

## Note on Land Cover and Use Classifications

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### Introduction

1. The consideration of land is central to any assessment of the environment and its assets. Land defines the space in which a large number of environmental assets are located and hence a broad assessment of these biological and physical assets, either as individual assets or as they interact to deliver ecosystem services, requires an understanding of land, of its biophysical cover and of its use. The scope of environmental assets will address all land cover, even though no economic benefits may have been established a present. Land can be therefore described as the asset the most commonly shared between the economy, the society in general and the ecosystem.

2. The SNA recognizes this particular status of land, which is at the same time an asset and the support of other assets: “*Land consists of the ground, including the soil covering and any associated surface waters, over which ownership rights are enforced and from which economic benefits can be derived by their owners by holding or using them*”. (SNA2008, 10.175). The SNA records **economic assets** which are defined as “*a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. All assets in the SNA are economic assets*”. (SNA2008, 10.8).

3. The SEEA which expands the scope of assets beyond the boundaries of the SNA will address all land surface, even though no economic benefits derived from it.

4. Generally, land is analysed either from the perspective of its bio-physical characteristics of which its vegetal or/and artificial cover is a good proxy – land cover – or from the perspective of the ways in which land is used by the economy – land use. Of course, these two perspectives are heavily intertwined and have to be understood within the geographical traits of land which relate to steepness and altitude, climate and availability of water resources, distance to the sea and accessibility, and regarding the social-economic interactions which are conditioned by the bio-physical environment as much as they

condition it. It is in the interaction of land use and land cover at multiple scales from basic functional area to various levels of aggregation and geographical areas that land as an asset provides the functions, processes and finally deliveries of ecosystem services. Land cover reflects how land use influences and modifies the ecosystem. The development of asset accounts for land is aimed at providing information that can be used to determine the state of and changes in land use and land cover and the connections between the two. Some of the issues that can be considered within a framework of land accounts include the impacts of urbanisation, crop and animal production, deforestation, use of water resources and other direct and indirect use of land and of the assets which cover it.

5. The land cover and use are observed in part through ground observations and in part from above ground with Earth observation satellites or airborne devices. The choice of the investigation methodology depends on the purpose of the survey. Land cover patterns and their changes are fairly well observed by satellites in an exhaustive way. High spatial and temporal resolution imagery is delivering daily amounts of detailed data fit for land cover monitoring.

6. For the aspects of land use, which are not clearly reflected in the land cover image such as population density, agriculture practices, details of crops or intensity of traffic on roads, the situation is more difficult and requires in situ data which need to be collected directly by area sampling or indirectly via surveys to the users of land. In situ data on biochemical cycles and biodiversity are as well necessary to observe the natural processes which take place in a given land cover. The combination of in situ and remote satellite observation, as reflected in geographical information systems as well as modern statistical sampling strategies optimised by stratification, does allow for observations of changes of land cover and use. The classifications and structures outlined in this section should support work of this type.

7. The principles of land cover classification use the FAO Land Cover Classification System (LCCS3) as building blocks. The classification of land cover gives a broader place to the bio-physical attributes of land, whether or not used as an economic asset. It needs to be fully consistent with the LCCS3 principles in order to support future developments and the possibility of integrating land accounts into various geographical and statistical assessments and at the same time clearly define the building blocks of the ecosystem units regarding land.

8. In addition to physical descriptions of land, there is an important monetary aspect to the measurement of land. Land is bought and sold in combination with the characteristics of the space and its bio-physical cover like built-up area and forest area but generally the combined asset will show a value of the space itself distinct from the value of the bio-physical cover characteristics. Monetary accounts for land thus constitute an important component in the assessment of national and institutional sector wealth. Monetary land accounts are precisely defined in the SNA, which rules apply by default. However, not all details of land are

described in the SNA 2008 which states in para 10.178: “The SNA does not specify a disaggregation of land but it is recommended that if a disaggregation is required, it should be according to that used in the SEEA.” The possibility of such disaggregation is examined considering land use and land cover.

9. This note is structured to define land for measurement purposes and to present the land classifications for the organisation of data by land cover and land use. The note then presents asset accounts for land in physical terms and finally asset accounts for land in monetary terms.

### **Definition of land**

10. Land, is an unique environmental asset that delineates terrestrial space and its cover within which economic activities and environmental processes are taking place and within which environmental inland assets and economic assets are located

11. The location of assets within areas of land means that land can be characterised by its topographic properties and by all of the various assets it supports, for example the water, soil and its nutrients, tree cover, and minerals. These land cover characteristics and assets, in their interactions with socio-economic influences are the functional building blocks for the analysis of ecosystem services generation.

12. The measurement boundary of land for a country is defined in relation to the national territory. *The national territory is defined by a country’s land and waters, and includes the maritime exclusive economic zone.* This boundary provides jurisdiction over marine resources such as fish and energy resources.

13. From an environmental perspective, the **maritime exclusive zone** has a land dimension when coming close to the coast. Coastal areas are specific socio-ecological systems which need to be addressed in an integrated way with other terrestrial ecosystems, because they provide economic resources like sea grass and algae beds and important habitats for many marine species. The functioning of the marine plant and animal life have to be understood in relation to impacts from aspects like the inland pollution transferred to the sea by rivers, the development of infrastructures on the coast line which modify the streams in the sea, the damming of rivers which reduce sediment inputs and overfishing. These coastal zones are described as mosaics of both terrestrial and aquatic ecosystems comprising seashore, tidal flats, coral reefs, and seaweed/ grass beds, with an emphasis on the aquatic ecosystems<sup>1</sup>.

14. In principle, the economic territory of a country should be adjusted to account for territorial enclaves<sup>2</sup> by adding territorial enclaves of a country that are located in the rest of the world and deducting territorial enclaves within the national land area. However, in practice, it is reasonable to ignore the adjustments for territorial enclaves, because the total

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1 Cf. *Satoyama-Satoumi Ecosystems and Human Well-being: Socio-ecological Production Landscapes of Japan – Summary for Decision Makers*. United Nations University, Tokyo, Japan, 2010

2 Territorial enclaves are clearly demarcated land areas (such as embassies, consulates and military bases).

area attributable to territorial enclaves is unlikely to be large relative to the overall size of a country and the land area attributable to territorial enclaves are likely to be influenced by the planning and other regulatory frameworks of the host country.

### **The classification of land**

15. Generally, the total area of land is best considered either in terms of its land cover or in terms of the associated land use.

***Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural and/or artificial vegetation and abiotic surfaces.***

***Land use reflects the total of arrangements, activities and inputs undertaken in a certain land cover type to produce, change and maintain it.***

16. While distinct concepts, it must be recognised that land cover results from the use of land through economic activities and natural processes, the latter modified by human activities or not. Consequently, the analysis of land cover must take into account those aspects of land use which are reflected in biophysical cover.

17. Each country or jurisdiction will have its own dominant types of land use and land cover. For example, in terms of land cover, areas with forest tree cover may be of major importance for most countries but forest types differ considerably from one region to the other in terms of composition or density. Areas with permanent glaciers and snow are not present in many countries. Consequently, the broad land categorizations may require more detailed supplementation for national purposes in order to highlight particular geophysical and biological features and meet information requirements.

18. The international standard for land cover for accounting will therefore remain fairly simple while streamlining and guiding the development of further detail required for characterising the variety of situations which result from geography and climate. This possibility of combining rigour and flexibility is made possible by the use of the LCCS3 classification tool.

### **Land use classification**

19. The land use classification is an essential element in bridging its use for economic activities and ecosystems of socio-ecological landscapes. In theory, while each parcel of land is characterised by a typical land cover, it can support a variety of uses such as agriculture production of crops, conservation of natural species or recreational use.

20. Land has to be understood in its multi-functional potential with the economic use of land being an important link of the relation between the economy and the environment. This economic use of land should be considered as a subset of a broader category called land use functions or land functions. These multiple land functions of a single land cover unit correspond closely to the ecosystem services and will be recorded with them. Therefore, the classification of land use for accounting will focus on main economic uses.

21. The land use classification is composed of four broad categories and 12 high level classes. The four categories are cultivated, forest and aquacultural land, built-up and related land, water areas and land not in use. The land use classification provides additional breakdowns of cultivated, forest and aquacultural land and water areas particularly as it concerns the types of crops grown in agricultural areas. The land use classification is provided in table1 and its full classification with the descriptions of classes is presented in Annex x.x.

**Table 1 Land Use Classification**

<b>Code</b>	<b>Level 1</b>	<b>Level 2</b>
	Cultivated, Forest and Aquacultural land	
		Agricultural land
		Forests and other wooded land
		Land with aquaculture facilities
	Built-up and related land	
		Land used for mining and quarrying
		Land used for construction
		Land used for manufacturing
		Land used for technical infrastructure
		Land use for commercial, financial and public services
		Land developed for recreational purposes
		Residential areas
	Land not in use	
		Land for conservation and environmental protection
		Other
	Water bodies	
		Inland waters
		Marine waters

22. The area of land not in use should represent a residual to ensure that the aggregate area of land classified according to the land use classification aligns with the total terrestrial land and water area within a given economic territory.

23. Land in use should generally be able to be directly related to economic activity of some type, including the owner-occupied dwellings through ownership or renting. Land not in economic use may include land that has been set aside for conservation and environmental protection purposes. This land should be clearly identified within this broad category.

24. In some cases the land may support multiple uses at the same time or, over an accounting period the same area of land may be used for different uses at different times. In these cases, the principle is that the primary or dominant use should be recorded in terms of ensuring that all of the land area within a territory has been attributed. At the same time, there may be

strong analytical interest in understanding the range of multiple uses and compilers should take this interest into account in developing land accounts.

### **Land cover classification**

25. The primary objective of the land cover classification is to facilitate the recording and accounting of the changes inferred by socio-economic activities and natural processes at different levels of aggregations, the local, regional and global level.

26. The land cover classification must inform the main changes that summarise interactions between human society and nature. Such changes are urban sprawl and development of infrastructures (converting agriculture and natural land), intensification and industrialisation of agriculture (converting family farming and mosaic landscapes that combine developed and natural land), extension of agriculture in general (converting forests and marginal land), abandonment of agricultural land, drainage of wetlands, deforestation (for timber production and or agriculture development), afforestation and desertification.

27. The conversion of or change in land cover needs to be accounted for in the land cover classification. As a consequence, details on vegetation in the land cover classification will be included only if they matter for capturing the important land cover change.

28. For environmental accounting purposes, it is paramount to define land cover in terms of land cover functional units that can be mapped, related to basic production of ecosystem services (e.g. crops, timber or useable water) and at the same time be used as building blocks to map the socio-ecological systems where such services are generated over time by conjunction of natural and socio-economic processes. These complex systems are defined for accounting as landscape units composed of land cover functional units and called socio-ecological landscape units (SELU).

### **Implementation of the land cover classification for ecosystem accounting**

29. The detailed land cover nomenclature for ecosystem accounting and its complete definition in terms of LCCS3 building blocks and attributes will be presented in the (forthcoming) Annex to this Chapter. The building blocks themselves are presented at this stage as long as they are the starting point of any other land cover classification, for example for the purpose of describing a particular natural asset.

30. The LCCS3 methodology will not be presented here, only the general principles, which support the process of classification.

31. The systematic description of land cover can be made by describing basic vegetal and abiotic objects, their characteristics (for the vegetal objects: grass, shrubs or trees, for the abiotic objects: mineral, water or snow/ice), their properties (e.g. tree types, managed or non-managed) and the spatial patterns, which reflect the way these basic objects are arranged on land. The way landscapes should be described starting from basic objects, their

characteristics, properties and spatial patterns has been established as a meta language and a software so-called Land Cover Classification System (LCCS3)<sup>3</sup>.

32. LCCS3 acknowledges that a cartographic legend or a statistical nomenclature needs to meet the requirements of its users and reflect the high diversity of situations, which leads to establish specific land classifications for specific purposes. At the same time, the geographical information systems and internet can allow an exponential development of applications as long as geographical data of different nature are interoperable, which means that they can be overlaid using a GIS and their information cross analysed on every point of the territory. This requires harmonisation of the geometry (facilitated by the modern software packages as well as by the reference to satellite images), geo-referencing of the in situ observations (using GPS) and some standardisation of the classification of land.

33. In order to achieve the highest result in the context of buoyant development of geographical databases driven by specific needs, LCCS defines a strict set of rules and a meta language to keep track in the classification of the primary observation and avoid risks of confusion when different sources are used in one particular application. For that purpose, the basic bio-physical objects and derived land cover types are scale-independent (a tree is a tree, whatever the scale...).

34. The “real world” to be mapped is, however, covered by countless combinations of vegetal and abiotic objects more or less intensively managed. The common language describes accordingly geographical areas, named according to their natural vegetation (like forests, scrubland, heathland, grassland, cropland and marshes), or to natural absence of vegetation (sand, rocks, glaciers, water bodies) or their artificial character (built-up areas). Many situations are expressed as composite of mixed covers or landscape mosaics. The classification established for ecosystem accounting purposes will describe in a strict way how these mappable units are defined in terms of objects, their characteristics and properties as well as of horizontal patterns of their spatial arrangements.

### **Definition and classification of land cover types**

35. The stepwise definition of the land cover functional units for accounting starts from the definition and classification of the scale independent land cover types which reflect the combination and characterisation of the basic objects.

36. The following land cover types classification has been adopted for accounting purposes. The classification is presented in Table 2

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3 Ref. FAO

**Table 2 Classification of Land Cover Types**

Code	
A	Herbaceous crop
A1	<i>Herbaceous crop/ Small size fields rainfed (&lt; 2 ha)</i>
A2	<i>Herbaceous crop/ Medium to large size fields rainfed</i>
A3	<i>Herbaceous crop/ Medium to large size fields irrigated</i>
B	Tree or shrub crop
C	Multiple or layered crop
D	Tree covered area
E	Shrub covered area
F	Herb covered area
G	Sparse natural vegetation (terrestrial/aquatic/regularly flooded)
H	Aquatic or regularly flooded tree covered area
I	Aquatic or regularly flooded shrub or herb covered area
J	Bare areas (terrestrial or regularly flooded)
K	Artificial surfaces and associated areas
L	Inland water bodies
M	Glacier and perennial snow

38. For agriculture, three subdivisions have been added for capturing major environmental aspects related to size of farms and resulting landscape (classes A1 for small fields vs. A2+A3 for medium and large ones) and to identify irrigated and flooded crops, which are at the same time major consumers of water and emitter of methane, a major greenhouse gas.

**Classification of mappable land cover functional units (LCFU)**

39. A land cover functional unit produces goods and services from a homogeneous land area that functionally forms a typical cluster of spatial relationships of objects, characteristics and properties of land. The building blocks of table 2 are arranged over space according to established patterns. The mappable classes are defined there with the LCCS3 tool. In particular, composite land cover units are documented in terms of composition of main and secondary objects. One particular example of composite land cover functional unit is urban and associated developed areas which include de facto significant amounts of herbaceous and tree vegetation (green urban areas, tree alignments alongside avenues and street) and in some cases of water surfaces. Another examples is the grouping of objects from “A1Herbaceous crop/ Small size fields rainfed (< 2 ha)” with other objects (trees, shrubs, water) in order to compose mosaic agriculture landscapes. Another example is with the creation of a class so called “forest tree cover” grouping most objects of types D and H.

40. The nomenclature of mappable land cover functional units (LCFU) is defined as an application of the classification of basic objects by land cover types. The complete definition

of the classification of LCFU is described in the Annex to this Chapter. The main categories presented in Table 3 aim on the one hand at producing standard land cover change accounts. The categories have been selected in order to make sure that the most important changes are recorded. On the other hand, mapped LCFUs are used as components of the concrete definition of socio-ecological landscape units.

**Table 3 Classification of Land Cover Functional Units (LCFU)**

01	Urban and associated developed areas
02	Medium to large fields rainfed herbaceous cropland
03	Medium to large fields irrigated herbaceous cropland
04	Permanent crops, agriculture plantations
05	Agriculture associations and mosaics
06	Pastures and natural grassland
07	Forest tree cover
08	Shrubland, bushland, heathland
09	Sparsely vegetated areas
10	Natural vegetation associations and mosaics
11	Barren land
12	Permanent snow and glaciers
13	Open wetlands
14	Inland water bodies
15	Coastal water bodies
16	Sea (pro memory)

41. These 15 main categories are the core classification, for which sub categories can be flexibly developed according to the various users' needs at the national/ regional levels or for sector applications (e.g. forests or agriculture sub-classes).

**Other possible classifications of land area**

42. In addition to classifying land areas by land cover and land use, it may be of interest to classify land area by ownership or by industrial activity. If so, land ownership would be usefully classified using the institutional sector classification of the 2008 SNA and land area by industrial activity would be usefully classified by ISIC. Use of these classifications would allow connection to macroeconomic data such as sector balance sheets and productivity statistics.

**Physical asset accounts for land (and associated surface water)**

43. The objective of land accounts in physical terms is to describe the area of land (stocks) and its changes during an accounting period. Land cover accounts have to be distinguished in that respect from land use accounts.

44. Land cover accounts supply basic information on conversion of existing cover and formation of new cover. Such changes or flows of capital relate to major environmental issues: urban sprawl and development of infrastructures (conversion of agriculture and natural land), intensification and industrialisation of agriculture (conversion of family

farming and mosaic landscapes), extension of agriculture in general (conversion of forests and marginal land), drainage of wetlands, deforestation (for timber production and or agriculture development), reforestation and afforestation (to reverse the effects of clearing and deforestation, desertification (at the expense of formerly vegetated areas).

45. The experience in accounting for land cover change does allow for broad categorised by a limited number of causes of change in new land cover account. Further detail can be added to refine the broad categories of land cover change. For example, conversions of natural land to agriculture can be subdivided according to the type of crops developed (formation) or to the natural ecosystems converted or both, without adding a priori such details in the classification of land cover change.

46. In that perspective of combinatory use of geodata, the simple classification of changes is rather straightforward. Examples can be found in the IPCC/LULUCF guidelines<sup>4</sup> as well as in the land cover accounts regularly produced by European Environment Agency<sup>5</sup>. Both classifications describe changes between broad classes. The EEA names them flows. LULUCF names them conversions when the EEA defines flows of cover. In addition, the EEA classification recognises “internal conversions” within urban, agricultural and forested land.

47. The classification of the land cover flows is presented in Table 5.

**Table 5 Nomenclature of land cover flows**

LF01	Urban sprawl and related development
LF02	Land cover rotation within urban areas
LF03	Conversion of land to agriculture
LF04	Land cover rotation within agriculture
LF05	Conversion of land to forest
LF06	Land cover rotation within forested land
LF07	Water bodies management
LF08	Change due to natural and multiple causes

48. The land cover flows are related to the stocks that they reduce (consumption of existing cover) or accrue (formation of new cover). The processes that they describe or reveal relate broadly changes in land use. The multiplication of these dimensions gives a detailed description of the land cover change.

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4 [http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf\\_files/Chp3/Chp3\\_1\\_Introduction.pdf](http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf_files/Chp3/Chp3_1_Introduction.pdf)

5 [http://www.eea.europa.eu/publications/eea\\_report\\_2006\\_11](http://www.eea.europa.eu/publications/eea_report_2006_11)

**Table 6 Example of land cover flow account**

Units: hectares of km<sup>2</sup>

Consumption of land cover t0							Formation of land cover t1							
Urban areas	Broad pattern agriculture	Agriculture mosaics	Pastures and natural grassland	Forest tree cover	Other natural land cover	TOTAL	Urban areas	Broad pattern agriculture	Agriculture mosaics	Pastures and natural grassland	Forest tree cover	Other natural land cover	TOTAL	
							<b>Stock t0</b>							
							LF01	Urban sprawl and related development						
							LF02	Land cover internal conversions of urban areas						
							LF03	Conversion of land to agriculture						
							LF04	Land cover internal conversions of agriculture						
							LF05	Conversion of land to forest						
							LF06	Land cover internal conversions of forested land						
							LF07	Water bodies creation and management						
							LF08	Change due to natural and multiple causes						
							<b>Stock t1</b>							
							TOTAL							

**Land use accounts**

49. Land use accounts can refer to the surface used or to the uses themselves.

50. Land accounts of used surfaces follow the same framework as land cover accounts from which they differ regarding the details in land uses and changes classification.

51. Land use being observed by field surveys (surveys to land owners or users, area sampling) or combination of field surveys and remote sensing is generally described with much more detail than land cover. It can includes for example details of land surfaces by types of crops or use by purposes such as leisure, organic farming, bio-fuel production, nature conservation and other management purposes.

52. Land use monitoring allows as well describing specific attributes of land use such as purpose of buildings (housing, services, government, trade), yields by types of crops, farming practices, livestock in pastures, management of forest territory, traffic on roads or tourists on beaches. In every cases, specific measurement units will be needed and accounts will be presented in quantities/hectare or by km. Such accounts are an important step for

assessing ecosystem services and should be established at the most detailed level allowed by the survey methodology, e.g. municipality, farm or land parcel.

53. Land cover flows are grouped by processes broadly related to land use: urban sprawl, agriculture internal conversions, water bodies creation and management.

54. The detail of the land use related information allows as well more specific description of land use change.

55. While various economic actors may use the same type of land cover (typically, the urban areas), land uses are closely related to specific activities. Land use accounts are prone at being developed at the same time by land units (land use units or/and land cover functional units) and by economic units (establishments).