related to land-use change are also provided.

FF = forest land remaining forest land
GG = grassland remaining grassland
CC = cropland remaining cropland
WW = wetlands remaining wetlands
SS = settlements remaining settlements
OO = other land remaining other land

LF = lands converted to forest land
LG = lands converted to grassland
LC = lands converted to cropland
LW = lands converted to wetlands
LS = lands converted to settlements
LO = lands converted to other land

4B. Reference to international statistical recommendations, frameworks and standards

- The System of Environmental-Economic Accounting 2012[36] and the Experimental Ecosystem Accounting,[37] provide guidance on environmental-economic accounting rather than principles of land use or land cover classifications. However, these accounts use statistical units which are spatial, and land cover and land use statistics are key aspects of the accounting principles.

- LCCS 3.0[38] discussed in Section 4A1 contains guidance on developing and measuring land cover using the LCCS 3.0 classification system.

- Intergovernmental Panel on Climate Change (IPCC)/Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF)[39] provides guidance on land use, land-use change and forestry for monitoring and reporting of carbon stock changes and greenhouse gas emissions. The guidelines address the estimation of land areas and change in land area associated with LUCF activities. It also contains guidance on mapping countries' land classification systems to the IPCC categories.

---

[35] IPCC (2003) *Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF)*, http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html (accessed 17 December 2017)
[36] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*. Studies in Methods, Series F, No. 109. Sales No. E.12.XVII.12. https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed 17 December 2017)
[37] United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) *System of Environmental-Economic Accounting 2012: Central Framework*. Studies in Methods, Series F, No. 109. Sales No. E.12.XVII.12. https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf (accessed 17 December 2017)
[38] FAO (2016) *Land Cover Classification System: Classification concepts Software Version 3*, FAO: Rome, www.fao.org/3/a-i5232e.pdf (accessed 17 December 2017)
[39] IPCC (2003) *Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF)*, http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html (accessed 17 December 2017)

4C. Sources of global and regional environment statistics and indicators series

It should be noted that each dataset determines the definitions and classifications used, therefore even though classes may use the same names, these may not cover the same elements of land cover or land use.

4C1. Global data sets produced by international agencies

- FAOSTAT Land Cover database[40] contains data on area by land cover class, by country, aggregated at national level according to the land cover classification of the SEEA. The underlying information is derived from publicly available Global Land Cover Map products. Data products used are the ICBP-MODIS – 500m resolution and the land cover maps at 300m resolution produced under the Climate Change Initiative of the European Space Agency.

- FAO also produces land use data from the agri-environmental indicators database[41] which provides information on the annual evolution of the distribution of agricultural and forest areas, and their sub-components, including irrigated areas at national, regional and global levels. The data is obtained from national statistical offices using the FAO Land Use questionnaire.

4C2. Global data sets produced by regional or national agencies

- The European Space Agency Global Land Cover Service[42] land-cover maps (GlobeLand30-GLC30). The European Space Agency produces 300m resolution global land cover data sets for 1988-2002, 2003-2007 and 2008-2012. The legend is aligned to the FAO Land Cover Classification System (LCCS).

- European Space Agency Land Cover Climate Change Initiative[43] produces MERIS Full resolution time series from 2003-2012, global land cover maps for 1998-2002, 2003-2007 and 2008-2012, global land cover seasonality products, global map of open and permanent water bodies and various tools to assist in using the products.

- MODIS Land Cover Type/Dynamics[44] of NASA at 500m spatial resolution for the years 2001 to 2016 using MODIS Terra+Aqua data, based on an International Geosphere-Biosphere Programme (IGBP) classification. The land cover dynamics products provide estimates of vegetation phenology twice a year from the two 12-month focus periods, July-June and January-December during the main growing seasons of the Northern and Southern hemispheres.

---

[40] FAO (2017) FAOSTAT webpage data on land use metadata, http://www.fao.org/faostat/en/#data/RL (accessed 17 December 2017)
[41] FAOSTAT (2017) Agri-environmental indicators database, http://ref.data.fao.org/dataset?entryId=8fcce18b-7f4c-4cdb-aad1-8d3c223ca9cd (accessed 17 December 2017)
[42] European Space Agency (2017) Global Land Cover Service webpage, http://due.esrin.esa.int/page_project68.php (accessed 17 December 2017)
[43] European Space Agency (2017) ESA Climate Change Initiative Land Cover webpage, https://www.esa-landcover-cci.org/?q=node/164 (accessed 17 December 2017)
[44] NASA (2017) MODIS Land Cover Type/Dynamics webpage, https://modis.gsfc.nasa.gov/data/dataprod/mod12.php (accessed 17 December 2017)

4C3. Other global datasets produced outside of international agencies

The IPCC Guidelines for National Greenhouse Gas Inventories[45] provide examples of international land cover datasets prepared by a variety of institutions at regional to global scales. These are mentioned as an option for greenhouse gas inventory compilation alongside national data sets. It should be noted that the specific purpose is for GHG inventory compilation and not necessarily for other purposes. The IPCC suggests the datasets can be used to estimate the spatial distribution of land use categories and to assess the reliability of existing land-use datasets.

There is no quality assessment of the datasets provided but IPCC suggests considering:

- How the classification scheme links to that used by the country and establishing a mapping.
- The need to aggregate finer resolution national data to the coarser categories of global data sets.
- Assessing the classification accuracy and geo-referencing errors before use.
- The need to interpolate or extrapolate between time periods to use the data for GHG inventory estimations.

4C4. Regional datasets produced by national governments or regional agencies

- North American Land Change Monitoring System (NALCMS)[46] is a collaborative initiative between Canada, Mexico, and the United States to monitor land cover and its change over time. Land cover data sets are available for North America for 2005 at 250m spatial resolution.

- CORINE Land cover products:[47] In 1985 the Corine programme for Coordination of Information on the Environment was initiated in the European Union to provide standardized data on land in Europe. Products available are:

    - CLC1990 compiling data covering years 1986-1999, CLC2000 for 2001 to 2006, CLC2006 for 2007-2010 and CLC2012 for 2013 to 2014. Corine Land Cover is a biophysical inventory of land cover and land use, providing geographic reference information for European countries. One of the main products is an inventory of land cover in forty-four land cover classes, with a minimum mapping unit of 25 hectares and 100m minimum mapping width. When presented as a cartographic product it is at a scale of 1:100 000.[48]

    - LCC 1990-2000, LCC 2000-2006 and LCC 2006-2012 are the land cover change products. These have a 5 hectare minimum mapping unit. The LCC products map the areas of change, rather than the comprehensive land cover of an area. The product is used for land use/land cover change analysis for studies such as ecosystem mapping, modelling the impacts of climate change, landscape fragmentation, farm land change and other structural changes such as agriculture, urban sprawl and water management.

---

[45] IPCC (2006) *IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4 Agriculture, Forestry and Other Land Use*, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html, IGES: Japan (accessed 17 December 2017)
[46] USGS (2017) *North American Land Change Monitoring System* webpage, https://landcover.usgs.gov/nalcms.php (accessed 17 December 2017)
[47] European Environment Agency (2017) *Data and maps* webpage, https://www.eea.europa.eu/data-and-maps (accessed 17 December 2017)
[48] European Environment Agency (2017) *Glossary of environmental terms used by EEA* website, http://glossary.eea.europa.eu//terminology/sitesearch?term=corine+land+cover (accessed 17 November 2017)

- The Land Use and Cover Area Frame Survey (LUCAS):[49] the LUCAS survey is carried out every three years, to gather harmonised information on land use and land cover. The latest available surveys were in spring-summer of 2009, 2012 and 2015. The first phase is a sample of around 1.1 million points which are photo-interpreted. This followed by a second phase, with a ground based sample survey of around 270,000 points which are classified to land use or land cover classes. Microdata is available for the survey points falling in each country. Also available are statistics on land cover, land use and landscape at NUTS0, NUTS1 and NUTS2 levels.[50] Mappings are provided between LUCAS and FAO classification for forest classes based on the classes of the Forest Resources Assessment of FAO.

[49] Eurostat (2017) LUCAS – *Land use and land cover survey* website, http://ec.europa.eu/eurostat/statistics-explained/index.php/LUCAS_- (accessed 17 December 2017)
[50] Eurostat (2017) *Land Cover/Use Statistics database* website, http://ec.europa.eu/eurostat/web/lucas/data/primary-data/2015 (accessed 17 December 2017)

5. Data collection and sources of data

Land use and land cover databases are normally produced by specialized agencies such as lands and surveys departments or national mapping agencies. Other agencies, such as those involved in natural resource management or land based production, e.g., forestry, water or agriculture, may keep records on land use for their specific thematic areas. The products are available in several formats: digitally in geospatial land cover or land use databases, or as map based formats, e.g., land cover or land use atlases. Several inputs of different formats may be necessary to create the land use or land cover product, e.g., satellite based raster data, land parcel cadastral data, and data from ground surveys. The environmental statistician will need to be cognisant of the data sharing arrangements between government agencies and other institutions, such as universities who may also hold useful input datasets.

This section provides the information necessary for the environmental statistician to communicate with geographic/remote sensing experts in commissioning products or in interpreting land cover or land use products. It does not provide a detailed methodology for production of such products. Methods relevant to statistics on irrigated area and organic area are covered under the methodology sheet on Crops and Livestock Statistics.

Uses of the Land Cover or Land Use database

The environmental statistician should be aware of the main use or uses of the land cover or land use data sets before commissioning a product, as the product required often varies by policy level (regional, national or international) and type of decision (development of frameworks or programmes or detailed monitoring and management). For example, different types of datasets are necessary for monitoring forest change, estimation of national greenhouse gas emissions, monitoring of habitat loss or degradation for conservation management. Each use prioritizes different classifications, spatial and temporal scales, and requires products with differing levels of thematic and geographic detail. For example, local applications such as forest management or risk assessment may require a more detailed scale than that for estimating greenhouse gas emissions.

Land cover or land use change

When there is interest in comparing land use or land cover change between two periods, the classification should be capable of detecting conversion of one category to another (e.g., from forest to grassland) and modification of condition within a category (e.g., rainfed cultivation to irrigated cultivation).[51] The broader and fewer the classes the lower the capacity to detect change. Direct comparison of two products may not be accurate if these are produced with different methods, inputs of differing scales, accuracies, or different classes. This can result in products with differing levels of accuracy and a direct comparison could show difference in mapping methods rather than real change. Land use or land cover data are often produced at long intervals, within which time methods and inputs have

[51] Jansen, L. and Digregorio, A. (1998) The problems of current land-cover classifications: development of a new approach, in Eurostat (1999): *Land Cover and Land Use information systems for European Union Policy Needs*. Proceedings of the seminar Luxembourg, 21-23 January 1998, European Communities: Luxembourg, http://aei.pitt.edu/85338/1/1999.pdf (accessed 17 December 2017)

improved.[52] In such cases when analysis of change is required this should be communicated to the specialist producers so that appropriate adjustments can be made or a special product enabling comparison between periods can be produced.

Products used to identify land use/land cover change, this should attempt to explain:

- Where change is occurring.
- Which land use/land cover types are changing, from one category to another.
- Types of changes taking place.
- Rates or amounts of land change and the time over which such changes occur.
- Causes of the changes.[53]

Updating the Land Use or Land Cover Database

The frequency of production of land use or land cover data varies with the ability of countries to create such data regularly and the level of change in the environment. However, land cover change is generally slow and successional, which does not require annual monitoring - a five or ten year interval is usually adopted where possible.[54]

Input data and use of the final product

Land use or land cover products are typically produced from aerial photos, ground surveys, cadastral surveys or remotely sensed data, together with directly observed data for ground truthing. For land use, remotely sensed data is combined with expert knowledge or interviews with land managers to determine the human activities occurring in the same part of the landscape.

The classes which can be detected and the scale or resolution of the final products depend on the characteristics of the data. These data characteristics are spatial scale or resolution, temporal resolution, and for remotely sensed data also spectral resolution and radiometric resolution. These characteristics are discussed in the sections below. The environmental statistician should be guided by the remote sensing professional in the most appropriate choice of input data.

Geographic Scope

Includes all land in the selected area of the country being covered, including vegetation and man-made features, including bare rock or bare soil and water surfaces, including inland water (e.g., rivers, lakes and ponds), coastal water bodies and inter-tidal areas but not marine water.[55] It should be made clear whether the product coverage is global,

[52] Eurostat (2001) *Manual of concepts on land cover and land use information systems*, Eurostat: Luxembourg, http://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-34-00-407?inheritRedirect=true (accessed 17 December 2017)
[53] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[54] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[55] United Nations Statistics Division (2017) *Framework for the Development of Environment Statistics (FDES 2013),* https://unstats.un.org/unsd/environment/fdes/FDES-2015-supporting-tools/FDES.pdf (accessed 17 December 2017)

regional or national as the level of spatial resolution or scale often varies. Global products have a smaller scale/lower resolution while national and sub-national products a larger scale/higher resolution.

Land cover and land use statistics are expressed in square kilometres and percentage, although other areal measurements can be used.

Classification

Land use or land cover products develop their legends based on a classification. There is often a lack of comparability between products as land use or land cover classification definitions can vary between dataset or map products even when the same term is used.[56] A verbal class definition may not be clear or the classification may contain overlaps in classes or gaps in features covered resulting in internal inconsistency and making comparison between products difficult. Use of standardized basic features such as the building blocks of the LCCS[57] to develop classifications would allow mapping between different land cover classifications and provide a consistent, standardized means of describing the classes while retaining flexibility to develop targeted classifications suited to particular landscape types or uses. The use of such elements in addition to a verbal description allows for easier interpretation of datasets and for renormalization of datasets for comparability, i.e., aggregation of common elements to the same classes.

The classification should be developed using classes and a level of thematic detail that matches the needs of users and the type of decisions to be taken. The level of detail shown in the product will depend on the level or tier of the classification, e.g., a product may distinguish between agricultural or non-agricultural area, but a more detailed product would disaggregate the types of agricultural land uses. To enable comparison between products, the complete classification should be referenced within the information system, not only the legend which contains a subset of classes.[58]

As classifications differ and the inputs used to generate the product affect accuracy, the entirety of the set of land use or land cover statistics should be obtained from one product and classes should not be mixed and matched from several products. For example, area forested from one product should not be compared to the shrub land area from another but only to other classes within the same product. Nevertheless, more than one land cover or land use product, such as the FAO Land Cover database, can be combined to produce a new product provided they are harmonized and standardized.

Spatial Scale

The issue of scale is particularly important for land use and land cover products as they are intrinsically geographical and the appropriate uses for the product depend on its scale or resolution. Land use and land cover products show different locations, spatial extents and patterns of uses. They are therefore affected by the Modifiable Areal Unit Problem[59] which can result in the same classification yielding different patterns and extents depending on the scale or resolution of data used and the minimum mapping area or resolution of the final product. Generally larger scales

[56] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[57] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[58] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[59] Openshaw S. (1984) *The Modifiable Areal Unit Problem*. Geobooks, Norwich: England

and finer resolutions can reveal a greater disaggregation of land use or land cover types than smaller scales or coarser resolutions.

The most appropriate spatial scale for the input data and final product depends on the level of detail necessary for the product; whether this can be realized is dependent on the spatial scale or resolution of the input data.

There are no clear guidelines on appropriate scales for particular geographic levels but some examples from previous practices are:

- Global products with scales up to 1km, 500m and 300m;
- Continental to national products with scales around the scales of 1/100 000 (e.g., Corine land cover, AfriCover) to 1/250 000 (e.g. TerraNorte/Russia) or similar;
- National or sub-national products, e.g., land use change of watersheds have used 5m to 30m resolution;
- Scales less detailed than 1/500 000 can produce a fair description of stocks but change detection is very limited.[60]

The level of thematic detail which can be shown is also dependent on the scale or resolution of both input data and final product. The most suitable minimum mapping unit (the smallest area measured and mapped) or the resolution of the product depends on the level of precision and accuracy needed for the specific use. For example, a product to detect land use change from small field family farming to large field intensive farming, or increases in use of irrigation would require both a classification which identifies these groupings and input data which can detect this.

Unless ancillary data is used, generally objects smaller than the spatial resolution of the input data would not be identified. However, a higher resolution does not always enable identification of the features of interest, e.g., crop types, as the ability for detection also depends on the landscape characteristics, and the trade-off with other data characteristics such as the level of pure or mixed pixels in the input data; the spectral homogeneity or heterogeneity of the classes; and the change in spectral variance of land cover types with resolution.

The environmental statistician should discuss with the specialists the level of spatial and thematic detail needed for the final product. However, the limitation of the input data and the trade-offs between its characteristics should be kept in mind.

Temporal aspects

The time of day, season or year the input data is produced and its periodicity should be aligned to the appropriate time of year and frequency of collection for its intended use, e.g., images used for agriculture should align with the growing period and harvest period for key crops, and different dates may be needed depending on the agro-ecological zones.

Input data have varying temporal resolutions, for example, remote sensing satellites which collect data pass over an area of the earth with a certain periodicity and at a certain date. More frequent periodicities allow for distinction of abrupt changes, such as extreme events, which would not be detected on a 5 - 10 year time scale.

---

[60] Digregorio, A., et al. (2011) *Land cover classification for ecosystem accounting,* presented at the Expert Meeting on Ecosystem Accounts, 5-7 December 2011, London, https://unstats.un.org/unsd/envaccounting/seeales/egm/Issue3_EEA_FAO.pdf (accessed 17 December 2017)

Other data characteristics

These characteristics apply primarily to data from remote sensing satellites.

- Spectral resolution – each landscape object has a particular reflectance, and some satellites are better at detecting particular features than others as they collect data from these wavelengths or record a larger number of 'bands' (ranges of wavelengths) or 'bands' with narrower ranges.
- Radiometric resolution – determines the number of bits used to record an image, which affects the level of detail in an image.

There is often a trade-off between characteristics of the data. For example, for crop specific monitoring it may be necessary to collect data from the same area at frequent intervals, and over a large geographic area. However, the satellites with frequent revisits may only collect data at a coarse resolution or for bands which are less suitable for differentiating crop types.

Accuracy

This section discusses how to assess the accuracy of the final land use/land cover products. Conducting the accuracy assessment of the classification will be the responsibility of the remote sensing professional. However, the environmental statistician should understand how to interpret the accuracy of a map or database for a given use.

The parameters to be considered are:

- Lineage – of the data set including data source, data content, data capture specifications, geographic coverage of the data, compilation method (e.g., digitized or scanned), transformation/pre-processing methods of the data, algorithms used during compilation (e.g., resampling, linear simplification, feature generalization, cloud cover, geometric corrections, atmospheric corrections and instrument calibration of the radiometric values.[61] In addition, the process steps to produce the classification should be described.
- Geometric or positional accuracy – this establishes how close the points in the digital data are to their actual location on the ground. This is assessed using higher accuracy satellite data or ground based data from high accuracy sources, e.g., survey quality GPS measurements. One indicator is the root mean squared error of the difference between the data set coordinate value and those from the independent higher accuracy source.[62]
- Semantic and content accuracy – this refers to whether the correct labelling has been assigned to specific features, e.g., agricultural land may have been identified as bare land, not as agricultural land. This type of accuracy is measured using a 'confusion matrix' which shows the percentage classified correctly for each land use or land cover class and those misclassified.[63] The misclassification shows errors of omission or producer accuracy are when the class on the ground is not the same as in the image, and errors of commission or user accuracy are those when the class in the image differs from those on the ground.

  The accuracy assessment is produced for the entire classified area and covers all classes. In most cases, a field survey is conducted which checks control points on the ground against the classified land uses or land

[61] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[62] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)
[63] Global Strategy to Improve Agricultural and Rural Statistics (2016) *Information on Land in the Context of Agricultural Statistics*, Technical Report Series GO-15-2016, http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/ (accessed 17 December 2017)

cover, although the check can also be conducted using higher resolution imagery. It should be noted that the assessment should be conducted close to the date of the images and in the same season otherwise land use/land cover changes may have occurred or differences observed may be due to seasonal differences and not to land cover or land use change.

Land tenure databases

The FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security (the Guidelines)[64] provide detailed information on administration of land tenure. Statistics can be derived from land tenure records for areas under different types of land ownership. Such records would cover both individual and collective rights, as well as the tenure rights and duties, and the cadastral records of parcels or holdings of land, fisheries or forests to which the rights and duties relate.

The Guidelines recommend that recording systems should be appropriate to the circumstances of the country and provide for socio-culturally appropriate ways of recording the rights of indigenous peoples and other communities with customary tenure systems. The system should be integrated and include for each jurisdiction, records of tenure rights of the State and public sector, private sector, and indigenous peoples and other communities with customary tenure systems. Whenever it is not possible to record tenure rights of indigenous peoples and other communities with customary tenure systems, or occupations in informal settlements, care should be taken to prevent the registration of competing rights in those areas.[65]

The spatial accuracy for parcels and other spatial units should be sufficient for their identification to meet local needs, with increased spatial accuracy being provided if required over time. To facilitate the use of records of tenure rights, implementing agencies should link information on the rights, the holders of those rights, and the spatial units related to those rights. Records should be indexed by spatial units as well as by holders to allow competing or overlapping rights to be identified.

Land under organic agriculture and area of land under irrigation

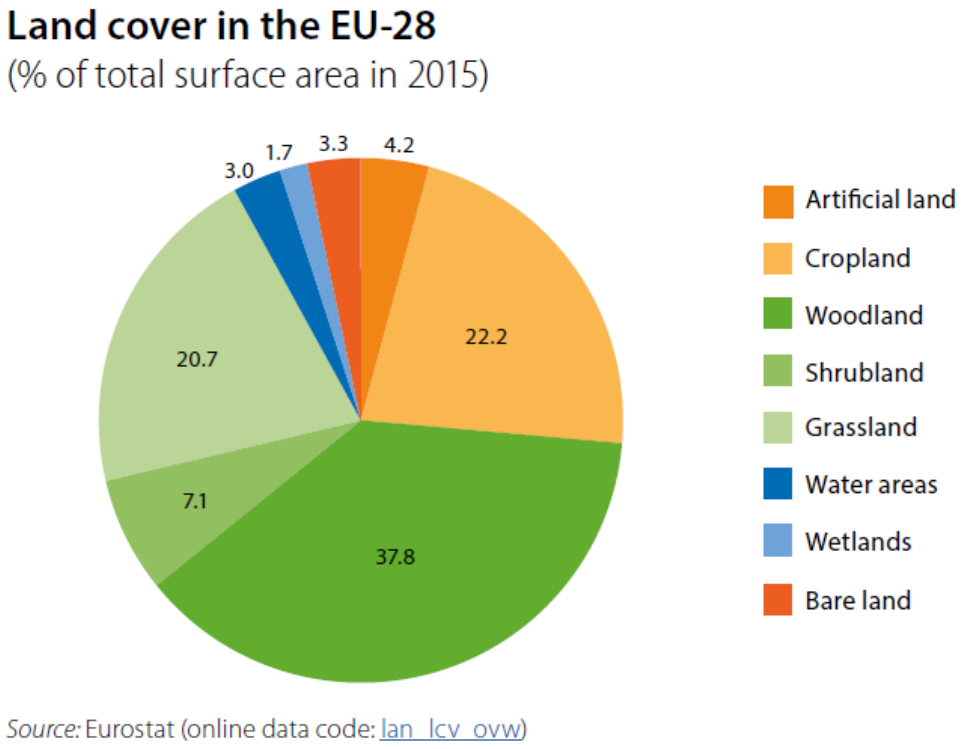
The area of land under irrigation or under organic agriculture is not usually identified by a land use classification or remotely sensed data but would be identified through records or data collection. However, for land under irrigation work is developing to use remote sensing as a complementary source of data. Further detail on data collection and sources of data for these variables can be found in the methodology sheet on Crops and Livestock Statistics.

[64] FAO (2012) *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security*, FAO: Rome, http://www.fao.org/docrep/016/i2801e/i2801e.pdf (accessed 17 December 2017)
[65] FAO (2012) *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security*, FAO: Rome, http://www.fao.org/docrep/016/i2801e/i2801e.pdf (accessed 17 December 2017)

6. Uses and dissemination

6A. Potential presentation/dissemination formats

Figure 6A.1: Land cover in the European Union -28, 2015



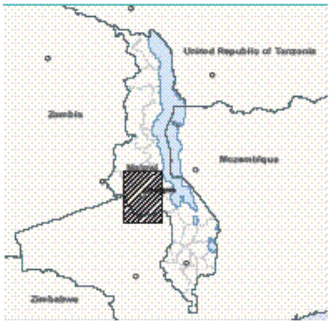
Source: Eurostat (2017) *LUCAS: The EU's Land Use and Land Cover Survey*, http://ec.europa.eu/eurostat/documents/4031688/8503684/KS-01-17-069-EN-N.pdf/91e45d7a-ee8c-47ea-a666-f49600d1ee6c (accessed 17 December 2017)

Figure 6A.2: Land cover change 1990-2010 by district, Malawi

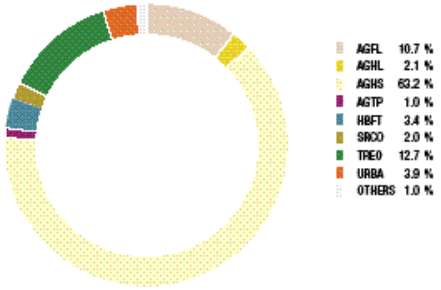
Lilongwe

The pie chart below shows the percentage of the predominant land cover classes. Classes rapresented by less than 1.0% of land cover were gathered onto a new class nominated "others".

INDEX MAP



LAND COVER IN PERCENTAGE

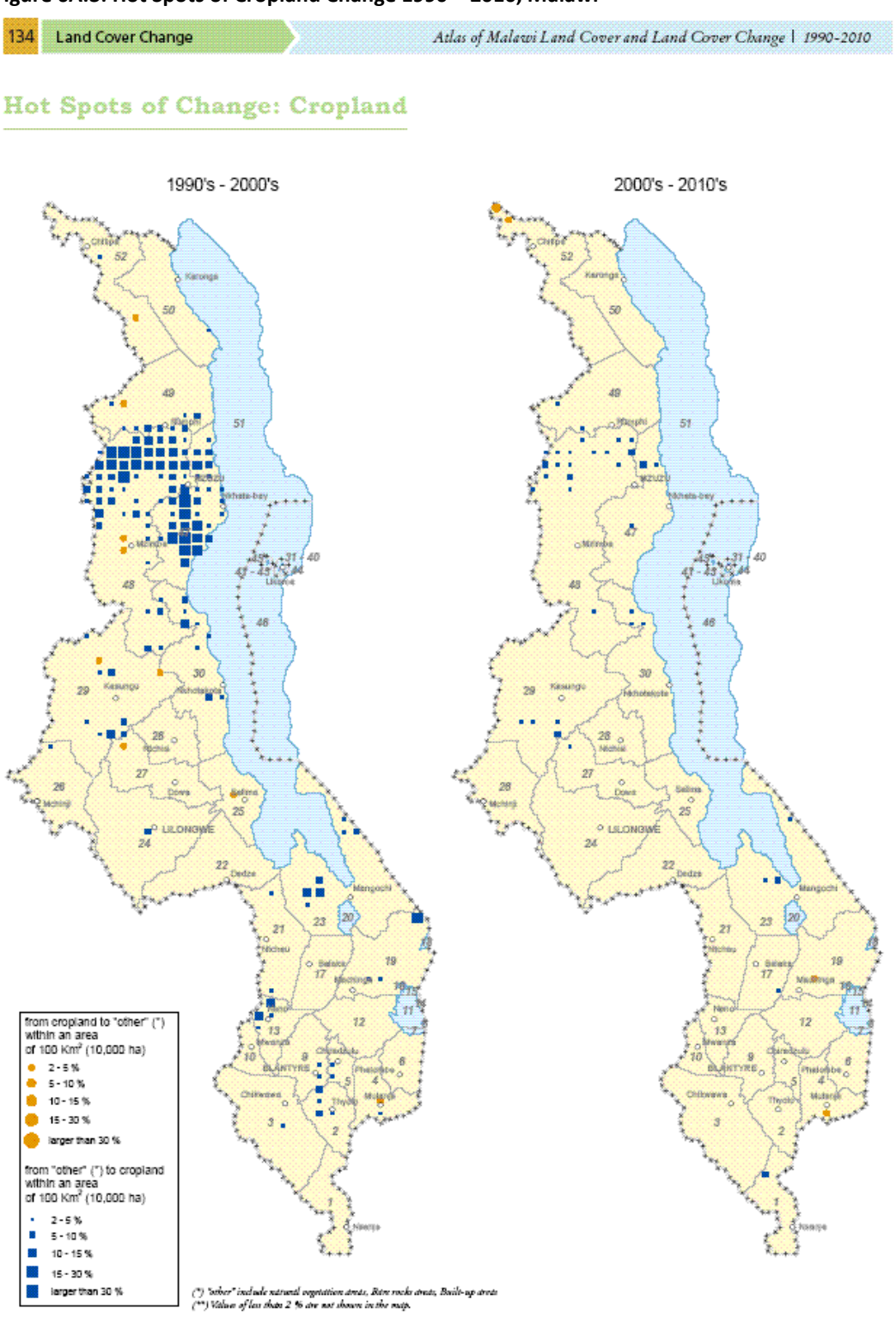


DISTRIBUTION OF LAND COVER IN HECTARES BY TA

LEGEND		Chadza	Chimutu	Chiseka	Chitukula	Kabudula	Kalolo	Kalumbu	Kalumbu	Khongoni	Lilongwe City	Malili	Mazengera	Mlema	Njewa	Tsabango	TOTAL	%
	AGFL	5,321.3	1,197.6	19,474.1	1,506.1	10,294.2	9,339.1	543.2	2,927.4	2,874.4	2,129.1	5,059.8	1,409.3	2,611.4	974.5	354.7	66,016.3	10.7
	AGHL	372.1	0	1,031.7	0	481.5	2,230.5	78.9	0	3,695.0	2,714.8	979.5	0	0	1,125.0	0	12,714.1	2.1
	AGHS	29,852.9	33,529.3	69,306.0	9,901.4	39,905.6	39,881.7	4,634.5	13,692.0	34,113.7	16,250.1	25,316.2	44,276.9	15,607.1	7,685.4	6,131.3	389,983.2	63.2
	AGOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	AGSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	AGTP	449.6	1.9	4,526.5	0	0	545.3	0	0	0	208.4	122.5	0	0	0	82.1	6,036.5	1.0
	AGTR	0	0	0	0	0	0	24.4	5.9	0	159.6	0	22.9	0	0	0	212.8	0
	ARIC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ASUG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ATEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BARE	0	0	0	0	0	0	0	0	0	0	0	442.0	0	0	0	442.0	0.1
	HBCL	681.1	0	0	0	0	0	0	0	0	241.8	0	448.3	0	0	0	1,371.0	0.2
	HBCO	0	0	503.4	0	0	0	0	0	0	1,558.3	38.2	0	0	0	0	2,099.9	0.3
	HBFP	0	0	86.5	0	1.5	0	0	0	0	259.0	0	0	0	26.8	0	365.7	0.1
	HBFT	867.5	2.4	1,169.3	258.1	3,303.7	2,312.2	0	364.0	11,157.9	40.7	790.2	0	381.6	245.6	0	20,892.9	3.4
	SRCO	0	2,703.8	0	0	0	0	1.4	0	0	0	18.2	9,506.4	0	0	24.8	12,252.7	2.0
	TREC	0	0	109.6	0	0	93.3	0	0	0	511.6	4.0	735.2	0	28.8	0	1,482.4	0.2
	TREO	111.1	1,918.3	59,219.6	0	4.9	773.2	0	0	27.2	824.3	18.8	15,554.5	0	182.9	5.7	78,540.5	12.7
	URBA	220.5	570.9	325.0	0	1,655.7	2,084.4	372.1	0	1,614.2	14,417.8	1,883.2	12.7	30.8	598.5	253.6	23,989.5	3.9
	WANP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WANT	0	0	78.0	0	0	0	0	0	0	0	0	0	0	0	0	78.0	0
	WATA	0	0	286.7	0	0	0	0	0	0	0	0	0	0	0	0	286.7	0
	WATP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mixed classes															GRAND TOTAL	616,734.0	

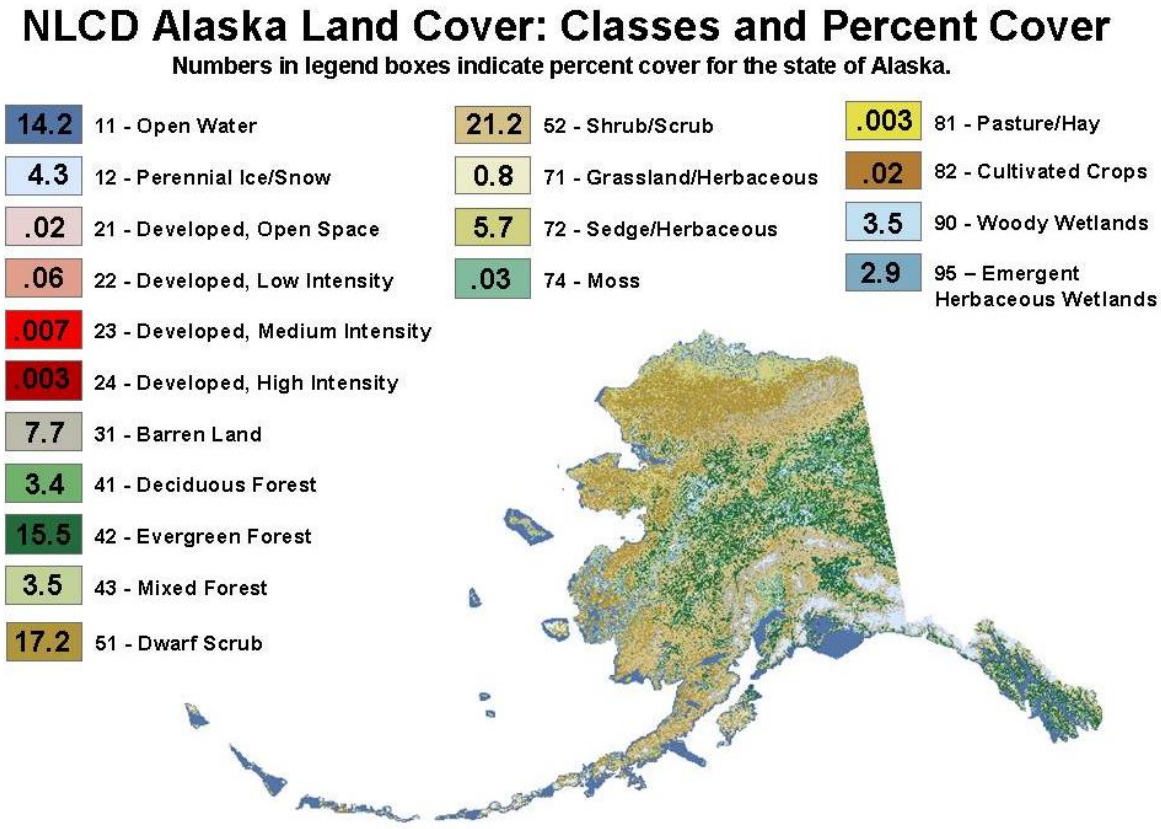
Source: FAO (2012) *Atlas of Malawi Land Cover and Land Cover Change 1990 – 2010*, http://www.fao.org/publications/card/en/c/830c7eef-560f-47c9-b8d2-51e4f80dc904/us (accessed 17 December 2017)

Figure 6A.3: Hot Spots of Cropland Change 1990 – 2010, Malawi



Source: FAO (2012) *Atlas of Malawi Land Cover and Land Cover Change 1990 – 2010*, http://www.fao.org/publications/card/en/c/830c7eef-560f-47c9-b8d2-51e4f80dc904/ (accessed 17 December 2017)

Figure 6A.4: Land Cover Alaska 2001, percentage cover by class



Source: United States Geological Service (2017) *National Land Cover Database* website, https://alaska.usgs.gov/science/program.php?pid=23 (accessed 17 December 2017)

6B. SEEA accounts/tables that use these statistics

The SEEA defines the physical asset account for land use and land cover, to facilitate assessment of land areas and their changes over time as a function of human activity. The focus is on the tables provided by the SEEA Agriculture, Forestry and Fisheries (SEEA AFF)[66], as these adapt the SEEA Central Framework (SEEA CF) to the primary economic activities related to land cover or land use. For instance, Table 4.17: Asset account for land use of the SEEA AFF (see Figure 6B.1) includes land use categories of the SEEA CF Section 5.6.2, with a special focus on the agriculture class. The physical asset account for land records the opening and closing stock of land area, classified by type of land use. It supports the recording of changes in land use over time (e.g., over successive accounting periods) through additions to and reductions in stock.

[66] United Nations and FAO (2017) *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries SEEA Agriculture*, Consultation Draft, https://unstats.un.org/unsd/envaccounting/aff/2GC_Draft.pdf (accessed 17 December 2017)

Figure 6B.1: Physical asset account for land use (hectares)[67]

		Opening stock	Additions to stock	Reductions in stock	Net changes in stock	Closing stock
Land use classes						
Land	Land used for agriculture					
	Arable Land					
	Permanent Crop					
	Arable land and permanent crop (tot)					
	Permanent meadows and pasture (cultivated)					
	Permanent meadows and pasture (naturally growing)					
	Permanent meadows and pastures (tot)					
	Total					
	Land used for forestry					
	Land used for aquaculture					
	Use of built up areas					
	Land used for maintenance and restoration of environmental functions					
	Other uses of land nec					
	Land not in use					
	Land area (total)					
Inland waters	Inland waters used for aquaculture or holding facilities					
	Inland waters used for maintenance and restoration of environmental functions					
	Other uses of inland waters nec					
	Inland waters not in use					
	Inland water (Total)					

The physical asset account for land cover records the opening and closing stock of land cover and its changes over time (SEEA AFF Table 4.9). The SEEA land cover types follow the FAO Land Cover Classification System (see Figure 6B.2).

[67] United Nations and FAO (2017) *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries SEEA Agriculture*, Consultation Draft, https://unstats.un.org/unsd/envaccounting/aff/2GC_Draft.pdf (accessed 17 December 2017)

Figure 6B.2 Physical asset account for land cover (hectares)[68]

	Opening stock	Additions to stock	Reductions in stock	Net changes in stock	Closing stock
Land cover classes					
Artificial surfaces					
Herbaceaous crops					
Woody crops					
Multiple or layered crops					
Grassland					
Tree covered areas					
Mangroves					
Shrub covered areas					
Shrubs regularly flooded					
Sparsely vegetated areas					
Terrestrial barren land					
Permanent snow and glaciers					
Inland water bodies					
Coastal water bodies					
TOTAL AREA					

6B1. Physical asset accounts for Land Use and Land Use Change in Brazil

This section provides an example of the application of the SEEA physical asset accounts for land use and land use change in Brazil. IBGE- Brazilian Institute of Geography and Statistics – produces estimates of the area of the land COVER classes, according to the 14 classes recommended by the SEEA Central Framework, with minor adjustments to the country's characteristics.

These data have been produced since 2000 and from 2010 with a bi-annual periodicity. Input data are MODIS satellite images, enhanced by other data, including Enhanced Vegetation Index (EVI), agricultural census data, forestry extent, etc. Cross tabulations of land use from one period to another are produced which show the change between land use classes from one period to the next. The data are presented in both tabular and vector formats. The data vectors (shapefile format) are used to derive the area in square kilometres. This database geographical units are a grid with 1km² cells, covering the entire country. The geography is used purely for statistical purposes. Database modelling rules and criteria were created that enable the program to identify areas of change or with no change.

The Earth Physical Accounts, were derived from cross-tabulations between periods 2000-2010 and 2010-2012, using the SEEA 2012 methodology. The main processes driving the changes were divided between forested and non-forested areas. This was partly due to the resolution needed for national scale land use and change detection and the characteristics of the MODIS data which affect the potential resolution and what land uses can be detected.

From 2000 to 2010 the results showed an increase of 38.8% (about 240,600 km²) in cultivated pasture intended for livestock which was significantly higher than the increase of 19.2% (approximately 77,700 km²) in agricultural area.

[68] United Nations and FAO (2017) *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries SEEA Agriculture*, Consultation Draft, https://unstats.un.org/unsd/envaccounting/aff/2GC_Draft.pdf (accessed 17 December 2017)

From 2010 to 2012, however, there was a change in the dynamics of the transformation processes, with a similar level of increase between agricultural and cultivated pasture areas, with increases of 8.6% (40,700 km^2) and (11.1% or 95,600 km^2) respectively, although cultivated pasture still presents a greater increase.

From 2010 to 2012 forested area decreased by 7.2% (254,200 km^2) which was equal to the decrease in natural grazing area by 7.7% (158,700 km^2). Unlike the previous comparison period, 2000 to 2002, where the percentage loss of natural grazing area by 7.8% (149,670 km^2) was four times higher than forest vegetation area (1.8% or 59,230 km^2).

In the period 2010-2012, changes in land cover and land use classes amounted to 3.5% of the country, half of the change observed from 2000 to 2010 which was 7.0%. This indicates an acceleration in the processes causing land cover change. Among the areas showing change there were noticeable differences between forest environments and natural pastures. Between 2000 and 2010, in the forested areas, the predominant process accounting for deforestation was agricultural expansion (65% or 236,600 km^2 followed by expansion of planted pastures (35% or 127,200 km^2). However, the decrease in natural pastures was due equally to agricultural expansion (89,500 km^2) and the expansion of planted pastures (89,780 km^2) which both increased by 48%.

6C. Commonly used indicators that incorporate these statistics

United Nations Convention to Combat Drought and Desertification - UNCCD[69]

UNCCD indicators that have potential for global and national level monitoring and mapping of drought and desertification.

- Trends in land productivity or functioning of the land: Based on long-term fluctuations and current efficiency levels of phenology and productivity factors affecting standing biomass conditions.
- Trends in land cover: To monitor land degradation in terms of long-term loss of ecosystem primary productivity, considering the effects of rainfall on net primary production. Intended as the distribution of land cover types of greatest concern for land degradation (excluding artificial surfaces) by characterizing vegetative land cover; it should include and specify natural habitat classes.

6D. SDG indicators that incorporate these statistics

6D1. SDG indicators related to land tenure

Indicator 1.4.2 Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure

[69] UNCCD (2012) *Decision 22/COP.11 Advice on how best to measure progress on strategic objectives 1, 2 and 3 of The Strategy, ICCD/COP(11)/23/Add.1*, http://www.unccd.int/en/programmes/Science/Monitoring-Assessment/Documents/Decision22-COP11.pdf (accessed 17 December 2017)

The indicator will be monitored through household survey questions which measure the presence of legally recognized land documentation and peoples' perceptions of their land tenure security.

Secure land tenure (2.3.1.c) / adult population

Indicator 5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure

The indicator is currently a Tier II indicator and the methodology to measure asset ownership including agricultural land is being tested.

FDES statistic on Land Tenure (2.3.1.c) is related but further detail is needed to identify agricultural land with secure land tenure rights by gender.

6D2. SDG indicators incorporating land use or land cover data

Indicator 9.1.1 Share of the rural population who live within 2 km of an all-season road[70]
The indicator is currently Tier III. The proposed methodology for the indicator uses spatial data on land use, namely road network and road condition, as well as population distribution to compute the Road Accessibility Index (RAI). The method uses other land use data as ancillary data in the method, for example, in defining urban and rural areas.

FDES statistic 2.3.1.a. Area under land use categories applies.

Indicator 11.3.1 Ratio of land consumption rate to population growth rate
The indicator measures the ratio of two concepts:

- Population growth rate (PGR) is the increase of a population in a country during a period, usually one year, expressed as a percentage of the population at the start of that period. It reflects the number of births and deaths during a period and the number of people migrating to and from a country.

- Land consumption includes: (a) The expansion of built-up area which can be directly measured; (b) the absolute extent of land that is subject to exploitation by agriculture, forestry or other economic activities; and (c) the over-intensive exploitation of land that is used for agriculture and forestry.

The land consumption rate is measured as:

$LCR=LN(Urb\_(t+n)/Urb\_t)/((y))$

where

Urb_t = Total areal extent of the urban agglomeration in km^2 for past/initial year

[70] World Bank (2016) *Measuring Rural Access Using new technologies,* http://documents.worldbank.org/curated/en/367391472117815229/Measuring-rural-access-using-new-technologies (accessed 17 December 2017)

Urb_(t+n) = Total areal extent of the urban agglomeration in km^2 for current year
y = The number of years between the two measurement periods

and the ratio of land consumption rate to population growth rate (LCRPGR) as:

LCRPGR= Land Consumption rate/Annual Population growth rate

FDES statistic 2.3.1.a. Area under land use categories applies with both change and absolute extent being relevant.

Indicator 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

The indicator uses data on land use to identify a) spatial analysis to delimit the built-up area of the city; b) estimation of the total open public space; and c) estimation of the total area allocated to streets.

It is calculated as:

Share of the built-up area of the city that is open space in public use (%)
= (Total surface of open public space + Total surface of land allocated to streets) / (Total surface of built up area of the urban agglomeration)

FDES statistic 2.3.1.a. Area under land use categories applies.

Indicator 15.1.1 Forest area as a proportion of total land area

The indicator provides a measure of the relative extent of forest in a country. Forest is defined as: "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

It is defined as:

*Forest area (reference year) / Land area (2015) * 100*

FDES statistic 1.2.1.a. Area under land cover categories applies.

Indicator 15.2.1 Progress towards sustainable forest management

Sustainable forest management (SFM) is [a] dynamic and evolving concept [that] aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations. It is measured through five sub indicators:

- Forest area net change rate
- Above-ground biomass stock in forest
- Proportion of forest area located within legally established protect areas
- Proportion of forest area under a long-term forest management plan
- Forest area under an independently verified forest management certification scheme

FDES statistic 2.3.1.b.3. Area of land under sustainable forest management applies.

Indicator 15.3.1 Proportion of land that is degraded over total land area

This indicator is defined as the amount of land area that is degraded. The measurement unit for indicator 15.3.1 is the spatial extent (hectares or km^2) expressed as the proportion (percentage) of land that is degraded over total land area.

It is derived by summing all those areas subject to change, whose conditions are considered negative by national authorities (i.e., land degradation) and evaluating changes to land cover and land cover change, land productivity and carbon stocks above and below ground.

FDES statistic 1.2.1.a. Area under land cover categories applies.

F D E S

Manual on the Basic Set of Environment Statistics

2018