Advancing Environmental-Economic Accounting

Concept Note on Global Land Cover for Policy Needs: Supporting SDG Monitoring and Ecosystem Accounting

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1. Introduction

The international community has galvanized the world into focussing on 17 Sustainable Development Goals (SDGs[1]) for the 2030 Agenda for Sustainable Development. Countries tasked with monitoring the global SDG indicators and their national adaptations are facing challenges in reporting due to incomplete, conflicting and incoherent information.

The UN System of Environmental-Economic Accounting (SEEA), an international statistical standard, provides a measurement framework that underpins the environmental and economic aspects of many of the SDG indicators. The Global Earth Observation (GEO) community produces the spatial data that will be required to calculate the spatially related indicators at a national and sub-national level.

The aim of this Concept Note is to contribute to a process of harmonizing efforts among and between the GEO and statistical communities with the aim of providing better and more coherent spatial evidence for decision makers. Specific objectives to motivate this harmonization include:

- Assessing current global land cover data,
- Improving global spatial data,
- Developing an international standard land cover[2] classification, and
- Establishing a global spatial reference grid.

Such a process can take advantage of the current initiatives of the GEO community to demonstrate societal benefits of GEO data for addressing the SDGs and ecosystem accounting. As well, it can leverage on the needs of UNSD, representing the international statistical community, to provide statistical guidance on using spatial information to inform the SDGs and environmental-economic accounting.

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[1] See https://sustainabledevelopment.un.org/topics.
[2] The term "land cover" here is used as a proxy for "surface", since it also refers to freshwater, coastal and marine areas.

The proposed side event at the GEO-XII Plenary and Ministerial Summit in Mexico City, in November 2015, is the result of recently evolving ideas of extending the GEOSS Societal Benefits Areas (SBAs) to the SDGs. The SBAs already include ecosystems, agriculture and biodiversity for making optimal (policy-support) use of rapidly growing EO data and techniques.

The SEEA, which comprises a Central Framework (SEEA-CF) (United Nations, European Commission et al. 2014a), and the SEEA Experimental Ecosystem Accounting (SEEA-EEA), is an integrated, comprehensive and coherent measurement framework linking the environment and the economy.

The SEEA already brings coherent terminology, classifications and statistical production processes to this transdisciplinary domain of environmental-economic accounting. However, the SEEA-EEA adds a spatial perspective that demands local information about ecosystems, their measure of extent, condition and their services. The GEO and statistical communities now need to address issues about terminology, work processes and challenges of developing standardized methods and products in spatial terms as well.

The focus of the GEO perspective has been on data management and data-driven approaches. Official statistics direct efforts towards building internationally agreed conceptual statistical frameworks for data collection, compilation and dissemination following principles of data quality, consistency, relevance and comparability. These principles rely on internationally agreed concepts, methods, definitions and classifications.

Land cover is a central crosscutting theme for both GEO and statistical communities. In the geospatial and earth observations communities, land cover and land use data are becoming more abundant in many areas related to the environment. The abundance of data is being fuelled by the increasing availability of sensors and their increasing levels of resolution and higher revisit rates. However, despite these advances, not all user communities are having their needs met. For example, while standardized global classification systems have been proposed, they are either still not universally used or do not always fulfil user needs at the regional and national scale. Moreover, efficient validation of the data is also a challenge.

Building on the practical experiences of the statistical community in environmental economic accounting, there is now a need and commensurate opportunity for developing a harmonized multipurpose internationally agreed classification that builds on FAO's LCCS and UNSD's SEEA provisional land cover and land use classifications. Other thematic classifications should provide further input to the proposed land cover classification including spatial classifications for biodiversity, climate change, deforestation, desertification etc., for which custom products have been developed at various scales.

The SEEA-EEA has introduced the notion of *ecosystem unit*, a spatial unit defined in a way that links the above themes. The unit is based on main characteristics such as land cover, soil, hydrology, lithology, vegetation, land use, and others, which underpin the supply of ecosystem services. These spatial units are considered *ecosystem assets* because the services they supply generate current and future benefits (including biodiversity conservation) to people.

The idea of developing a hierarchical land cover/use classification that is coherent with these physiographic and ecological attributes should allow for crosswalks at both the global level, for example with the IGBP nomenclatures[3], and locally with detailed national physiographic and ecological classifications.

This report will outline the contributions of environmental-economic accounting in articulating the principles and conceptual framework for an *a priori* land cover classification and related spatial

[3] See http://www.igbp.net/researchprojects/pastprojects/landuseandcoverchange.4.1b8ae20512db692f2a680009062.html.

unit with full recognition of the global data products and their related land categorizations and attributes. The report should stimulate discussion to identify paths towards greater harmonization, applying emerging methods and engaging potential partners for a longer-term project to develop an internationally agreed conceptual spatial framework.

It would benefit this discussion to keep in mind two dichotomies: (a) short term versus long-term objectives and (b) *a priori* versus *a posteriori* classifications. While the short-term objective of such a project is to apply existing data and classifications (*a posteriori)* to existing needs, the longer-term objective is to facilitate the development of new data and classifications (*a priori)* that conform to a coherent methodological framework. That is, *a posteriori* is bound by what we have. *A priori* expresses what we want.

It should also be kept in mind that institutions implementing the SEEA are national or sub-national stakeholders. Countries, generally under the coordination of the National Statistical Office (NSO), use the best available data and classifications to produce SEEA accounts. Since countries have varying technical capacities and qualities of data, some will already have well-developed land classifications and spatial data. Others will depend on international guidance as to which classifications and data to use.

In keeping with the long-term objective, all countries will benefit from an international conceptual framework and standard classification of land cover and readily available, frequent and cost effective spatial data based on that framework and classification.

2. The SEEA and its policy applications

This report focusses on ecosystem accounting, since implementing the SEEA-EEA requires that countries have access to detailed spatial data. However, other components of the SEEA, such as energy, water, agriculture, fisheries and forestry would also benefit from a standard land cover classification.

"*Ecosystem accounting is a coherent and integrated approach to the assessment of the environment through the measurement of ecosystems, and measurement of the flows of services from ecosystems into economic and other human activity*." (United Nations, European Commission et al. 2014b)

The SEEA is proposed as a common measurement framework for several environmental, biodiversity and sustainable-development related international initiatives including the SDGs, the OECD Green Growth initiative, the World Bank WAVES, IPBES, BioFin, Sustainable Consumption and Production, and the CBD Aichi Targets.

At the country level, regular reporting on SEEA accounts will support the monitoring and reporting of at least 12 of the SDGs:

- Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture,
- Goal 6: Availability and sustainable management of water and sanitation,
- Goal 7: Access to affordable, reliable, sustainable, and modern energy,
- Goal 8: Sustainable economic growth,
- Goal 9: Industry, innovation and infrastructure
- Goal 10: Reduced inequalities
- Goal 11: Safe, resilient and sustainable cities,
- Goal 12: Sustainable consumption and production,
- Goal 13: Combat climate change and its impacts,
- Goal 14: Sustainable use of oceans, seas and marine resources,

- Goal 15: Sustainable use of terrestrial ecosystems, especially 15.9 integrating ecosystem and biodiversity values into national and local planning and development processes and poverty reduction strategies and accounts, and
- Goal 17: Enhancing capacity building to increase availability of data.

The main mechanism for accomplishing this at the national level is for countries to produce priority environmental-economic and ecosystem accounts as ongoing statistical production processes. The degree to which these accounts follow the SEEA guidelines will determine the degree to which the results are internationally comparable.

3. The SEEA-EEA spatial framework

The SEEA-EEA provides a broad definition of ecosystem assets as "*spatial areas comprising a combination of biotic and abiotic components and other characteristics that function together*". This is essentially the operational definition of "ecosystem" or "optimal service providing unit". Land cover data are necessary, but insufficient, for delineating these spatial areas. In practice, these ecosystem assets should have a strong correlation to the ecosystem services they produce.

The current recommended approach in the SEEA-EEA is to use reference land cover data (each pixel of which constitutes a Basic Spatial Unit or BSU) and other information, if available, to delineate contiguous and homogenous Ecosystem Units (EUs) (**Figure 1**), classified according 15 LCCS3/CORINE-based classes (**Table 1**). Data on extent, condition and services production are then attributed to these EUs. Tabulations are produced by EU type (essentially ecosystem asset type) for various Ecosystem Reporting Areas (ERAs), which could be drainage basins, ecozones or administrative regions within the country.

In practice, the delineation of EUs could simply be based on land cover classes. However, if information were available, the contiguous land cover areas could be further split using information such as land use, hydrology, elevation, slope, lithology, vegetation type, etc.

In testing, this has raised several issues:

- **What data to use?** Countries may have their own land cover data or they could use one of the global datasets. Countries would need to have timely, detailed and comparable data over two periods (e.g., 2005 and 2010) to calculate changes in ecosystem assets.

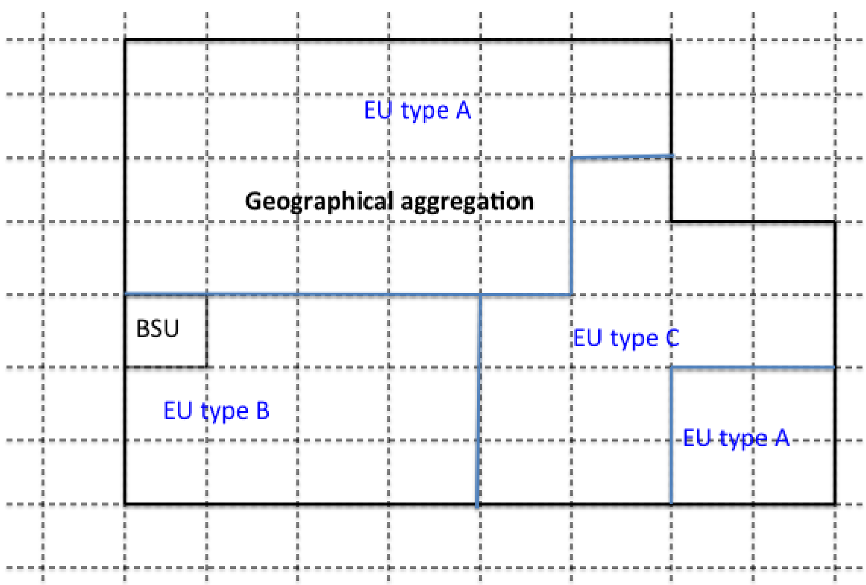
Table 1 Land cover (ecosystem asset, ecosystem unit) classification from SEEA-CF

No.	Description of classes
01	Artificial areas (including urban and associated areas)
02	Herbaceous crops
03	Woody crops
04	Multiple or layered crops
05	Grassland
06	Tree-covered areas
07	Mangroves
08	Shrub-covered areas
09	Shrubs, and/or herbaceous vegetation, aquatic or regularly flooded
10	Sparsely natural vegetated areas
11	Terrestrial barren land
12	Permanent snow and glaciers
13	Inland water bodies
14	Coastal water bodies and intertidal areas
15	Sea and marine areas*

Source: SEEA Central Framework Table 5.12.
* A class for "Sea and marine areas" has been incorporated to ensure appropriate coverage for all of a country's area that may be included within ecosystem accounting.

- **What classification to use?** Beyond the 15 SEEA land cover classes, there are no recommended sub-classes. Sub-classes would be required to correspond national land cover classifications to the SEEA standard. Countries also require means of linking their own priority ecosystem assets (e.g., protected areas, wetlands, or specific ecozones) with the SEEA standard.
- **Land cover does not always correlate well with ecosystem services.** Countries may prefer to base ecosystem accounts on their own ecological classifications. Some ecosystem services may correlate better with physiographic (e.g., elevation), socio-economic (e.g., land use, ownership and condition) and ecological (e.g., vegetation associations)

Figure 1 SEEA-EEA Spatial units model for one Ecosystem Reporting Area (ERA)



Source: Adapted from SEEA-EEA Figure 2.4

characteristics than with land cover. Some countries include information on condition (e.g., natural, semi-natural, cultivated, degraded) in their classifications as well.

- **Registering BSUs and other spatial data over time.** Remote sensing pixels may refer to a slightly different area on subsequent revisits. Data may use different resolutions. Environmental data will need to be referenced in the same spatial information system as socio-economic data.

4. What is needed? (the Spatial Development Goals)

To address these issues arising from testing the SEEA-EEA spatial units model and classification, initiatives are required that focus on the following four areas:

- **Assessing current global land cover data** with respect to its applicability to ecosystem accounting,
- **Improving global spatial data** for ecosystem accounting by guiding the GEO community towards applying emerging methods,
- **Developing an international standard land cover classification** for general purpose applications, including ecosystem accounting, and
- **Establishing a global spatial reference grid** for harmonizing socio-economic and environmental data.

4.1 Assessing current global land cover data

There are many choices for global land cover data and, often within a country, alternative sources and interpretations. Although progress is being made in cross-referencing existing land cover data, countries would benefit from an assessment of global land cover data sources in terms of applicability to ecosystem accounting and ongoing statistical processes. That is, an ideal data source is well-documented, of high quality, of high resolution, thematically detailed, and available frequently, cheaply and consistently. **Section 5** provides some criteria for beginning this discussion.

Is such an assessment available or can we suggest a small number of global datasets to assess? Can we agree on criteria to be used and a process to produce a joint assessment?

4.2 Improving global spatial data

There are drawbacks to delineating ecosystem assets using remotely sensed land cover information alone[4]. There is little consensus that land cover correlates strongly with the production of ecosystem services. On the one hand, land cover data do not always represent the more permanent physical features (bioclimate, landform, lithology, hydrology) nor the vertical dimension (elevation, depth, strata, atmosphere, groundwater) that influence the distribution and potential distribution of biota. On the other hand, land cover data do not always represent the detail of biotic associations that influence the generation of ecosystem services. In between, there are also aspects of the condition, use and management regime of the ecosystem assets that often change on a short time scale.

Addressing this will require not only creating a classification that links across domains (see **Section 4.3** below), but also pushing existing technology to regularly and globally detect important ecosystem assets, their extent, condition and the services they provide.

[4] Recognizing that some such aspects of land use, condition and species associations are currently feasible with very high-resolution imagery and custom interpretations.

For example, detecting wetlands from standard remote sensing images has been a challenge. Wetlands may exist under the tree canopy, they may be smaller than the resolution of the sensor (e.g., prairie potholes) and they may only exist for part of the year.

Similarly, specific plant species, habitats (e.g., coastal and marine) and the condition of ecosystems (habitat naturalness, pollutants, physical degradation, changing vegetation mixes) are often referenced in specific studies, but these data are neither available globally nor frequently.

What would be required to focus existing technology on providing these data globally and frequently?

4.3 Developing an international standard land cover classification

The lack of a coherent and integrated classification and data across the domains of physiography, land cover, ecology and socio-economics has led to a situation where implementing the SEEA-EEA spatial infrastructure at the national level requires either (a) compromising precision by using readily available products or (b) compromising comparability by developing custom interpretations.

A single classification comprising all these aspects would be neither feasible nor especially useful[5]. One approach would be to develop an integrated, multi-layer spatial framework in which a standard land cover classification plays a central role (**Figure 2**).

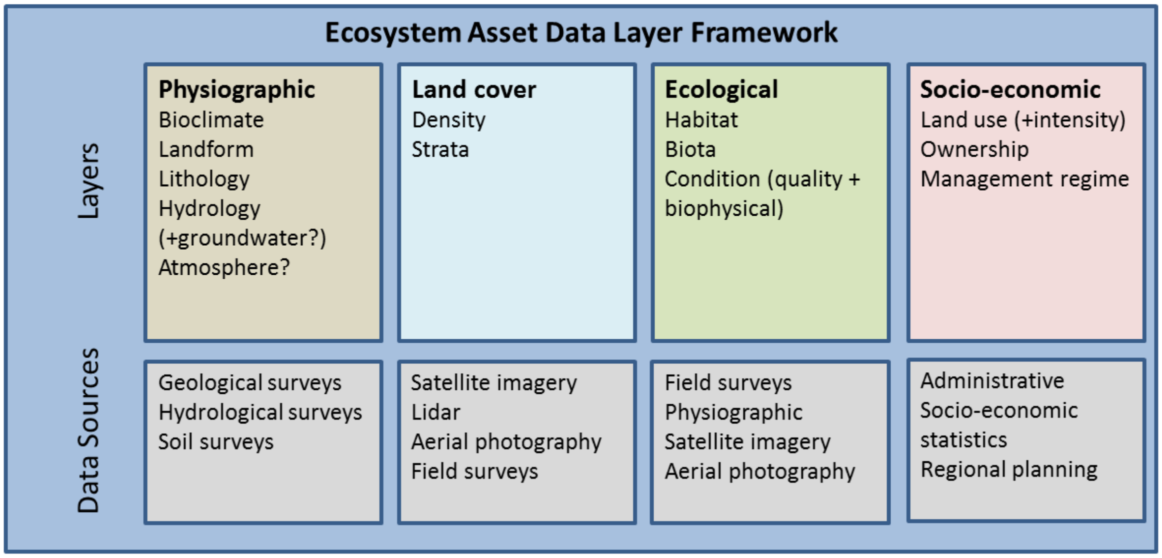
Land cover data are commonly available and serve as the basis of many international, national and local established policy, planning and management processes. Therefore, developing a harmonized land cover classification would serve many users.

To be of greatest benefit, such a classification would also take into account existing work on physiographic, ecological, land use, freshwater, coastal and marine spatial classifications. Coherence across these aspects would reduce conflicts (e.g., between hydrological, land cover and ecological definitions of “wetland”) when combining these sources in delineating ecosystem assets. It would also support the development of a common language across these disciplines. As well, it would simplify the process of deciding which datasets to use for which applications. That is, the most appropriate datasets would be those that provide the necessary linkages.

What is the most appropriate starting point for an international land cover classification? Who needs to be involved?

[5] Much like a 1:1 scale map of the world. Where would you put it?

Figure 2 Components of a data layer framework for ecosystem assets



4.4 Establishing a global spatial reference grid

Reference grids are common in some countries, especially in Europe, where there is a need to spatially reference population, dwelling and business data in a coherent way across the continent[6]. These countries will have legacy spatial boundaries, based on different criteria. As well, much land analysis in Europe is based on CORINE[7] 1km grids. Such a grid facilitates the integration of socio-economic and environmental data by providing a consistent unit that does not change location or size over time.

Furthermore, countries use different spatial areas for socio-economic and environmental data. For example, in Canada, socio-economic data are referenced to census geographical units (census block, dissemination areas, census divisions, provinces). Environmental data are often referenced to a drainage area or ecozone hierarchy. When allocating socio-economic data to environmental geographies (such as counting the number of farms in a sub-sub-drainage area) problems of residual disclosure need to be addressed. That is, the intersection of two polygons may create smaller polygons which risk revealing data about the one, two or three farms that exist in that smaller polygon. The common approach to addressing this is either to mark the smaller polygon as confidential or to combine it with a neighbouring polygon.

A common reference grid would simplify statistical production since referencing the data, assuring confidentiality and methods for extracting it can be regularized. For example, standard procedures for assuring the confidentiality of socio-economic data would only need to be applied once. Also, this would standardize methods of creating aggregates of environmental data (e.g., river length, dominant land cover type) and fixing remote sensing information.

Would it be feasible to establish a common global reference grid for integrating, storing and extracting social, economic and environmental data?

[6] See http://ggim.un.org/docs/meetings/UNSG_EG/ESA_STAT_AC.279_P7_UN-GGIM-Expertgroup_SF_MTL_.pdf and http://www.efgs.info/

[7] See http://effis-viewer.jrc.ec.europa.eu/documents/general/land_cover.pdf.

5. Scope and principles

5.1 Assessing current global land cover data

Global land cover product assessment is currently part of the GEO Global Land Cover Task. **Annex 1** provides a set of additional criteria that would be of benefit to assess the applicability of the data for ecosystem accounting. This presumes that standard spatial metadata are already included (e.g., frequency, sensor type, etc.).

For ecosystem accounting, countries require consolidated metadata on global land cover datasets in terms of the quality of documentation, quality of data, resolution, thematic detail, frequency, cost and consistency over time.

5.2 Improving global spatial data

The GEO community is well positioned to advise on what *can* be done with existing and emerging EO technology and what *could* be done if the technology were adapted for ecosystem accounting purposes. The ultimate goal would be to provide global, frequent (seasonal), high-resolution coverage of not only highly detailed land cover, but also information on ecosystems that are not easily detected with standard products (wetlands, marine, coastal, soil, specific species and habitats) and their condition.

This will require not only the adaptation of existing sensors, methods and processes, but also the development of new technologies. To do this will require close collaboration of the GEO community with the statistical and physical science communities.

5.3 Developing an international standard land use classification

EO data products largely rely on data-driven or *a posteriori* classification approaches, while official statistics, having developed principles, concepts and theoretical foundations irrespective of available data, rely on *a priori* classifications. The lack of commonly agreed and widely applicable standards for classifying land cover, and other environmental subjects, has resulted in limited applicability of the global data products, as well as lack of comparability between the projects and societal benefit areas, where each has undertaken its own approach (with different nomenclature, timing, spatial detail, etc.)

The experience of the official statistical community and UNSD can support the process of developing harmonized and multipurpose land cover classification by supplying working principles and criteria, which ensure structured comparability (across space and time), pursuing agreement among the involved communities and standardization of methods and classifications.

Collaboration among international agencies that have developed and maintain related data and classifications is essential. The intent is not that these agencies would change the classifications they require to fulfil their sectoral mandates to a new standard. However, they should recognize that linking to a standard classification as an important vehicle for exchanging and using information.

Such a classification could constitute an international standard that provides a common point of departure to which other classifications and products could be compared. It could also eventually provide the basis for global, standard, low-cost data product to support ecosystem accounting and other users.

The objective of classification

The objective is to develop an appropriate classification of global land cover that will be the standard used by countries implementing the SEEA-EEA. Such a classification should:

- not be limited to existing spatial data products, but should also foresee what global data ***could*** be available in the near future (e.g., detailed species types, environmental quality and other conditions),
- take into account not only surface properties, but whenever possible, include consideration of vegetation strata (canopy levels) and detectable sub-surface characteristics (soil type, water depth), and
- be multi-purpose, over the long-term becoming the international standard by providing sufficient detail and documentation to support correspondence with existing special-purpose classifications and data.

The principles

The classification should be seen as one component of a coherent international standard classification of "ecosystem assets". That is, it should be interoperable with existing and future classifications of physiography, land use and habitats (including freshwater, coastal and marine, among others).

To be an international standard, it should adhere to statistical principles of:

- **Comprehensiveness**: All land and water surfaces of the world should be included.
- **Mutual exclusivity**: Well-defined rules should ensure there are no overlaps and that no spatial areas are excluded.
- **Hierarchy**: Sub-classes should clearly be associated with higher classes. The classification may require four or more levels.
- **Coherence**:
    - Sufficiently detailed and well defined to develop crosswalks between (and therefore be interoperable with) existing land cover classifications as well as physiographic, land use and ecological classifications
    - Sufficiently detailed to support the classification of ecologically important surface features such as wetlands and ecotones,
    - Promote a standard terminology for land cover types

For the purposes of this discussion, a land cover classification is a hierarchical, detailed description of classes.

Since this will be an *a priori* classification (that is, based on principles rather than existing data), it should be independent of data sources. To produce a spatial dataset based on the classification multiple sources of data may be required.

5.4 Establishing a global spatial reference grid

Reference grids are used in some countries to reference socio-economic data and, often separately, for environmental data. Ideally, these two domains would benefit from a common, global reference grid. Such a grid would need to ensure equal area at all latitudes and independent of slope. Current reference systems are either country-specific or imply distortions of scale (e.g., Universal Transverse Mercator, UTM).

Perhaps this has not been previously developed is due to the complexities of converting from latitude/longitude coordinates. The possibility should, however, be explored. If this is not feasible, then countries should be advised on methods of developing country-specific or regional reference grids.

6. Possible starting points

The side event of GEO-XII is an excellent opportunity to bring the geospatial and statistical community together to consult them on the proposed launch of a joint multi-year GEO-UNSD project to (a) assess existing global land cover data, (b) improve global spatial data, (c) develop an international agreed land cover classification and its modalities, and (d) research the feasibility of a global reference grid.

This section focuses on some starting points that could contribute to developing standard, international classification of land cover that (a) links to physiographic, socio-economic and ecological classifications and (b) serves the needs of ecosystem accounting and other general users.

6.1 The LCCS3

LLCS3 is a process for comparing and validating map legends. It serves to translate common terminology (such as “forest”) into standard descriptors (e.g., density, canopy strata). The approach constitutes two phases to classification:

- a dichotomous phase, which classifies land into a hierarch of eight major land cover classes (**Figure 3**), and
- a modular-hierarchical phase, in which classes are created using rules (classifiers) that are specific to each of the eight major land cover types.

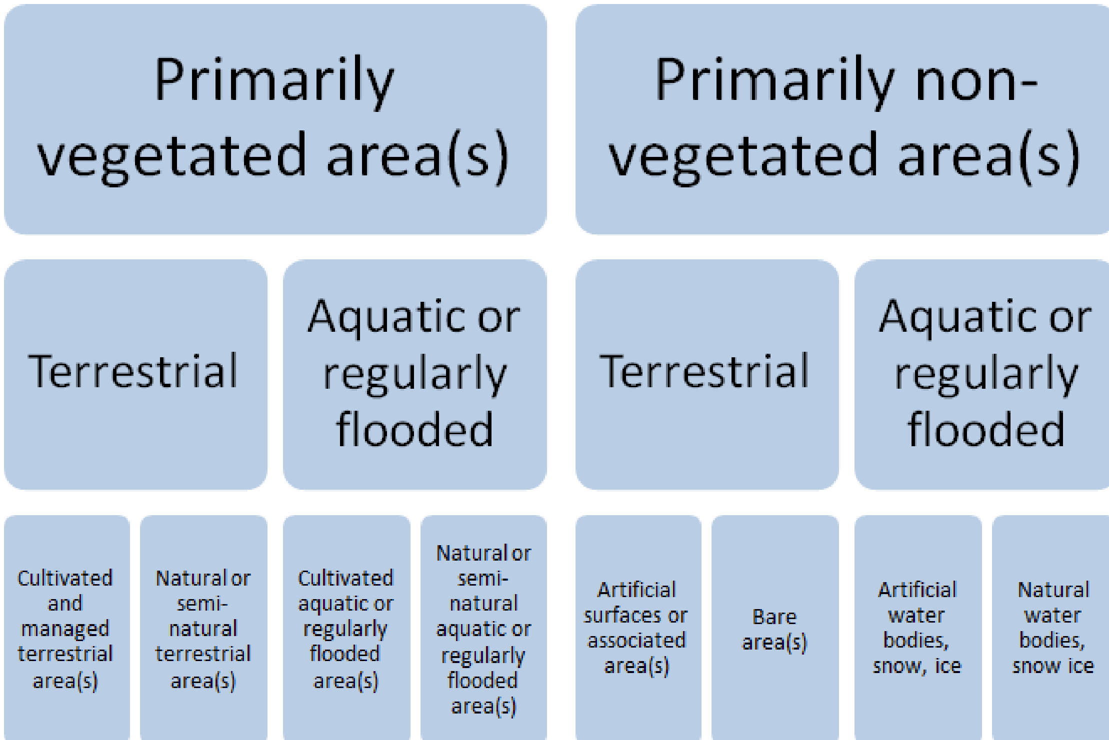
Since it is a process, it does not result in a traditional detailed hierarchical classification. The process is useful for testing the integrity of existing map legends (e.g., for comprehensiveness and mutual exclusivity) and comparing different legends.

The suggested classifiers are sufficiently rich (they include the environmental attributes of landform, lithology/soils, climate, altitude, erosion, water quality and many more) to test for linkages with existing physiographic, socio-economic and ecological classifications.

The LCCS3 has been tested with respect to several other common land cover classification systems. However, (a) it is not clear the degree to which the classifiers have been accepted outside the land cover community of practice, and (b) the process is not intended to generate a single standard legend.

Would it be possible to use the LCCS3 as a basis for a comprehensive land cover classification that (a) links to climate, lithology, landform and ecosystem asset, and (b) includes sufficient detail for cross-referencing national classifications?

Figure 3 Dicotomous phase of LCCS3



Source: (Di Gregorio 2005)

6.2 The CORINE-EUNIS crosswalk

CORINE[8] (Coordination of Information on the Environment) CLC (CORINE Land Cover) is a land cover/land use database that serves as the European standard[9]. It comprises 44 classes that are used as the basis of many of Europe's land management initiatives.

EUNIS[10] (European Nature Information System) is a detailed description of over 5,000 habitat types and 77,000 species.

The MAES (Mapping and Assessment of Ecosystems and their Services) project has produced a crosswalk between CLC classes and EUNIS ecosystem types[11]. This has resulted in a draft map of European ecosystem types that includes marine habitats[12].

What would be required to develop such a land cover/ecosystem type linkage at the global level?

[8] See http://ec.europa.eu/agriculture/publi/landscape/about.htm and http://land.copernicus.eu/pan-european/corine-land-cover/view.
[9] Di Gregorio (2005) notes that CORINE itself is internally inconsistent.
[10] See http://eunis.eea.europa.eu/habitats.jsp.
[11] See http://biodiversity.europa.eu/maes/correspondence-between-corine-land-cover-classes-and-ecosystem-types.
[12] See http://biodiversity.europa.eu/maes/mapping-ecosystems/map-of-european-ecosystem-types.

6.3 The USGS/ESRI Global Ecological Land Units

The USGS, in collaboration with ESRI, GEO and the Association of American Geographers, has produced a classification and map of global ecological land units (Sayre, Dangermond et al. 2014)[13]. This is an *a posteriori* classification as it is data driven.

The map is the result of combining global maps of bioclimate (37 categories), landform (10 categories), lithology (16 categories) and land cover (23 categories, based on 300m GlobCover 2009 data). Of the theoretical 136 thousand combinations (or Ecological Facets), 48 thousand were found to exist. These were further reduced statistically to 3,923 Ecological Land Units (or types).

The map is proposed as a depiction of ecosystems that is closer to an environmental (physical features) classification than a taxonomic one (biological features). As such, it may provide a useful starting point for (a) the physiographic classification of ecosystem assets and (b) providing harmonized global data for countries wishing to develop ecosystem accounts.

What would be required to expand on the USGS/ESRI ELU concept to include the vertical dimension (UNSD 2015) and aquatic ecosystems? Could the classifications of bioclimate, landform and lithology serve as the standard classification for physiographic information?

7. Summary and conclusions

The suggested initiatives of:

- Assessing current global land cover data,
- Improving global spatial data,
- Developing an international standard land cover[14] classification, and
- Establishing a global spatial reference grid.

will require close collaboration between the GEO and statistical communities, as well as others in the physical sciences.

Further research and discussions are required to develop a proposal for the institutional framework, scope and areas of work, working methods, timeline and budget for a collaborative project to achieve these objectives.

[13] See http://blogs.esri.com/esri/esri-insider/2014/12/09/the-first-detailed-ecological-land-unitsmap-in-the-world/.
[14] The term "land cover" here is used as a proxy for "surface", since it also refers to freshwater, coastal and marine areas.

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9. Annex 1 Proposed criteria for assessing land cover and related classifications and datasets

- **Name**: Name of product
- **Lead agency/developer**:
- **Internet address of full description/documentation**:
- **Type of product**: Classification only, spatial dataset, meta-language
    - If spatial dataset: Source of data
    - If spatial dataset: Resolution
    - If spatial dataset: Frequency
    - If spatial dataset: Cost estimate range for national coverage
- **Examples of use or assessment**: Bibliographic citation(s)
- **Geographic coverage**: The product is applicable globally, sub-globally, nationally or locally.
- **Main source of classes**: *A posteriori* (i.e., empirical, based on available data); *a priori* (theoretical, based on principles)
- **Treatment of vertical dimension**: Surface only, surface and sub-surface, other
- **Land cover**:
    - Number of categories: number
    - Hierarchical: yes/no
- **Land use**:
    - Number of categories: number
    - Includes intensity of use: yes/no
    - Includes nature of owner: yes/no
    - Includes protection status: yes/no
- **Ecological**:
    - Features: habitats, species, both
    - Number of categories: number
- **Physiographic**:
    - Elevation/depth: number of categories
    - Slope: number of categories
    - Landform: number of categories
    - Climate: number of categories
    - Lithology: number of categories
- **Freshwater**:
    - Features: streams, rivers, lakes, wetlands, estuaries
    - Number of categories: number
- **Coastal and marine**:
    - Features: coral reefs, islands, estuaries, seagrass beds, etc.
    - Number of categories: number