Draft SEEA Technical Note: Land Accounting

Background to SEEA Technical notes

This draft note aims to provide an indication of the style and content for a series of technical notes to assist with the implementation of the System of Environmental-Economic Accounting (SEEA). The general purpose of the SEEA Technical Notes is to summarise the range of relevant features and considerations when implementing the accounts. While the Technical Notes provide a general guide to implementation of the SEEA, individual countries will need to tailor implementation to their requirements, environmental characteristics and statistical circumstances.

The purposes of this particular draft are: (1) to seek general feedback on the style and level of information contained in the note and; (2) specific comments on the content related to land accounting.

1. Introduction to land accounting

This note provides an introduction to land accounting, covering the motivation for producing them as well as their development, compilation and use.

Land is a unique environmental asset that delineates the space in which economic activities and environmental processes take place, and within which environmental assets and economic assets are located. The SEEA land accounts' scope is the total area of a country, including areas covered by inland water resources, such as rivers and lakes and, in certain applications, may also be extended to include areas of coastal water and a country's Exclusive Economic Zone (EEZ). The total country area should be defined as the area enclosed by all inland borders and, if applicable, the normal baselines (such as the low-water mark) and straight baselines on the seaward side.[1]

Land area is analysed in many different ways and as such accounts can be prepared from several points of view. From a spatial point of view accounts can be compiled for the country as a whole or for regions occurring within countries. For example, accounts can be compiled for administrative regions (e.g. state, provincial or local government boundaries) or bio-geographic regions. That is, regions based on the physical characteristics, such as flora and fauna or topography (e.g. mountains, plains). From an economic view point accounting can be done by the area of land owned by different institutional sectors, land used by different industries and land zoned for different activities (e.g. residential, industrial, conservation).

While a range of different accounts can be prepared the core land accounts are for land use and land cover.

[1] The boundaries between the land and the sea vary considerably between countries depending on the different geographical features of a country. The conventions by which country area is determined, in particular the definition of baselines, focus on the boundary between land and sea and have been agreed internationally in the United Nations Convention on the Law of the Sea of 10 December 1982 (UNCLOS) (UN, 1982).

> **Land use** *reflects both (i) the activities undertaken and (ii) the institutional arrangements put in place; for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions*[2].

In effect, an area that is "used" implies the existence of some human intervention, including ownership or management. Land in use therefore includes protected areas which are under the active management of institutional units of a country for the purpose of excluding economic or human activity from that area.

> **Land cover** *refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces*[3].

At its most basic level it comprises all of the individual features that cover the area within a country. For the purposes of land cover statistics the relevant country area includes only land and inland waters. The area of coastal waters is generally excluded from land accounts but may be extended to include the EEZ. The accounts for land use and land cover are described in Section 4.

Section 2 describes the motivation for producing land accounts, including the types of questions that may be addressed and the derivation of relevant indicators. This is followed by a general description of the core accounts (Section 3), some extensions and links to the core accounts (Section 4) as well as the main concepts, data sources and methods needed to compile land accounts as described in the SEEA Central Framework (Section 5). Lastly, Section 6 provides references to a range of material that may assist readers in developing and using land accounts, including country examples.

2. Motivation for land accounting

Land is central to economic and environmental accounting. Beyond an assessment of the ownership and use of land as part of economic production, some of the issues that can be considered in the context of land accounts include the impacts of urbanisation, the sustainability of agriculture and forestry, the use of inland freshwater resources, and biodiversity conservation.

Land also constitutes an important component in the assessment of national and institutional sector wealth. Land is bought and sold in combination with physical characteristics (buildings, soil, trees, water) and the composite value will incorporate a value of the space itself (the location) as well as a value for the physical characteristics.

National assessments of the changing shares of different land use and land cover within a country can provide useful indicators of change. In addition, land accounts also help unlock the power of Geographic Information Systems (GIS) to locate areas of change and map a wide range of social, economic and environmental information. For example, how land ownership (e.g. public or private) is related to income, land use and land cover. Such information can be used to assess how different factors interact in particular areas and help to target areas for intervention.

As well as spatial targeting, the land accounts can be used to produce a range of the indicators identified in international initiatives. For example, some of the indicators of sustainable

[2] Definition from the SEEA Central Framework, paragraph 5.246

[3] Definition from the SEEA Central Framework, paragraph 5.257

development developed by the Commission for Sustainable Development for land use change, land degradation, arable area, and forest area. They are also specifically linked to three of the OECDs proposed Green Growth Indictors (7, 10 and 11):

- Indicator 7. Forest resources (area and volume of forests; stock changes over time);
- Indicator 10. Land resources (land cover types, conversions and cover changes; land use state and changes);
- Indicator 11. Soil resources (erosion of topsoil, particularly on agricultural land)

3. Core accounts for land cover and land use

Land accounts can be prepared in both physical (eg. hectares) and monetary terms ($, €, ¥, etc.). In the first instance it is recommended that countries develop estimates of the total land area classified by land cover at the beginning and end of each accounting period. This is because data on the physical areas of land cover from remote sensing (either aerial photography or satellite images) are usually available and requires less interpretation than land use, while monetary information is often harder to obtain and is often scattered in a range of administrative data (e.g. held by local governments).

It is noted that land cover and land use are interrelated. For example, agricultural production is closely aligned to crop area. However, while land use and land cover are closely related, this is not always the case. For example, tree covered areas can be used for forestry, for the maintenance and restoration of environmental functions, or may not be used at all (i.e. land not in use).

With data structured in an accounting format it is possible to link land cover to land use, including accounts showing land cover by land use as well as matrices showing the changes in both land cover and land use over an accounting period. In assessing land cover and land use change it may be useful to determine the proportion of the opening stock of land whose cover or use has remained unchanged. To undertake this type of analysis the data must be based on spatially referenced data sources.

The total land area of a country defines the scope of the land cover and land cover accounts. For most purposes this will be the area of land and associated inland waters, as defined in the land cover classification presented in the SEEA Central Framework. This classification is shown in the row and column heading of Table 1. It is possible to use other land cover classifications and for the purposes of creating internationally comparable results a correspondence table may be produced as part of the compilation process (see Section 5). The accounts could be extended to coastal water bodies and inter-tidal areas if there is interest in these area (e.g. because fish or other marine resources are harvested).

Generally the total area of land for a country will remain unchanged from one period to the next and so the total opening and closing stock of land in physical terms (hectares) will be unchanged. However, there are situations where the area of land for a country may change. It may increase, for

example due to reclamation of land through the construction of dykes and other barriers. It may also decrease, for example due to land subsidence or higher water levels.

Changes in the total area of land may also occur due to political factors. For example, the total area may increase or decrease due to war and associated events and there are commonly areas of disputed territory.

The starting point for land cover accounts is usually a land cover change matrix, showing net changes in land cover (Table 1). This shows land cover at two different points in time. It shows the area of different land cover types at the beginning of the reference period (opening area), the net increases and decreases of this area according to the land cover type it was converted from (in the case of increases), or what it was converted to (in the case of decreases), and finally, the area covered by different land cover types at the end of the reference period (closing area). The table shows, for example, that between time 1 and time 2 the area of crops grew from 7,756 to 8,454 thousand hectares, comprising additions to crop area from grassland (643,000 ha), tree covered area (12,000 ha) and regularly flooded areas (43,000 ha). The table also shows the corresponding reductions (as negative numbers) to the areas of grasslands, tree covered area and regularly flooded areas.

It is important to understand that the matrix shows net changes, which may mask information. For example, if natural forest is lost in one place but plantation forest is added elsewhere, then no net change of tree covered area would be shown. Similarly, when high quality agricultural land is converted into built-up land, but, at the same time, less productive agricultural land is added through deforestation, total crop or grassland (used for agriculture) will not change. Where these phenomena are relevant, the format of Table 1 can be extended to show increases and decreases in separate tables and thus allow more detailed analysis.

Land use accounts are structured along similar lines to land cover accounts. For instance, rows and columns showing land cover classification in Table 1 would be replaced with the land use classification. In this, the classification of land use is again presented in the SEEA Central Framework. The column categories for land use would comprise: 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, and Land not in use. For inland waters there are four main categories: 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; and Inland waters not in use. Various sub-categories and classes are presented in the SEEA Central framework, including a listing of classes relevant for extended analysis of coastal waters and the EEZ.

Both land use and land cover accounts can also be presented in monetary terms. That is, while the table structure remains the same, the units of measurement are in monetary units ($, €, ¥, etc.).

Table 1 Net land cover change matrix (hectares)

Land cover	Opening area, time 1	Net increases (positive numbers) and decreases (negative numbers) from other land covers, time 1 to time 2 (1,000 ha)											Net change (increase – decreases)	Closing area, time 2
		Artificial surfaces	Crops	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas		
Artificial surfaces	987	-	-	29	-	-	-	-	-	-	-	-	29	1016
Crops	7756	-	-	643	12	-	-	43	-	-	-	-	698	8454
Grassland	14345	-29	-643	-	-	-	-	-	-	-	-	-	-672	14316
Tree covered area	23345		-12	-	-	-	-	-	-	-	-	-	-12	23333
Mangroves	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shrub covered area	16342	-	-	-	-	-	-	-	-	-	-	-		16342
Regularly flooded areas	567	-	-43	-	-	-	-	-	-	-	-	-	-43	524
Sparse natural vegetated areas	112	-	-	-	-	-	-	2		-	-	-	2	114
Terrestrial barren land	45	-	-	-	-	-	-		-2	-	-	-	-2	43
Permanent snow, glaciers and inland water bodies	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coastal water and inter-tidal areas	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: Crops includes herbaceous crops, woody crops and multiple or layered crops.

4. Extensions and links

An extension to the analysis of the physical accounts for land cover change would be the construction of tables showing reasons for land cover change. Table 2 shows a physical account for land cover from the SEEA Central Framework. It shows the opening and closing areas for different land cover types and various additions and reductions in those areas over the accounting period. The different additions and reductions are explained in the following paragraphs.

Managed expansion represents an increase in the area of a land cover type due to human activity. For example, crop areas may be converted to tree covered areas as a result of silvicultural measures such as planting and seeding, or tree covered areas may be converted to crop or grassland following tree clearing. Generally, the managed expansion of one land cover type will also lead to the recording of a matching entry for managed regression of the reducing land cover types. A matching entry is not recorded if there is a managed expansion in the total area of land within scope of the account (e.g. in the case of land reclamation).

Natural expansion is an increase in area resulting from natural processes including seeding, sprouting, suckering or layering. In the case of sparse natural vegetation and terrestrial barren land, the natural loss of vegetation from other vegetation types would lead to increases in these areas. Changes in the extent of permanent snow, glaciers and inland water bodies can also be due to natural variation in, for example, rainfall. Generally, the natural expansion of one land cover type will also lead to the recording of a matching entry for natural regression of the reducing land cover types. A matching entry is not recorded if there is a natural expansion in the total area of land within scope of the account (e.g. in the case when land is created through volcanic activity or landslide).

Managed regression represents a decrease in the area of a land cover type due to human activity. As for managed expansion, a matching entry is recorded in all cases of managed regression, except in cases where there is a managed regression in the total land area.

Table 2 Physical account for land cover (hectares)

	Artificial surfaces	Crops (a)	Grassland	Tree covered area	Mangroves	Shrub covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies
Opening stock of resources										
Additions to stock										
Managed expansion										
Natural expansion										
Upwards reappraisals										
Total additions to stock										
Reductions in stock										
Managed regression										
Natural regression										
Downwards reappraisals										
Total reductions in stock										
Closing stock										

(a) Crops includes herbaceous crops, woody crops, and multiple or layered crops.

Natural regression should be recorded when the area of a land cover type reduces for natural reasons. As for natural expansion, a matching entry is recorded in all cases of natural regression, except in cases where there is a natural regression in the total land area (e.g. the loss of land due to erosion by the sea).

Reappraisals can be upward or downward and reflect changes due to the use of updated information that permits a reassessment of the size of the area of different land covers. For example, new satellite imagery or interpretation of satellite imagery. The use of updated information may require the revision of previous estimates to ensure a continuity of time series.

A starting point for the general approach in Table 2 is the land cover change matrix. For example, managed expansion can be derived from the changes in land cover related to urban growth and development of infrastructure (through conversion of crops or tree covered area), intensification and industrialisation of agriculture (through conversion of family farming and mosaic landscapes), extension of agriculture in general (through conversion of tree covered land), drainage of regularly flooded areas (wetlands) for crops or artificial surfaces (urban land), and deforestation (of tree covered areas for timber production or agriculture development). Relating land cover and land use is particularly important. The relationship of land cover to land use and can be highlighted by preparing accounts showing, land cover by land use. If this is done for several points in time, then changes between two points in time can be highlighted. Such change accounts would, for example, show the extent to which forest area (a land cover) that is used for the maintenance and restoration of environmental functions (a land use) is changing.

Further extensions to land accounts can relate to the spatial disaggregation of data contained in other accounts of the SEEA Central Framework as well as to the SEEA Experimental Ecosystem Accounting.

The accounts described in the SEEA Central Framework largely relate to specific materials, substances and resources, and the various stocks and flows are accounted for a country as a whole. However, all materials, substances and resources are found in particular locations and, from a policy perspective, knowledge of the location of various stocks and flows may be of particular relevance. Thus, knowledge of the locations of depleted fish stocks, or places of high emissions to water bodies, will be of greater use than knowledge of the total stocks or flows for the country as a whole. Indeed, national averages usually hide important local variations and spatially disaggregating data can help to better identify environmental pressure points.

The potential of combining geospatial analysis with the data contained in SEEA style accounts are demonstrated by two examples. These examples work within the general framework provided and show measures of and changes in stocks of land in terms of areas of land use and cover. The accounts may also be structured to consider land in terms of ownership by economic units, for example by industry or institutional sector. It should be recognised that the completion of geospatial analysis requires strong underlying information systems. A description of the systems, methodologies and best practices in GIS is beyond the scope of the SEEA Central Framework and this note, but this type of information can be found elsewhere[4].

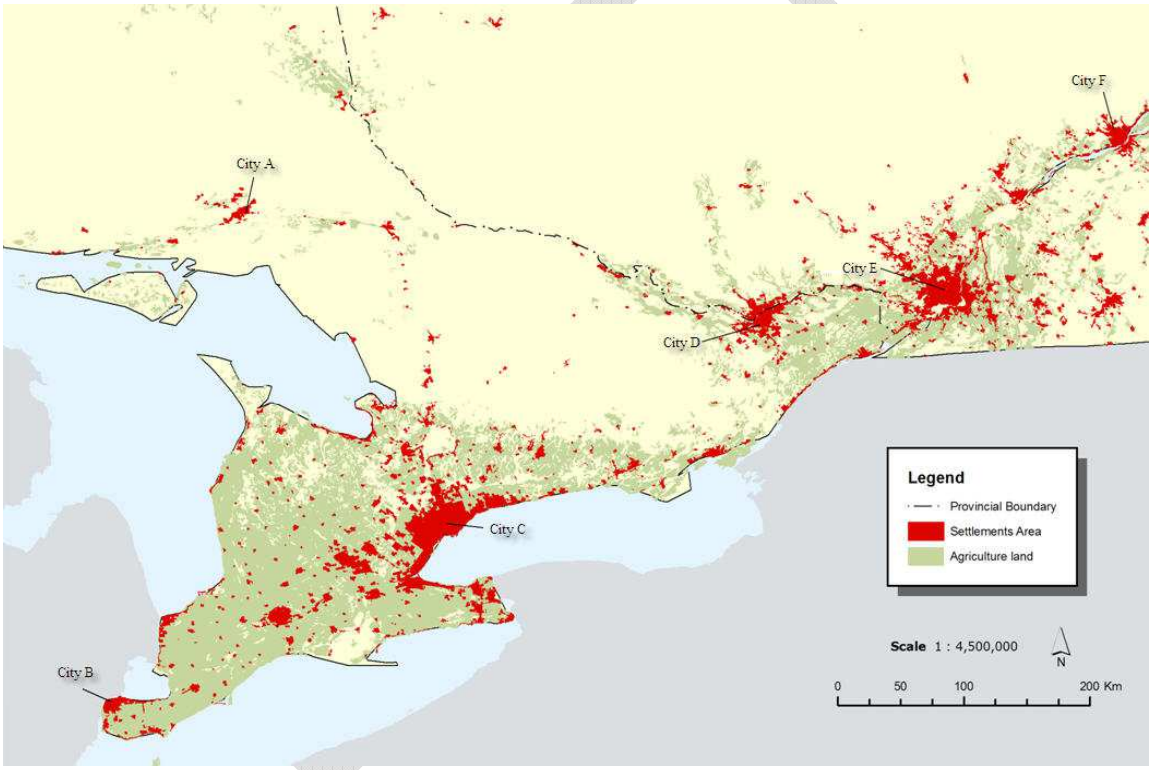
Two relatively simple examples of spatially attributed information are presented in Figures 1 and 2. A focus on the use of specific spatial areas enables a stronger, joint consideration of social, economic and environmental implications of various policy choices and options. The expansion in the use of land for housing, for example, requires in turn infrastructure such as roads, sewers, and water

[4] For example, see the text books of de Simth et al (2013) or Tomlinson (2005) and a range of on-line information. For example the websites of ESRI, ESA, Geoscience Australia, NASA, and USGS

supply lines and at the same time can lead to encroachment into high quality agricultural land. Potential environmental impacts include loss of wildlife habitat, increased air pollution and greenhouse gas emissions, and the contamination of rivers, lakes and aquifers. The type or form of expansion may also be significant. For example, is the expansion relatively high or low density in terms of changes in human population?

Figure 1 shows a simple presentation of human settlements and agricultural land (Statistics Canada 2010). In this, settlements were defined as tracts of land where humans have altered the physical environment, while dependable agricultural land is land free of severe constraints to crop production. The methodology used to create this map also provides a more detailed, harmonised and comparable suite of data that enables a more complete analysis of settlements and formed the basis for the development of indicators that can be used to track land cover and land use change (Filoso 2011).

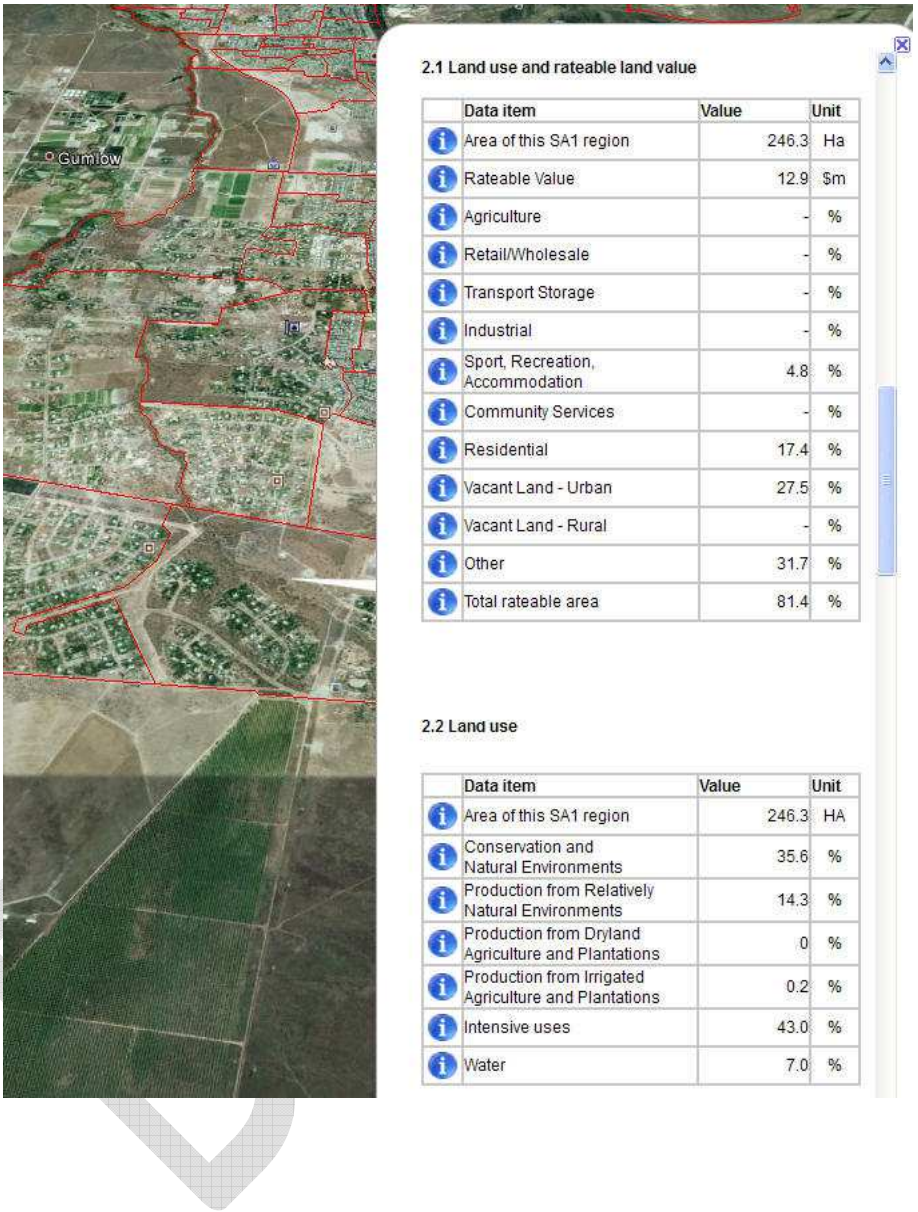
Figure 1. Map of settlements and dependable agricultural land



The second example concerns the presentation of basic environmental and economic information over a large coastal area in Australia (ABS 2011). By carefully defining the spatial areas, and through attribution of various data sources to these areas; a rich dataset was constructed. The types of information included population, land use, land ownership, land values, vegetation cover, forest extent and change, water consumption, agricultural production (physical and monetary terms), land management practices (such as use of fertiliser, irrigation) and topographical features (e.g. elevation and slope). The integration of socio-economic data and environmental data is a particular feature of this dataset and enables the investigation of a broad range of issues. These data can be presented in

tables and maps[5]. Figure 2 shows a map to which a small selection of data has been overlaid for each spatially defined area.

Figure 2. Map of Statistical Local Area



5. Compilation

The compilation of land accounts involves the integration of information from a variety of sources. While multiple data sources can present problems, it is often easier to produce land accounts than some of the other accounts of the SEEA Central Framework. This is because there is often national or international information available on land cover, typically derived from remote sensing, as well as information on agriculture — a major use of land — available from Agricultural Surveys or Censuses.

[5] ABS 2011. *Land Account: Great Barrier Reef Region, Experimental Estimates* (cat. No. 4609.0.55.001)

The integration and arrangement of this information requires expert skills and knowledge of GIS in addition to statistical skills and knowledge of accounts and information about land. A prerequisite to the production of land accounts is GIS information technology.

Following the decision to produce land accounts and the allocation of resources for this, a general process for the compilation of land accounts may be followed. This is described below as 10 components, however, the components are not strictly sequential. For example, components 4 and 5 could occur concurrently. The 10 components are:

1. Define the area or areas of interest (e.g. a country as whole or particular areas within a country or spanning countries and determine the particular accounts of interest (e.g. land cover or land use) and other information wanted to be linked (e.g. agricultural production, population, economic statistics)
2. Identify potential data sources and assess their suitability for accounts (considering, spatial and temporal coverage, classifications used, frequency of production, accuracy and ease of access of data). In this, the metadata associated with the data sources should be closely examined.
3. Secure access to data, including metadata and the rights to make available the accounts that are derived from that data
4. Import data and prepare data for analysis. This includes ensuring a common format, especially for projection (for area calculations this requires an equal area projection). If needed prepare concordances between the classifications used in the imported data (which should be articulated in the metadata associated with the important data) and the classifications outline in the SEEA
5. Identify the basic statistical units (i.e. common geographic building blocks) used in the data sets and determine and then link to appropriate output areas using GIS
6. Analyse data, including data quality, and align the classifications to classifications used in the SEEA Central Framework, and develop methodologies
7. Prepare draft tables and graphic representations of data (especially maps) and validate.
8. Disseminate accounts, including material to assist interpretation such as indicators, methodological notes and statements of data quality
9. Archive data and related methodological and other documentation
10. Review accounts, actively seeking user feedback

While data sources for particular countries will vary, data are typically available from government agencies concerned with: agriculture; forestry; fishing; environment; geological survey; urban planning and land administration. Statistical offices may also have data on agricultural, or natural resource management more generally, based on mail-out/mail back surveys. The operators of satellites, such as the European Space Agency (ESA) and National Aeronautics Space Administration (NASA), international agencies such as the Food and Agricultural Organisation (FAO) as well as

conservation organisation (ARIES) also provide information on land cover, land use and other data related to land.

In developing land accounts a particular need is to understand the means by which the underlying data on land cover and land use are collected. Broadly, two methods are used – field surveys and satellite images. Field surveys are important as they can provide a high level of specificity regarding the land cover and, in particular, the land use in a given area. Satellite images are important as they enable a broader assessment of all areas in a country and new forms of analysis, and as higher resolution images become available permit more detailed analyses.. Increasingly, data based on combinations of field surveys and satellite images are being compiled. The classifications and accounting structures of SEEA are defined and described independently of the means by which data are collected. However, in practice, the type of data and the level of detail that can be compiled may depend on the means by which data have been collected.

In some cases, the data may be collected and compiled so that the location of the data is known. For example, data may be attributed to a particular point (e.g. via coordinates of latitude and longitude) or in reference to small areas, such as grid cells (e.g. 100m x 100m), land parcels (e.g. the areas of land defined by land ownership as identified in land title registers) or small areas defined by particular administrative or data collection requirements (e.g. census collection districts).

When considering the key data to be used for land accounting, scale, resolution and accuracy are important. However it is essential that data sets that are well established and likely to be produced and updated on an ongoing basis are used. This will enable repeated reporting of change over time. In some instances it may be necessary to forego quality in favour of continuity.

A particular challenge in geospatial analysis is combining information from various sources according to a common geographical classification.[6] For this purpose it is necessary to delineate (or mark out) a set of relatively small spatial areas (essentially building blocks). Information is then attributed to these spatial areas. A common difficulty is that observations for different types of data may not all be able to be easily attributed to the same level of spatial area.

When multiple sets of information are attributed to particular places, the power of geospatial analysis increases. Also, where information can be organised to the same spatial areas in a time series, geospatial analysis allows the change over time to be examined in a way that is not possible through analysis of standard accounts and tables.

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[6] A specific geographic classification is not described in the SEEA Central Framework. However, related classifications on land use and land cover are discussed in Chapter 5 and SEEA Experimental Ecosystem Accounting discusses the measurement issues in more detail.

7. References and links

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