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Land Accounting

System of Environmental-Economic Accounting Central Framework (SEEA-CF)

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Overview: Land Accounting

- Learning objectives
- Review of Level 0 (5m)
- Level 1 (Compilers)
  - Concepts (15m)
  - Group exercise & Discussion (30m)
- Level 2 (Data providers)
  - Data options, examples & issues (15m)
  - Group exercise & Discussion (15m)
- Closing Discussion (10m)

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SEEA-CF Training Levels 1 and 2

- Learning objectives
  - Level 1
    - Understand the basic concepts of the Land Account
    - Learn the steps of compiling an Land Account
  - Level 2
    - Be familiar with some important conceptual issues
    - Understand the data options and sources
    - Be aware of how other countries have approached measuring land

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Environment accounts and statistics

SEEA-CF (Central Framework)	• **Assets** • **Physical flows** • **Monetary flows**	• Minerals & Energy, Land, Timber, Soil, Water, Aquatic, Other Biological • Materials, Energy, Water, Emissions, Effluents, Wastes • Protection expenditures, taxes & subsidies
SEEA Water; SEEA Energy; SEEA Agriculture, Forestry and Fisheries	Add sector detail	As above for • Water • Energy • Agricultural, Forestry and Fisheries
SEEA-EEA (Experimental Ecosystem Accounting)	Adds spatial detail and ecosystem perspective	Extent, Condition, Ecosystem Services, Carbon, Water, Biodiversity
FDES (Framework for the Development of Environment Statistics)	Basic statistics for above plus…	• Extreme events and disasters • Human settlements and health • Protection, management & engagement

Review: Land Accounting

What?

- *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.* (SEEA-CF Sections 5.62, p. 174)
- **National**
  - Land cover (terrestrial, freshwater, coastal and marine areas)
  - Land use, ownership (optional)
- Inter-institutional **agreement** on what exists on national land and water

Why?

- Spatial foundation for all national administrative data and policies
- Land & resource management, conservation policies, land tenure
- Links to SEEA-CF (Forest, Soil); SEEA-Agriculture, Fisheries & Forests
- Foundation for SEEA-EEA (Ecosystem Accounting)
- Indicators:
  - Land cover change → where are changes occurring?
  - Land cover by land use → who manages it?

Review: Land Accounting

Land accounts support many SDGs

Table	Use land accounts to	To address SDG	Indicators
Land cover & change	Distinguish urban/rural	Goal 1: No poverty	1.1.1 Poverty (by urban rural)
		Goal 4: Quality education	(11 indicators by location)
	Distinguish freshwater areas	Goal 6: Clean water and sanitation	(11 indicators by location)
		Goal 9: Industry, innovation and infrastructure	9.1.1 Rural population with access to all-season road
	Provide detail within urban	Goal 11: Sustainable cities and communities	11.1.1 Urban population living in slums
			11.3.1 Land consumption rate
			11.7.1 Urban open space for public use
	Distinguish catchment areas	Goal 14: Life below water	14.1.1 Costal eutrophication and floating plastic
	Distinguish marine and coastal areas	Goal 14: Life below water	14.2.1 Ecosystem-based management of exclusive economic zones
	Distinguish forest area	Goal 15: Life on land	15.1.1 Forest area share of total land area
			15.2.1 Sustainable forest management
			15.2.2 Net permanent forest loss
	Distinguish degraded land	Goal 15: Life on land	15.3.1 Proportion of land that is degraded
	Distinguish mountain areas	Goal 15: Life on land	15.4.1 Sites for mountain biodiversity
			15.4.2 Mountain Green Cover Index

Review: Land Accounting

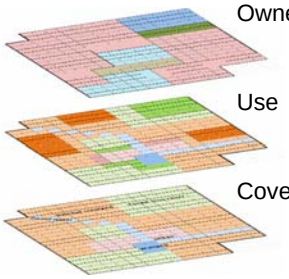
Land accounts support many SDGs

Table	Use land accounts to	To address SDG	Indicators
Land use	Distinguish agricultural areas	Goal 2: Zero hunger	2.3.2 Income of small-scale farmers
			2.4.1 Productive and sustainable agriculture
	Distinguish marine and coastal protected areas	Goal 14: Life below water	14.5.1 Protected marine areas
	Distinguish forestry area	Goal 15: Life on land	15.2.1 Sustainable forest management
Land ownership	Agree on land tenure (who owns?)	Goal 1: No poverty	1.4.2 Land tenure rights
		Goal 5: Gender equality	5.a.1 Rights over agricultural land

Review: Land Accounting

What does a Land Account look like?

Maps



Many data sources

Tables

Table 5.13
Physical account for land cover *(hectares)*

	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
Opening stock of resources	12 292.5	445 431.0	106 180.5	338 514.0	214.5	66 475.5	73.5	1 966.5		12 949.5	19 351.5
Additions to stock											
Managed expansion	183.0	9 357.0									
Natural expansion			64.5								1.5
Upward reappraisals			4.5								
Total additions to stock	183.0	9 357.0	69.0								1.5
Reductions in stock											
Managed regression		147.0	4 704.0	3 118.5	9.0	1 560.0	1.5				
Natural regression					1.5	64.5					
Downward reappraisals						4.5					
Total reductions in stock		147.0	4 704.0	3 118.5	10.5	1 629.0	1.5				
Closing stock	12 475.5	454 641.0	101 545.5	335 395.5	204.0	64 846.5	72.0	1 966.5		12 949.5	19 353.0

Note: Crops include herbaceous crops, woody crops, and multiple or layered crops.

Classifications

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Review: Land Accounting

What does a Land Account look like?

- An integrated spatial (GIS) database that overlays:
  - Land cover (including water)
  - Use and intensity of use (optional)
  - Ownership (optional)
- For two or more periods
- Based on comparable: classifications, quality and methods
- Units: hectares
- Output tables:

  Opening stock
  + Additions
  - Reductions
  = Closing stock

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Review: Land Accounting

What do you need to compile a Land Account?

- GIS platform: Software, protocols (e.g., standard projection)
- Classifications: Land cover, land use, ownership
- Land cover data
  - Satellite, aerial photography, field research
  - Hydrological, topographic (rivers, drainage areas, elevation, coastlines)
- Land use data (optional)
  - Agriculture, population census, administrative, forest inventories
- Ownership data (optional)
  - Cadastral (ownership, tenure, zoning, tax, price)
- Expertise
  - Land managers (forestry, agriculture, lands…),
  - Geographers (GIS, satellite imagery, integration)
  - Statisticians (classifications, accounts)

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Welcome to Level 1: Land Accounting

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Level 1: Land Accounting

- Basic spatial analysis concepts
  - Classifications
  - Thinking spatially: maps to data to accounts
  - Boundaries
  - Land cover change

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Level 1: Land Accounting

- Classifications = map legend

Land cover classification (SEEA-CF, Table 5.12, p.178; and Annex p. 299)

1 Artificial surfaces (including urban and associated areas)
2 Herbaceous crops
3 Woody crops
4 Multiple or layered crops
5 Grassland
6 Tree-covered areas
7 Mangroves
8 Shrub-covered areas
9 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

Crops

Swamps
Bogs…

Sparsely vegetated/barren

15 Marine

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Level 1: Land Accounting

- Classifications

Land use classification (SEEA-CF, Table 5.11, p. 176; and Annex 1 p. 289)

1. Land
1.1 Agriculture
1.2 Forestry
1.3 Land used for aquaculture
1.4 Use of built-up and related areas
1.5 Land used for maintenance and restoration of environmental functions
1.6 Other uses of land n.e.c.
1.7 Land not in use!
2. Inland waters
2.1 Inland waters used for aquaculture or holding facilities
2.2 Inland waters used for maintenance and restoration of environmental functions
2.3 Other uses of inland waters n.e.c.
2.4 Inland waters not in use!
3. Coastal waters…
4. Exclusive economic Zone (EEZ)…

1.1.1 Land under temporary crops
1.1.1.1 Cereals
…

Level 1: Land Accounting

- Classifications

Land ownership: (SEEA-CF p. 178)

By institutional sector (e.g. corporations, general government, households, NPISH)

OR

By industry/activity (e.g. mining, forestry, agriculture, manufacturing, services…)

Level 1: Land Accounting

- Thinking spatially: Maps to data to accounts

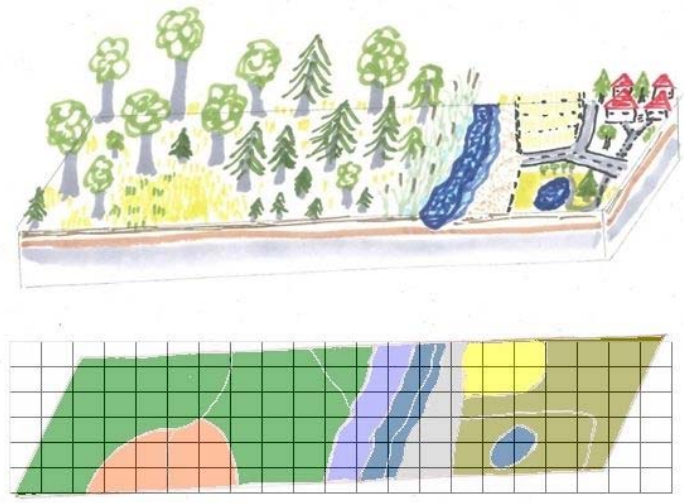
What you see…

- Many kinds of "Tree covered areas"
- Many kinds of "Artificial Surfaces"

Is simplified into classes… (vector)

Level 1: Land Accounting

- Thinking spatially: Maps to data to accounts



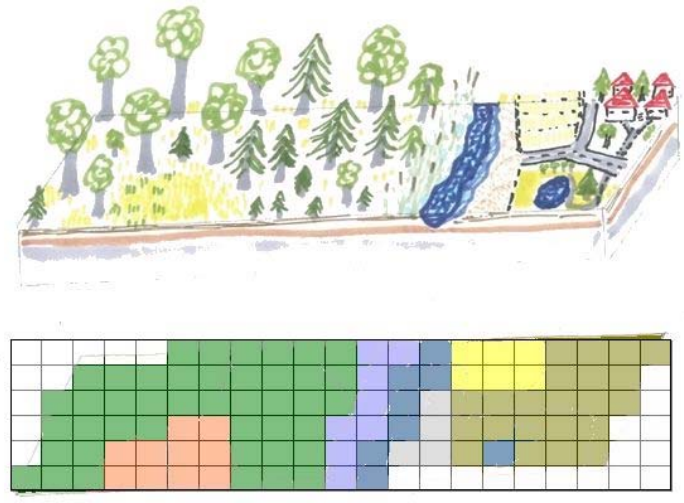
What you see…

and generalized to a grid (raster)

	LEGEND
	Artificial Surfaces
	Crops
	Grassland
	Tree covered areas
	Regularly flooded
	Inland waters
	Barren land

Level 1: Land Accounting

- Thinking spatially: Maps to data to accounts



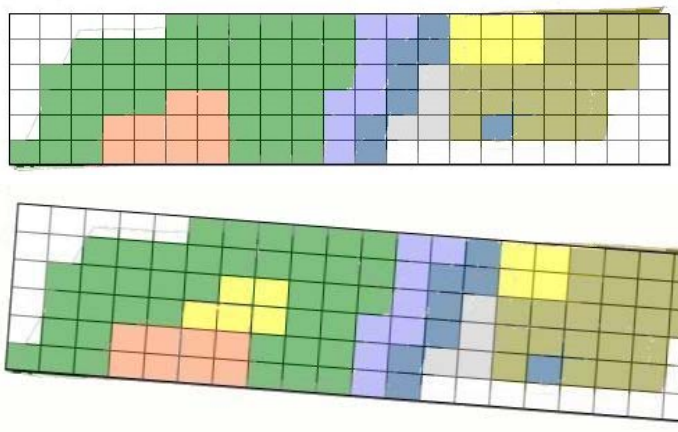
What you see…

…where cell value is "predominant" land cover type

	LEGEND
	Artificial Surfaces
	Crops
	Grassland
	Tree covered areas
	Regularly flooded
	Inland waters
	Barren land

Level 1: Land Accounting

- Boundaries…



…don't always match because of different:

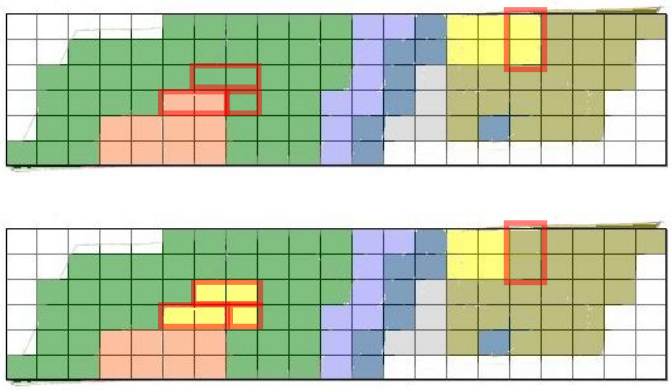
- projections
- scales
- sources
- methods

and need some adjustment before overlaying

Level 1: Land Accounting

- Land cover change

2ha Crops to artificial



Now we can compare the two!

What has changed?

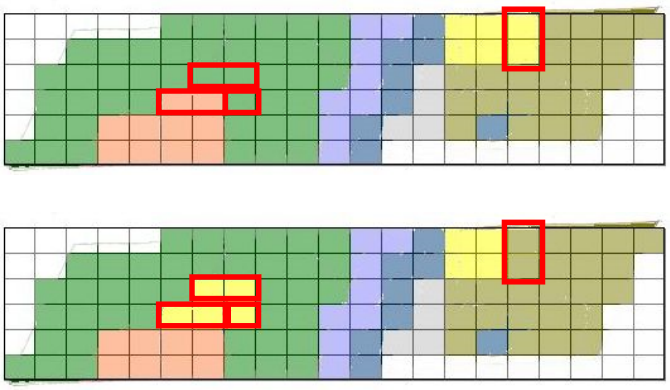
	LEGEND
	Artificial Surfaces
	Crops
	Grassland
	Tree covered areas
	Regularly flooded
	Inland waters
	Barren land

2ha Grassland to crops

3ha Tree covered to crops

Level 1: Land Accounting

2ha Crops to artificial



2ha Grassland to crops

3ha Tree covered to crops

	LEGEND
	Artificial Surfaces
	Crops
	Grassland
	Tree covered areas
	Regularly flooded
	Inland waters
	Barren land

Level 1: Land Accounting

- Land cover change matrix

Opening balance

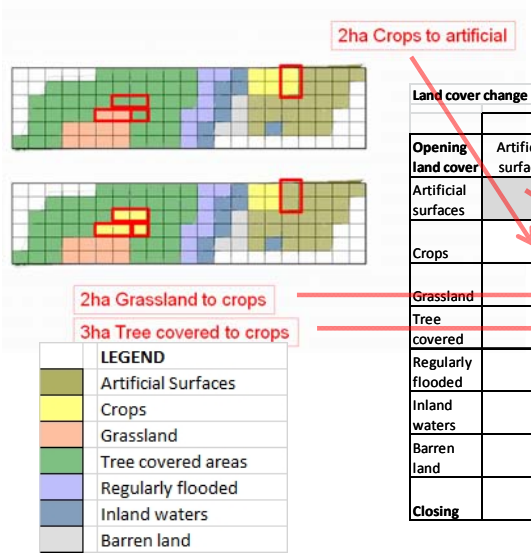
Land cover change matrix

	Closing land cover							
Opening land cover	Artificial surfaces	Crops	Grass-land	Tree covered	Regularly flooded	Inland waters	Barren land	**Opening**
Artificial surfaces								
Crops								
Grassland								
Tree covered								
Regularly flooded								
Inland waters								
Barren land								
Closing								101

Closing balance

Level 1: Land Accounting

- Land cover change matrix



No change

Land cover change matrix

	Closing land cover							
Opening land cover	Artificial surfaces	Crops	Grass-land	Tree covered	Regularly flooded	Inland waters	Barren land	**Opening**
Artificial surfaces								22
Crops								6
Grassland								10
Tree covered								43
Regularly flooded								8
Inland waters								8
Barren land								4
Closing	24	9	8	40	8	8	4	101

Level 1: Land Accounting

- Physical account for land cover

Land cover change matrix

	Closing land cover								
Opening land cover	Artificial surfaces	Crops	Grass-land	Tree covered	Regularly flooded	Inland waters	Barren land	**Opening**	**Reductions**
Artificial surfaces	22							22	0
Crops	2	4						6	2
Grassland		2	8					10	2
Tree covered		3		40				43	3
Regularly flooded					8			8	0
Inland waters						8		8	0
Barren land							4	4	0
Closing	24	9	8	40	8	8	4	101	
Additions	2	5	0	0	0	0	0		

Crops:
Closing = Opening +add -red
9 = 6 + 5 - 2

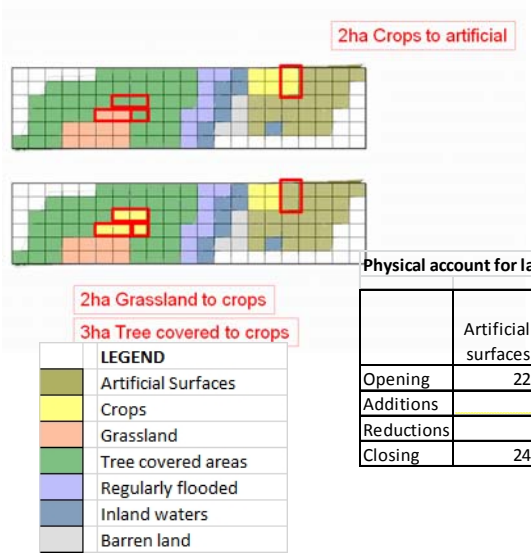
Level 1: Land Accounting

- Physical account for land cover

Artificial surfaces +2
Crops -2

Grassland -2
Crops +2

Tree covered -3
Crops +3



Physical account for land cover

	Artificial surfaces	Crops	Grass-land	Tree covered	Regularly flooded	Inland waters	Barren land	**Total**
Opening	22	6	10	43	8	8	4	101
Additions		2 + 3 = 5						
Reductions								
Closing	24	9	8	40	8	8	4	101

Gross additions and reductions

Level 1: Land Accounting

- Compilation **Group Exercise** (30m)
  - Situation:
    - Land cover units defined for two periods (Opening and Closing)
    - Need to calculate:
      - Land Cover **Opening** and **Closing** stocks,
      - Land Cover **Change** matrix
      - **Physical Account for Land Cover**
  - Objective (Groups of 3-5; Not alone!):
    1. Transfer Land Cover from map to Land Cover Table
    2. Calculate Land Cover Change Matrix
    3. Calculate Physical Account for Land Cover
    4. Report and discuss results

Level 1: Land Accounting

Group Exercise: Step 1 – Calculate opening and closing stocks

Opening land cover stock

M	M	C	A	A
R	R	C	C	A
R	R	C	C	C
T	T	T	T	T
T	T	T	T	T

Closing land cover stock

M	C	C	A	A
R	C	C	A	A
R	R	C	C	A
T	T	C	C	T
T	T	T	T	T

Land Cover Table

Code	Land cover	Opening stock
A	Artificial Surfaces	
C	Crop	
M	Mangrove	
T	Tree covered	
R	Regularly flooded	
Total		**25**

Code	Land cover	Closing stock
A	Artificial Surfaces	
C	Crop	
M	Mangrove	
T	Tree covered	
R	Regularly flooded	
Total		**25**

Level 1: Land accounting

Group Exercise: Step 2a – Record opening and closing stock

Land Cover Table

Code	Land cover	Opening stock
A	Artificial Surfaces	
C	Crop	
M	Mangrove	
T	Tree covered	
R	Regularly flooded	
Total		**25**

Code	Land cover	Closing stock
A	Artificial Surfaces	
C	Crop	
M	Mangrove	
T	Tree covered	
R	Regularly flooded	
Total		**25**

Land Cover Change Matrix

Opening land cover	Closing land cover					Opening Stock
	A	C	M	T	R	
A						
C						
M						
T						
R						
Closing Stock						25

MB24

Level 1: Land Accounting

Group Exercise: Step 2b – Calculate Land Cover Change

Opening land cover stock

M	M	C	A	A
R	R	C	C	A
R	R	C	C	C
T	T	T	T	T
T	T	T	T	T

Compare each corresponding cell.

Count cells that didn't change.

Count cells that changed (to what).

Closing land cover stock

M	C	C	A	A
R	C	C	A	A
R	R	C	C	A
T	T	C	C	T
T	T	T	T	T

Artificial:
3 = no change
2 = new from C

Land Cover Change Matrix

Opening land cover	Closing land cover A	C	M	T	R	Opening Stock
A	3					3
C	2					
M						
T						
R						
Closing Stock	5					25

Record "No change" in diagonal
Rows = No change + Reductions
Columns = No change + Additions

Slide 29

MB24 Simplify to 4x4
Michael Bordt, 17/10/2016

Level 1: Land Accounting

Group Exercise: Step 3 – Calculate Physical Land Cover

Land Cover Change Matrix

Opening land cover	Closing land cover					Opening Stock
	A	C	M	T	R	
A						
C						
M						
T						
R						
Closing Stock						25

Additions to (C) Crops

Reductions from (C) Crops

Physical Land Cover Account

Physical land cover account (ha)

	A	C	M	T	R	Total
Opening stock						25
Additions						
Reductions						
Closing stock						25

Gross additions
Gross reductions

Level 1: Land Accounting

- Is everyone clear on the objectives?
- 30 minutes **group** work
- Please ask questions!
- Results:
  - Each group report:
    - Additions to Stock
    - Reductions in Stock
    - What were the largest sources of change?

Physical land cover account (ha)

	A	C	M	T	R	Total
Opening stock						25
Additions						
Reductions						
Closing stock						25

Level 1: Land Accounting

The answers:

Land Cover Change Matrix

- Rows add to Opening
- Columns add to Closing

Physical Account for Land Cover

- Gross additions
- Gross reductions

Major source of change

- 4 ha crops added

Land cover change matrix (ha)

Opening land cover	Closing land cover					Opening Stock
	A	C	M	T	R	
A	3	-	-	-	-	3
C	2	4	-	-	-	6
M	-	1	1	-	-	2
T	-	2	-	8	-	10
R	-	1	-	-	3	4
Closing Stock	5	8	1	8	3	25

Physical land cover account (ha)

	A	C	M	T	R	Total
Opening stock	3	6	2	10	4	25
Additions	2	4	-	-	-	6
Reductions	-	2	1	2	1	6
Closing stock	5	8	1	8	3	25

Welcome to Level 2: Land Accounting

Level 2: Land Accounting

- **Learning objectives (Level 2)**
  - Review how Land Accounts are represented in the SEEA-CF
  - Understand some important conceptual issues
  - Understand the data options and sources
  - Be aware of how other countries have approached Land Accounting

Level 2: Land Accounting

- Land accounts in the SEEA-CF
  - Definitions of Land Cover
  - Table 5.13 Physical account for land cover (hectares)
  - Table 5.14 Land cover change matrix (hectares)

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Level 2: Land Accounting

- Description of land cover classes (p. 300)

01	**Artificial surfaces (including urban and associated areas)**
	The class is composed of any type of areas with a predominant artificial surface. Any urban or related feature is included in this class, for example, urban parks (parks, parkland and laws). The class also includes industrial areas, and waste dump deposit and extraction sites.
02	**Herbaceous crops**
	The class is composed of a main layer of cultivated herbaceous plants (graminoids or forbs). It includes herbaceous crops used for hay. All the non-perennial crops that do not last for more than two growing seasons and crops like sugar cane, where the upper part of the plant is regularly harvested while the root system can remain for more than one year in the field, are included in this class.
03	**Woody crops**
	The class is composed of a main layer of permanent crops (trees or shrub crops) and includes all types of orchards and plantations (fruit trees, coffee and tea plantation, oil palms, rubber plantation, Christmas trees, etc.).
04	**Multiple or layered crops**
	This class combine two different land cover situations: *Two layers of different crops.* A common case is the presence of one layer of woody crops (trees or shrubs) and another layer of herbaceous crop, e.g., wheat fields with olive trees in the Mediterranean area and intense horticulture, or oasis or typical coastal agriculture in Africa, where herbaceous fields are covered by palm trees. *Presence of one important layer of natural vegetation (mainly trees) that covers one layer of cultivated crops.* Coffee plantations shadowed by natural trees in the equatorial area of Africa are a typical example.

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Level 2: Land Accounting

- Description of land cover classes (p. 300)

05	**Grassland**
	This class includes any geographical area dominated by natural herbaceous plants (grasslands, prairies, steppes and savannahs) with a cover of 10 per cent or more, irrespective of different human and/or animal activities, such as grazing or selective fire management. Woody plants (trees and/or shrubs) can be present, assuming their cover is less that 10 per cent.
06	**Tree-covered areas**
	This class includes any geographical area dominated by natural tree plants with a cover of 10 per cent or more. Other types of plants (shrubs and/or herbs) can be present, even with a density higher than that of trees. Areas planted with trees for afforestation purposes and forest plantations are included in this class. This class includes areas seasonally or permanently flooded with freshwater. It excludes coastal mangroves (→07).
07	**Mangroves**
	This class includes any geographical area dominated by woody vegetation (trees and/or shrubs) with a cover of 10 per cent or more that is permanently or regularly flooded by salt and/or brackish water located in the coastal areas or in the deltas of rivers.
08	**Shrub-covered areas**
	This class includes any geographical area dominated by natural shrubs having a cover of 10 per cent or more. Trees can be present in scattered form if their cover is less than 10 per cent. Herbaceous plants can also be present at any density. The class includes shrub-covered areas permanently or regularly flooded by inland fresh water. It excludes shrubs flooded by salt or brackish water in coastal areas (→07).

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Level 2: Land Accounting

- Description of land cover classes (p. 300)

09	**Shrubs and/or herbaceous vegetation, aquatic or regularly flooded**
	This class includes any geographical area dominated by natural herbaceous vegetation (cover of 10 per cent or more) that is permanently or regularly flooded by fresh or brackish water (swamps, marsh areas, etc.). Flooding must persist for at least two months per year to be considered regular. Woody vegetation (trees and/or shrubs) can be present if their cover is less than 10 per cent.
10	**Sparsely natural vegetated areas**
	This class includes any geographical areas were the cover of natural vegetation is between 2 per cent and 10 per cent. This includes permanently or regularly flooded areas.
11	**Terrestrial barren land**
	This class includes any geographical area dominated by natural abiotic surfaces (bare soil, sand, rocks, etc.) where the natural vegetation is absent or almost absent (covers less than 2 per cent). The class includes areas regularly flooded by inland water (lake shores, river banks, salt flats, etc.). It excludes coastal areas affected by the tidal movement of saltwater (→14).

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Level 2: Land Accounting

- Description of land cover classes (p. 300)

12	**Permanent snow and glaciers**
	This class includes any geographical area covered by snow or glaciers persistently for 10 months or more.
13	**Inland water bodies**
	This class includes any geographical area covered for most of the year by inland water bodies. In some cases, the water can be frozen for part of the year (less than 10 months). Because the geographical extent of water bodies can change, boundaries must be set consistently with those set by class 11, according to the dominant situation during the year and/or across multiple years.
14	**Coastal water bodies and intertidal areas**
	The class is defined on the basis of geographical features of the land in relation to the sea (coastal water bodies, i.e., lagoons and estuaries) and abiotic surfaces subject to water persistence (intertidal areas, i.e., coastal flats and coral reefs).

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Level 2: Land Accounting

Table 5.13
Physical account for land cover (*hectares*)

	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
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Downward reappraisals						4.5					
Total reductions in stock		147.0	4 704.0	3 118.5	10.5	1 629.0	1.5				
Closing stock	12 475.5	454 641.0	101 545.5	335 395.5	204.0	64 846.5	72.0	1 966.5		12 949.5	19 353.0

Note: Crops include herbaceous crops, woody crops, and multiple or layered crops.

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- Scope and definitions (Table 5.13)
  - Scope: The land area, inland waters & coastal areas of a country
  - **Managed expansion/regression**: a change in the area of a land cover type due to human activity. [matching entry]
  - **Natural expansion/regression**: a change in area resulting from natural processes. [matching entry]
  - A matching entry is not recorded if there is a change in the total land area.
  - **Reappraisals (upward or downward)**: changes due to updated information on the area of different land covers.

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Level 2: Land Accounting

Table 5.14
Land cover change matrix (*hectares*)

Land cover	Opening area	Increases (positive numbers) and decreases (negative numbers) from other land covers											Net change (increase-decrease)	Closing area
		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 intertidal areas		
Artificial surfaces	12 292.5		147.0	27.0		9.0							183.0	12 475.5
Crops	445 431.0	-147.0		4 677.0	3 118.5		1 560.0	1.5					9 210.0	454 641.0
Grassland	106 180.5	- 27.0	- 4 677.0				69.0						- 4 635.0	101 545.5
Tree-covered area	338 514.0		- 3 118.5										- 3 118.5	335 395.5
Mangroves	214.5	-9.0										-1.5	-10.5	204.0
Shrub-covered area	66 475.5		-1 560.0	-69.0									-1 629.0	64 846.5
Regularly flooded areas	73.5		-1.5										-1.5	72.0
Sparse natural vegetated areas	1 966.5													1 966.5
Terrestrial barren land														
Permanent snow, glaciers and inland water bodies	12 949.5													12 949.5
Coastal water and intertidal areas	19 351.5					1.5							1.5	19 353.0

Note: Including herbaceous crops, woody crops and multiple or layered crops.

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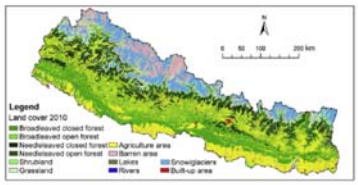
Level 2: Land Accounting

- **What are "comparable" classes?**
  - Land cover change analysis requires "comparable" maps for two or more periods
  - Comparing different sources (scales, projections, classifications, methods…) can be done with:
    - Re-scaling, re-projecting
    - Re-classification (e.g., collapse classes)
  - Need to understand differences and assumptions
    - Detailed metadata are important!

Level 2: Land Accounting



- **What are "comparable" classes?**
- From Uddin et. al (2014)
  - Compared "global" sources (columns) with detailed **local** data for Nepal (rows)
  - 30-60% differences (e.g., grassland/agricultural)

→"Reality check" with local information is essential!

Comparison of land cover statistics for Nepal between present study and global study using Landsat TM data. The grey shade indicates, no change areas within respective class.

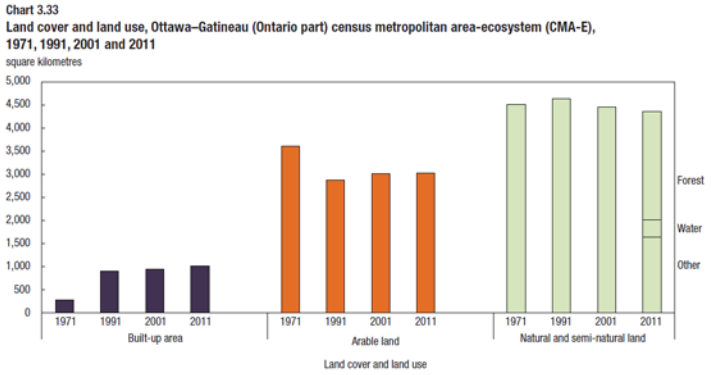
Land cover (km^2)	Forest	Shrubland	Grassland	Agriculture area	Barren area	Water	Snow/glaciers	Built-up area	Total (present study)	% (present study)
Forest	41,445	3913	3650	3164	1842	1325	11	2187	57,538	39.1
Shrubland	2252	279	879	173	372	695	57	301	5008	3.40
Grassland	1465	547	4388	158	3330	558	1156	32	11,634	7.90
Agriculture area	11,509	4524	10,137	7697	8441	236	1	1366	43,910	29.83
Barren area	436	164	1350	294	9239	1260	2913	22	15,678	10.65
Water	77	20	106	36	363	257	7	16	882	0.60
Snow/glaciers	77	32	439	2	3224	2069	6216	3	12,062	8.20
Built-up areas	56	18	116	79	197	1	0	2	469	0.32
Total (global study)	57,317	9497	21,065	11,603	27,008	6401	10,361	3929	147,181	100.00
% (global study)	38.94	6.45	14.31	7.88	18.35	4.35	7.04	2.67	100.00	

Landsat TM = Thematic Mapper

Level 2: Land Accounting

- **What are "comparable" classes?**
- From Statistics Canada (2016)
  - Collapsed 1971-2011 land cover to 3 classes

→ Less detail may make better comparisons



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Level 2: Land Accounting

- **What are "comparable" classes?**
  - INEGI (Mexico)
  - Five historical series: difficult to compare
  - Classification, scale, methods (corrections)

	SERIES I 1985	SERIES II 1993	SERIES III 2002	SERIES IV 2007	SERIES V 2011
Source	Aerial photos	Printed maps	LANDSAT TM (30m)	SPOT 5 (10 m)	LANDSAT (30 m)
					
Product	Digital Maps	Digital Maps	Integrated GIS	Integrated GIS	Integrated GIS
					

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Level 2: Land Accounting

- **Land cover or land use?**
  - **Land cover** is physical and biological **surface features**
    - Often mis-interpreted or combined with land use
    - e.g., forestry, agriculture, urban
  - **Land use** is social or economic **function**
    - "Forestry" lands may have no trees
    - "Agricultural" lands may have no crops
    - "Urban" areas may have large parks or grasslands
  - Resource departments (forestry, agriculture, environment) often record "designated use"
    → May not agree with land cover assessments
  - → Agree on land cover first!
  - → Compare with resource departments on "use"
  - → Will also help resolve "ownership" issues

Level 2: Land Accounting

- **More detail than land cover may be required**

- Remote sensing not always good at identifying:
  - Small features (e.g., streams)
  - Features underlying canopy (e.g., wetlands)
  - Difference between crops and grasslands (see Nepal)
  - Infrastructure (e.g., roads and transmission lines)
  - Elevations (e.g., mountain vs. valley) & slopes

→ Establish basic spatial database & incrementally improve it

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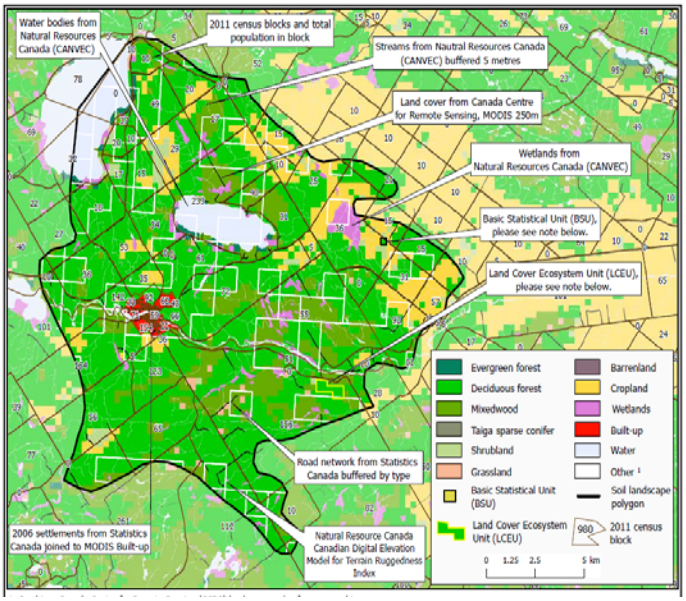
Level 2: Land Accounting



Statistics Canada (2013) MEGS (Measuring Ecosystem Goods and Services)

- Started with 250m MODIS Land Cover
- Added hydrological, topographic, population and road data.
- Created geospatial database to serve:

- Land accounts
- Ecosystem accounts

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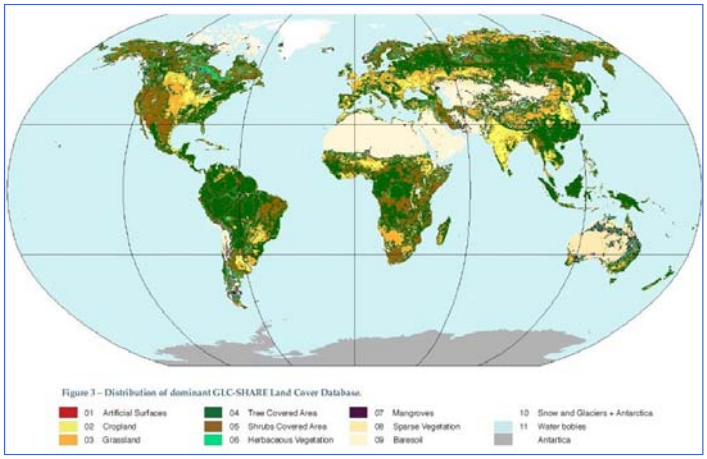
Level 2: Land Accounting

- **Global land cover datasets**
- FAO Global Land Cover-SHARE (1km)



The FAO product Global Land Cover-SHARE (year 2014 Beta-Release 1.0) is constructed using the best quality national and international data sources.

11 land cover classes were harmonized and reclassified according to the SEEA-CF land cover classification

http://www.glcn.org/databases/lc_glcshare_en.jsp

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Level 2: Land Accounting

- **Global land cover datasets**
- MODIS Land Cover
  - 'Land Cover Type Yearly L3' (version Q2 is the latest)
  - Annual products based on NASA's MODIS imagery
  - Available at 500m x 500m spatial resolution.
    - Land Cover Type 1: IGBP global vegetation classification scheme
    - Land Cover Type 2: University of Maryland (UMD) scheme
    - Land Cover Type 3: MODIS-derived LAI/fPAR scheme
    - Land Cover Type 4: MODIS-derived Net Primary Production (NPP) scheme
    - Land Cover Type 5: Plant Functional Type (PFT) scheme
  - Downloadable from http://reverb.echo.nasa.gov/

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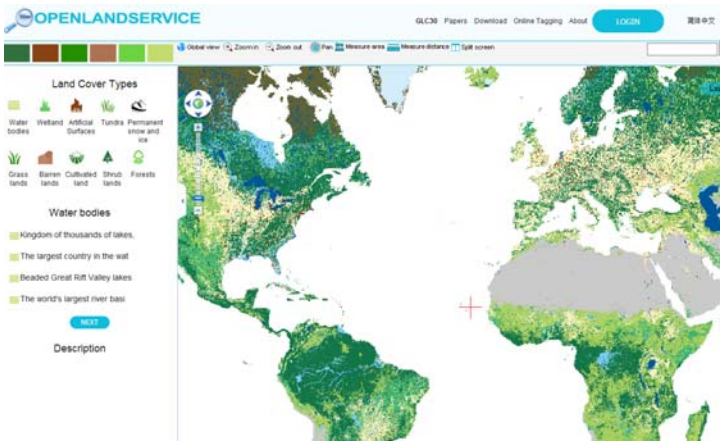
- **Global land cover datasets**

GlobeLand30



- High resolution (30m)
- Produced by China
- Years 2000 and 2010
- 10 land cover classes
- based on NASA Landsat satellite (freely available)

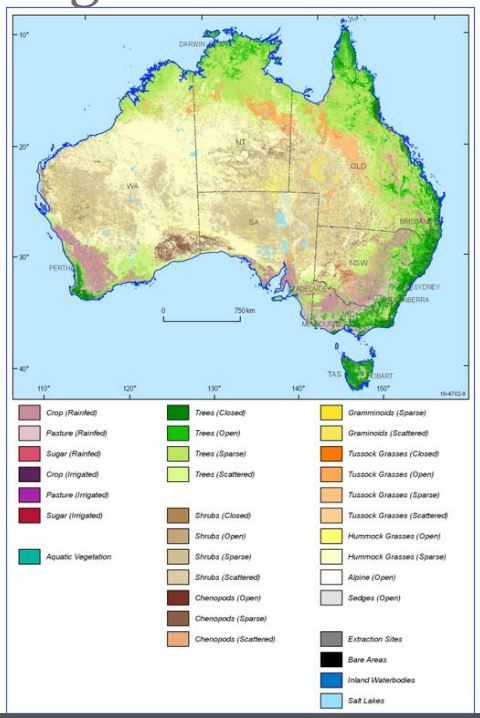
http://www.globallandcover.com/GLC30Download/index.aspx

Level 2: Land Accounting

- **Australia's Land Accounts (2000-2008)**
- MODIS 250m Land Cover, aggregating 25 classes to seven categories

Australian Dynamic Land Cover	AEEA presentation
Built Up Areas	Built Up Areas
Rainfed Cropping	Rainfed cropping and pasture
Rainfed Pasture	
Alpine Grasses - Open	Grasses and Sedges
Hummock Grasses - Open	
Sedges - Open	
Tussock Grasses - Open	
Hummock Grasses - Sparse	
Tussock Grasses - Sparse	
Trees - Closed	Trees
Trees - Open	
Trees - Scattered	
Trees - Sparse	
Irrigated Cropping	Irrigated cropping and pasture
Irrigated Pasture	
Shrubs - Closed	Shrubs
Shrubs - Open	
Chenopod Shrubs - Open	
Shrubs - Scattered	
Shrubs - Sparse	
Chenopod Shrubs - Sparse	
Extraction Sites	Other
Inland Water bodies	
Salt Lakes	
Wetlands	

National Dynamic Land Cover Dataset



Level 2: Land Accounting

- Related accounts
  - Table 5.15 Physical asset account for forest and other wooded land
  - Table 5.16 Monetary asset account for land (currency units)
  - Table 5.17 Physical asset account for area of soil resources (hectares)
  - Table 5.18 Physical asset account for volume of soil resources (cubic meters)
  - Table 5.19 Physical asset account for timber resources (thousands of cubic metres over bark)
  - Table 5.20 Monetary asset account for timber resources (currency units)

Level 2: Land Accounting

More detailed types

Data?
Land cover/use
Forest inventories

Table 5.15
Physical asset account for forest and other wooded land (*hectares*)

	Type of forest and other wooded land				
	Primary forest	Other naturally regenerated forest	Planted forest	Other wooded land	Total
Opening stock of forest and other wooded land	20	100	150	130	400
Additions to stock					
Afforestation		2	5		7
Natural expansion		3			3
Total additions to stock		5	5		10
Reductions in stock					
Deforestation	2	10		5	17
Natural regression				3	3
Total reductions in stock	2	10	0	8	20
Closing stock of forest and other wooded land	18	95	155	122	390

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Level 2: Land Accounting

Exchange value

Data?
Cadastral, tax (value)
Real estate transactions

Table 5.16
Monetary asset account for land (*currency units*)

	Type of land use								
	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 n.e.c.	Land not in use	Inland water	Total
Opening value of stock of land	420 000	187 500		386 000	2 000				995 500
Additions to stock									
Acquisitions of land	3 500								3 500
Reclassifications		200		2 500					2 700
Total additions to stock	3 500	200		2 500					6 200
Reductions in stock									
Disposals of land		3 500							3 500
Reclassifications		1 250			200				1 450
Total reductions in stock		4 750			200				4 950
Revaluations	18 250	15 350		65 000					98 600
Closing value of stock of land	441 750	198 300		453 500	1 800				1 095 350

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Level 2: Land Accounting

Soil classes

Data?
Soil inventories

Table 5.17
Physical asset account for area of soil resources (*hectares*)

	Type of soil resource	Total area
Opening stock of soil resources		
Additions to stock		
Due to changes in land cover		
Due to changes in soil quality		
Due to changes in soil environment		
Total additions to stock		
Reductions in stock		
Due to changes in land use		
Due to changes in soil quality		
Due to changes in soil environment		
Total reductions in stock		
Closing stock of soil resources		

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Level 2: Land Accounting

Soil classes, Land cover, Land use

Table 5.18
Physical asset account for volume of soil resources (*cubic metres*)

	Type of soil resource
Opening stock of soil resources	
Additions to stock	
Soil formation and deposition	
Upward reappraisals	
Reclassifications	
Total additions to stock	
Reductions in stock	
Extractions	
Soil erosion	
Catastrophic losses	
Downward reappraisals	
Reclassifications	
Total reductions in stock	
Closing stock of soil resources	

Data?
Soil inventories

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Level 2: Land Accounting

Volume of timber

Table 5.19
Physical asset account for timber resources (*thousands of cubic metres over bark*)

	Type of timber resource		
	Cultivated timber resources	Natural timber resources	
		Available for wood supply	Not available for wood supply
Opening stock of timber resources	8 400	8 000	1 600
Additions to stock			
Natural growth	1 200	1 100	20
Reclassifications	50	150	
Total additions to stock	1 250	1 250	20
Reductions in stock			
Removals	1 300	1 000	
Felling residues	170	120	
Natural losses	30	30	20
Catastrophic losses			
Reclassifications	150		150
Total reductions in stock	1 650	1 150	170
Closing stock of timber resources	8 000	8 100	1 450
Supplementary information			
Fellings	1 250	1 050	

Data?
Forest inventories
Model dynamics

Level 2: Land Accounting

Value of standing timber

Table 5.20
Monetary asset account for timber resources (*currency units*)

	Type of timber resource		
	Cultivated timber resources	Natural timber resources (available for wood supply)	Total
Opening stock of timber resources	86 549	82 428	168 977
Additions to stock			
Natural growth	12 364	11 334	23 698
Reclassification	515	1 546	2 061
Total additions to stock	12 879	12 879	25 759
Reductions in stock			
Removals	13 395	10 303	23 698
Felling residues	1 752	1 236	2 988
Natural losses	309	309	618
Catastrophic losses			
Reclassification	1 546		1 546
Total reductions in stock	17 001	11 849	28 850
Revaluations		16 692	16 692
Closing stock of timber resources	82 428	100 150	182 578

How to calculate?
$\frac{Vol\ Asset \times Value\ Removals}{Vol\ Removals}$

Where is Supply/use?

Materials PSUT

Level 2: Land Accounting

- Concepts: Group Exercise (15m) (Groups of 3-5)

1. What national data and classifications for Land Accounts are already available for your country?
2. If there are no national sources, what data could you use to create a Land Account?
3. What would be the priorities (Cover, Use, Ownership; Agreement on "One Map")?
4. Discuss and report your results

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Level 2: Land Accounting

- Concepts group Exercise

- Group reports:
  - National **data and classifications** for Land Accounts already available for your country
  - Alternative sources of data for Land Accounts?
  - Priorities for Land Accounting?
- Discussion
  - Who would need to participate in creating a pilot Land Account?

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Level 2: Land Accounting

- Take home points
  - Land Cover maps, classified by the SEEA-CF classification are a useful starting point for creating a Land Account
  - Data need to be national and comparable
  - Global data for Land Cover may be used if there is no national alternative
  - An interdepartmental team should agree on “One Map”

Level 2: Land Accounting

- Discussion and questions

Level 2: Land Accounting

- References

- Australian Bureau of Statistics, 2013. Land Account: Queensland, Experimental Estimates, 2013
- Geosciences Australia, nd. The National Dynamic Land Cover Dataset
- Statistics Canada, 2016. Human Activity and the Environment: The changing landscape of Canadian metropolitan areas 2016. 16-201-XWE. Ottawa: Government of Canada
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- Uddin, K., et al., Development of 2010 national land cover database for the Nepal, Journal of Environmental Management (2014), http://dx.doi.org/10.1016/j.jenvman.2014.07.047

- Further Information
  - SEEA Experimental Ecosystem Accounting (2012)
  - SEEA-EEA Technical Guidance (forthcoming)
    - Detailed supporting document on "Land Accounts and Ecosystem Extent" by UNSD

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      ESCAP Statistics Division
      bordt@un.org
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