DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
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Outcome Paper

Outcome Paper for Global Consultation

Issue #19b: Land cover classification[1]

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[1] This outcome paper has been prepared by the SEEA Editor. It is based on papers presented to the London Group of Experts on Environmental Accounting and discussions among those experts. Investigation and research for this outcome paper was led by Jean-Louis Weber of the European Environmental Agency.

A. Introduction

1. Land is a central feature in any discussion of the environment. It provides the basis for plants, animals and ecosystems to operate, it underlies human infrastructure such as buildings and roads and, perhaps, most importantly, areas of land delineate the space in which we live. It is essential that in the revised System of Environmental and Economic Accounts (SEEA) there is a full discussion of relevant concepts and accounting treatments.

2. Because land is so central to so many things the way in which it is considered from an analytical perspective can vary greatly. At times the interest is on how humans use the land surface, at times it is a description of the physical characteristics of the land that is the focus and at still other time it might be the "services" that the land provides that is of main concern.

3. These varying analytical perspectives may often overlap depending on which area of land is being considered. This has lead to the development of a wide range of classifications of different land areas depending on the specific analytical purpose. Generally speaking there are three concepts around which classifications are developed – land use, land cover and land function – but there are very few examples of classifications that stay true to one particular concept. Land can be also described on the basis of its ownership and registered and mapped in cadastral databases. These latest databases generally record information on land use, cover and functions which can be extracted (sampled) and used for accounting purposes.

4. In the process of revising the SEEA it was recognised that there were no internationally agreed statistical classifications of land use or land cover and, given the importance of land in environmental accounting it was recommended that work be undertaken to investigate the possibility of developing standard classifications in these two areas for SEEA purposes.

5. This outcome paper reflects the results of investigation into a classification for land cover. A separate outcome paper has also been distributed discussing a proposed classification for land use (see Issue #19a: Land Use Classification). The discussion on land functions and the relationships between land and the measurement of ecosystem services will not take place in Volume 1 of the revised SEEA. While work in this area is progressing it is not yet developed sufficiently for inclusion as part of an international statistical standard. Rather, this work will be incorporated into Volume 2 of the revised SEEA which will focus on accounting for ecosystems.

6. Discussion on land and related classifications has taken place at all London Group meetings since the 11th London Group meeting in March 2007. The work has been led by the UN Food and Agriculture Organisation (FAO) and the European Environment Agency (EEA).

7. This paper is structured to provide some context to the development of classifications concerning land including a description of the distinction between land cover and land use, a presentation of the latest version of the Land Cover Classification System (LCCS3) developed by FAO, and a discussion on the application of the LCCS3 in an accounting context including a possible higher level structure for SEEA purposes based on the LCCS3.

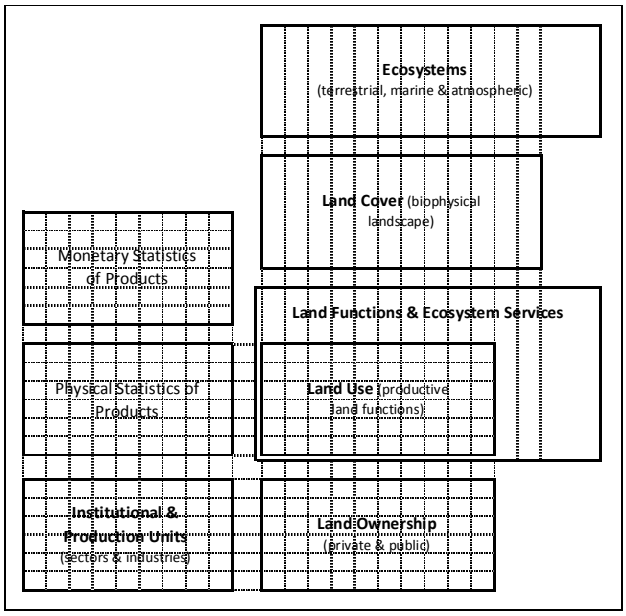
B. Defining land cover and land use

8. The theoretical distinction between land cover and land use is well established**.** Land Cover (LC) refers to the observed physical and biological cover of the Earth's surface; the definition embraces vegetation and natural and artifical abiotic surfaces. Land Use (LU) reflects the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation) are land use characteristics[2]. Thus land cover is about the biophysical aspect of land and land use is about the functional aspect of land[3].

[2] This formulation is borrowed from the IPCC glossary of the "Land Use, Land-Use Change and Forestry" webpage. http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=13. Similar definition is proposed by

9. The following graphic gives a useful description of the links between land cover, land use and other areas of statistical and analytical interest.

Figure 1: Main nomenclature for land accounting and their relationships



10. Discussion in the London Group concluded that in the revised SEEA land use should be defined primarily with regard to productive or economic land use. To meet this goal the existing FAO classification was considered a suitable starting point that needed to be supplemented with detail regarding urban and other artificial land uses. The UNECE classification of land use was recommended as good basis for undertaking this enlargement. It was considered that other land use functions that concern the delivery of non-market ecosystem services and that may co-exist on the same parcel of land should be recorded separately. This work is described in more detail and with relevant recommendations under the SEEA Revision Issue #19a: Land Use Classification.

11. With regard to land cover the situation is not as straightforward. In the first instance it is necessary to describe all of the biological and physical characteristics of an area of territory. Some excellent advances have been made in this area with the most important development being the development of the comprehensive Land Cover Classification System (LCCS) developed by the FAO. The LCCS provides a basis for the any piece of land cover to be defined and classified on a consistent basis, starting from a small set of "classifiers" defined from "basic" "features" or geographical "objects".[4]The general approach by FAO is that of a Land Cover Classification System (LCCS) made of a set of

FAO (e.g. in *Land Cover vs. Land Use*, Antonio Di Gregorio, FAO – Global Land Cover Network, Global Land Use Data Workshop, Vienna 22 – 23 May 2008

[3] Gong, Xiaoning, Lars Gunnar Marklund, and Sachiko Tsuji (2009). "Land Use Classification", paper submitted to the 14th London Group Meeting (28 April - 1 May 2009, Canberra, Australia).

[4] A higher level abstraction of the basic elements that compose land cover classes, as used in LCCS, called the "LCML" (for Land Cover Meta Language) is currently undergoing the approval process to become an ISO standard as a framework to classify land cover and compare systems internationally. This metalanguage allows the existing well established national and regional land cover systems to remain in place, while still allowing the data to be integrated into common world level data sets following a common land cover standard.

consistent rules and a software tool allowing the production of consistent classifications in a variety of different conditions. This is the basis of land cover classification.

12. It is then possible to consider how, having classified each individual area of land according to its biological and physical characteristics, the different classes might be aggregated to serve different purposes. Thus there is a notion of land cover nomenclatures or legends. Choices of higher level nomenclatures need to be aligned to particular policy or research purposes. The development of proposals associated with SEEA are presented in Section D.

C. A land cover classification

13. As mentioned in paragraph 11 a significant advance in the area of land cover measurement has been the development of the LCCS by FAO over the last decade which has resulted in the proposal for an ISO standard to be included in the set "geographical information – classification systems" under the name of "LCML" - Land Cover Meta Language.

> "The LCCS 3/ LCML is an attempt to classify the "real world features" (specifically Land Cover features) with a very simple groups of elements arranged in different ways that act as building blocks to describe the more complex semantic in any separate application ontology (legends). LCML should be able to work as "boundary object" to mediate and support negotiations of different ways to represent Land Cover around which similarities and differences can be understood and expressed. This means that classes derived by LCML can be customized to user requirements but must have common identities between users.
>
> Fundamental idea of the language is that a predefined set of land cover basic elements (called BASIC OBJECTS) enriched on their semantic significance with external qualities and attributes and arranged in different types of strata can be used to describe a wide variety of distinctive and detailed land cover situations." (FAO/Global Land Cover Network webpage http://www.glcn.org/ont_2_en.jsp)

14. This paper does not attempt to describe the LCCS in detail. It is clear that much rigour has been placed into its development and it is increasingly being recognised as the common world-wide basis for the description and definition of land cover features.

15. For further detail readers are referred to the FAO LCCS[5] Data from other national or regional land cover systems can be converted into the LCCS by first describing the national or regional land cover system using the LCML as described in ISO standard 19144-2 Geographic Information - Classification Systems - Land Cover Meta Language (LCML). Then the description in the LCML can be used to generate equivalent classes in the UN FAO LCCS. This uses the LCML as a common semantic bridge to permit data to be gathered from a broad variety of sources.

16. It is noted here that the latest version of LCCS, LCCS 3, has been developed on the basis of LCML with the purpose of having an international framework to classify land cover and compare information systems. In order to align standards and classifications to as great a degree as possible it is recommended that, in the SEEA, analysis of land cover be based on data and information that has been collected and classified according to the LCCS. In that sense the LCCS 3 should become the land cover classification system for the SEEA and LCML should provide the basis by which various land cover data and be integrated to a common classification.

Recommendation 19b.1: That the Land Cover Classification System (LCCS 3) developed by FAO should be adopted as the land cover classification system in the revised SEEA and that the LCML (ISO 19144-2) should be adopted at the methodology for linking to external sources of land cover data described in other land cover systems.

[5] UNFAO, 2005, *LCCS – Land Cover Classification System – Classification concepts and user manual, Version 2*, By A. Di Gregorio, Rome, ISBN 92-5-105327-8

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D. Accounting for land in the revised SEEA

16. As mentioned in Section B, while the LCCS provides a firm basis for the description and classification of land cover, aggregated groups of different types of land cover may also be defined for different purposes. This is no different from the choices that can be taken in the development of economic statistics classifications and hierarchies. For example, one might define a range of characteristics to describe businesses such as the number of employees, type of activity, floor space, sole ownership or incorporated business, government or private ownership, country of residence, etc. Once each business has been fully described the question becomes which groupings of similar businesses are of accounting interest.

17. In order to direct thinking in this regard when it comes to land cover, it is useful to consider the purposes to which an aggregated set of land cover statistics might be put in an accounting sense. It is suggested that for SEEA an aggregated structure should be:

a. Fit for purpose in accounting for land cover change: The analysis of change between two dates has to inform clearly of the main processes taking place as well as of their meaning regarding the socio-economic drivers. Unnecessary detail in natural land should be avoided when change between these classes are not likely to happen. Instead, direct information on urban sprawl (and the main types of land consumed), intensification of agriculture, afforestation and deforestation have to be easily readable.
b. Easy to connect to land use statistics in order to facilitate joint uses. This is in particular important when addressing climate change issues like carbon release and sequestration from agriculture land and the establishment of carbon balance integrating agriculture yields by types of crops and for forestry.
c. Easy to connect to ecosystem accounts. Because ecosystems are diverse and their dynamics are influenced by a variety of human and human factors, impacts are to be analysed by location. The aggregated structure, which should play a role in connecting (via land use) socio-economic statistics and ecosystem accounts, needs to support data collection in detailed grids.
d. Able to support feasible applications. It has to be easy to implement from various data sources: administrative data and surveys, area sampling and remote sensing. From an international standpoint, the possibility of implementing land cover accounts on the basis of the Global Earth Observation by satellite programmes is an important point to consider.
e. Simple to translate into other land cover nomenclatures or legends. The SEEA aggregated structure should be usable with LCCS-based classifications currently in use in international programmes (IGBP DISCover, MODIS land cover products, FAO-Africover, Global Land Cover, and ESA GlobCover), IPCC and the EU Corine Land Cover. The translation possibility is important for those countries that have developed detailed land cover maps at the national level or in an international context (for example Africover, Corine).
f. Able to be expanded in detail. One way of further detailing an aggregated structure is by implementing the LCCS 3 classification rules for a given purpose; the hierarchical approach and the combination of “classifiers” and other attributes allows the highest level of detail to be presented while keeping overall consistency. This can be done where it is useful and feasible for national, regional or local applications. Another way is to combine the basic LC classes with bio-geo-climatic zoning (“ecozones”, biomes, “life forms”) in order to differentiate between, for example forest or shrubs types.

18. Based on this set of purposes and in particular the interest in analysing and accounting for land cover change and ecosystem accounts, the approach that is considered most useful is to define groupings of common “basic” landscape features as shaped by land use rather than focus on aggregations of specific vegetation forms. The impact of this is that the total land area would, in principle, be divided up into groupings that each contains an inherent systemic relationship.

19. This approach leads logically to a consideration of ecosystem accounting which, on the whole, will be based on land areas that have inherent systemic relationships. To the extent that the groupings

defined within an aggregated structure based on land cover can also be reflective of differences in the nature and composition of the ecosystem services that are delivered from a particular land area then this adds to the analytical usefulness of the aggregated structure.

20. However, defining these groupings is not straightforward. Different decisions might be taken depending on the size of area under consideration (i.e., there may be a dependence on scale), depending on how the principle of dominance is applied and depending on the various properties and characteristics of the area surrounding the land cover of interest. Inevitably therefore there are differences of view as to the nature and definition of higher level nomenclatures that are intended to serve particular purposes.

21. The issue can be seen in considering of the following list of categories that is one way that has been suggested by which a land cover nomenclature could be structured. In a number of cases the higher level groupings in the list have the same scope as individual, basic underlying LCCS vegetation/cover types. For example, the groupings “Bare land” and “Permanent snow and glaciers” are both basic land cover types. However, there is less clarity about categories such as “Agriculture associations and mosaics” and “Woodland/shrubland in transitional process”. In both of these categories there is necessarily a combination of LCCS vegetation/cover types.

Table 1: Possible aggregated structure based on LCCS

01	Built up and associated areas
02	Rainfed annual crops
03	Post-flooding and regularly irrigated cropland
04	Permanent crops, agriculture plantations
05	Agriculture associations and mosaics
06	Pastures and natural grassland
07	Forests
08	Woodland/shrubland in transitional process
09	Shrubland, bushland, heathland
10	Sparsely vegetated areas
11	Bare land
12	Permanent snow and glaciers
13	Open wetlands
14	Inland water bodies
15	Coastal water bodies
16	Sea

22. The alternative to going in the direction suggested in Table 1 is to stay more closely with aggregations of vegetation and land cover types. Thus, for example, rather than make a distinction between land areas dominated by rainfed annual crops and irrigated crops, the distinction might be drawn between the nature of the vegetation of the crops – for example herbaceous crops or woody crops. For some types of analysis groupings based more directly on vegetation types may be appropriate.

23. From the perspective of SEEA it has been considered that it is important to account for situations in which different vegetation types are combined into complex landscape patterns, particularly for the

analysis of ecosystems. Thus, for example, the proposed grouping, “Agriculture associations and mosaics” will include a range of vegetation forms that are characteristic of annual and permanent cropland together with a range of natural features which are intertwined with them. This will form land cover systems dominated by agriculture with specific characteristics regarding protection against soil erosion, carbon storage and biodiversity which are different from those of broad pattern agriculture. Overall, from a SEEA perspective, the aim of creating groupings of land areas by which accounting analysis can be undertaken would appear to require dealing with complex landscape patterns.

24. As might be expected there are some important definitional and boundary issues that need to be fully resolved such that an aggregated structure can be meaningfully constructed based on individual land cover basic objects as defined in the LCCS 3. A proposal for the SEEA that provides definitions regarding the categories listed above based on underlying LCCS vegetation and land cover types is currently under discussion between EEA and FAO.

25. The use of terms needs to be carefully considered, regarding their intrinsic semantic accuracy, simplicity of naming as well as the possibility of fair understanding by a wide range of users. In data modelling terms the ontology of an aggregated structure for land cover for the SEEA will have to be established once a consensus is achieved on the land cover classes for accounting.

26. Since the final proposal for adoption in the SEEA must be one that meets the demands of SEEA users it would be instructive at this stage to determine the preferred direction. That is, whether there is general interest and support for developing an aggregated structure that directly allows for the presentation of data according to landscape features influenced by land use or whether there is a preference for a nomenclature that reflects more strongly the underlying vegetation and land cover types. It should be recognised that the choice is important but not black or white since a pure vegetation type land cover classification cannot be defined and nor will a structure that has little link to vegetation type be useful.

27. For the purposes of understanding the preference of SEEA users the following question is posed. It is noted that in considering the options it is relevant to consider the extent to which either approach would generate a set of statistics that would fulfil the objectives as outlined in paragraph 17.

Question 19b.2: In the revised SEEA should an aggregated structure for land cover (Land Cover Nomenclature (LCN)) based on the FAO Land Cover Classification System (LCCS 3) be defined where the aggregated groups are defined according to landscape features influenced by land use?

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