System of Environmental Economic Accounting

Introduction to Land Cover and Use Accounts

Jessica Ying Chan

Environmental-Economic Accounts Section

United Nations Statistics Division

United Nations

Contents

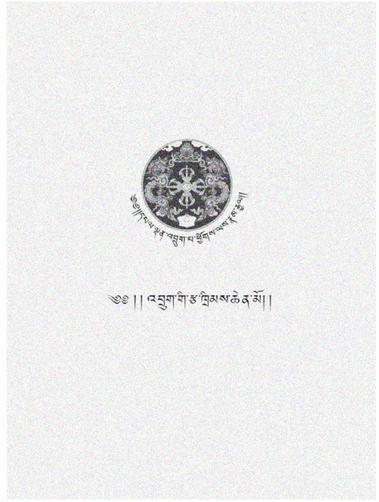
- Why account for land?
- Land accounts
- Practical steps in compilation
- Examples

Why account for land?

- Constitutional mandate in case of Bhutan!
- Answers wide range of policy questions→ from urban planning, to conservation and beyond
- Land accounts can inform multiple (inter)national initiatives
  - >Sustainable Development Goals, 15.3.1: Proportion of land that is degraded over total land area
  - >UNCCD
- Land cover accounts are the basis for ecosystem accounts—importance for Kunming-Montreal Global Biodiversity Framework
  - >E.g. Goal A: Integrity of all ecosystems is enhanced, increase in area of natural ecosystems

United Nations
Convention to Combat Desertification

Convention on Biological Diversity



UN CLIMATE CHANGE CONFERENCE UK 2021
IN PARTNERSHIP WITH ITALY

SUSTAINABLE DEVELOPMENT GOALS

15 LIFE ON LAND

SEEA

Land accounts

Land cover

- *The observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces*
- Current land cover is a function of natural changes in the environment and of previous and current land use
- Interim land cover classification based on FAO Land Cover Classification System
  - > International **reference** classification

	Category
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 inter-tidal areas

Sl.No	Land cover class
1	Snow and Glacier
2	Agriculture Land
3	Built up
4	Shrubs
5	Forests
6	Landslides
7	Water Bodies
8	Sandy Bank
9	Meadows
10	Non Built up
11	Moraines
12	Rocky Outcrops
13	Alpine Scrubs

Source: National Land Commission, Land Use Land Cover Assessment 2020

Land use

- 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*
- Accounts include land in use (human intervention) and land not in use
- Categories not defined on economic activity, but rather general purpose and role of the user of the area
  - > Often aligns with scope of economic activity, but not always
  - > If multiple uses, go with primary/dominant use

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
2.3	Other uses of inland waters n.e.c.
2.4	Inland waters not in use

Land account: basic form

	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

- Land cover
  - > Managed→ due to human activity
  - > Natural→ resulting from natural processes
  - > Reappraisals→ reflect changes due to use of updated information (e.g. new satellite imagery)

Land account: basic form

	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

- Land cover
  - > Managed→ due to human activity
  - > Natural→ resulting from natural processes
  - > Reappraisals→ reflect changes due to use of updated information (e.g. new satellite imagery)

Example South Africa

- Most countries only distinguish additions and reductions

Broad land cover classes (tier 1)	Natural or semi-natural	Cultivated	Built-up	Waterbodies*	TOTAL
Opening stock 1990	**100 710 016**	**16 156 026**	**3 003 883**	**2 096 528**	**121 966 453**
Additions to stock	3 366 559	1 991 959	597 238	288 754	6 244 510
Reductions in stock	2 540 175	2 339 226	400 503	964 606	6 244 510
Net change in stock	826 384	(347 267)	196 735	(675 852)	
Net change as % of opening	**0.8%**	**-2.1%**	**6.5%**	**-32.2%**	
Unchanged (opening - reductions)	98 169 841	13 816 800	2 603 380	1 131 922	
Unchanged as % of opening	97.5%	85.5%	86.7%	54.0%	
Turnover (additions + reductions)	5 906 734	4 331 185	997 741	1 253 360	
Turnover as % of opening	5.9%	26.8%	33.2%	59.8%	
Closing stock 2014	**101 536 400**	**15 808 759**	**3 200 618**	**1 420 676**	**121 966 453**

Source: Statistics South Africa 2020

Land account: change matrix

Land cover change matrix (hectares)

Opening land cover	Closing land cover					
	Artificial surfaces (urban)	Herbaceous crops	Grassland	Inland water bodies	Shrubs..regularly flooded (w	**Opening stock**
Artificial surfaces (urban)	20	0	0	0	0	**20**
Herbaceous crops	3	142	8	0	0	**153**
Tree-covered areas	0	2	88	0	0	**90**
Inland water bodies	0	0	0	19	0	**19**
Shrubs..regularly flooded (wetlan	0	1	0	0	5	**6**
Closing stock	**23**	**145**	**96**	**19**	**5**	**288**

Land account change matrix: example India

- Important to remember: these are NET changes/conversions!

Table 1: *Extent account for India's land use and land cover between 2011-12 and 2015-16*

Land use / land cover classes		2015-16							Grand total (2011-12)	
		Agriculture	**Barren / un-culturable**	**Built-up**	**Forest**	**Grass / grazing**	**Snow and glacier**	**Wetlands / water bodies**	**Area**	**% of geo-graphic area**
2011 -12	Agriculture	1,809,033	5,103	2,648	2,299	94	8	2,547	**1,821,732**	**55.41**
	Barren / unculturable	4,237	348,460	589	2,285	61	68,471	614	**424,717**	**12.92**
	Built-up	238	442	118,239	48	2	0	29	**118,998**	**3.62**
	Forest	5,085	6,838	205	712,342	207	637	230	**725,543**	**22.07**
	Grass / grazing	147	408	118	368	22,502	1,333	521	**25,397**	**0.77**
	Snow and glacier	0	1,643	0	131	7	30,799	1	**32,581**	**0.99**
	Wetlands / water bodies	2,536	966	49	155	679	77	133,833	**138,294**	**4.21**
Grand total (2015-16)	**Area**	**1,821,276**	**363,860**	**121,848**	**717,629**	**23,551**	**101,325**	**137,774**	**3,287,263**	**99.99**
	% of geo-graphic area	**55.40**	**11.07**	**3.71**	**21.83**	**0.72**	**3.08**	**4.19**	**99.99**	

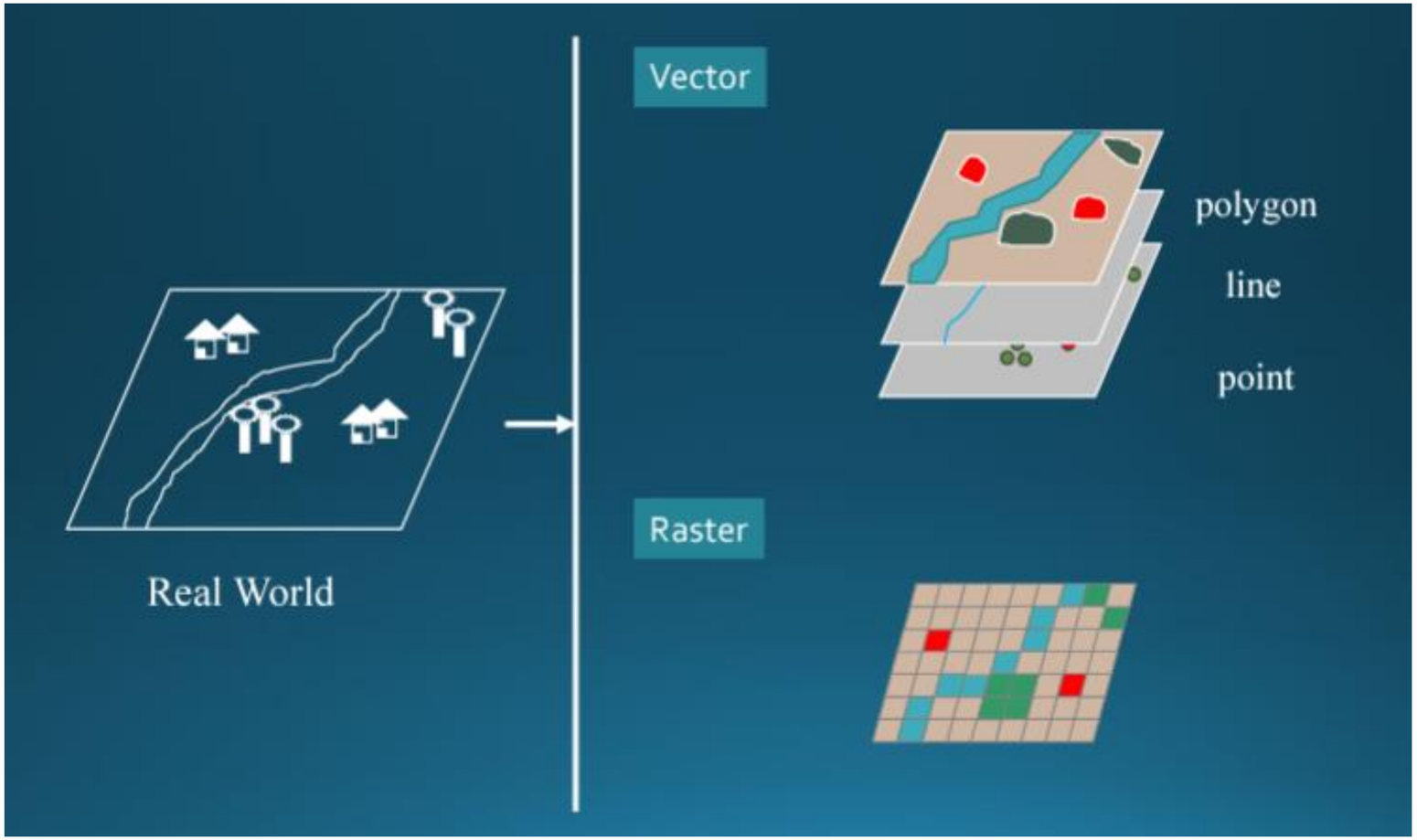
Source: India Policy Brief 2021

Land account compilation

Spatially-explicit account

- SEEA takes a geospatial approach to accounting
- Tabular presentation:
  - Land accounts are commonly presented as tables (e.g. land cover change matrix)
  - The values ‘behind’ the tables are derived from an analysis involving land cover maps
- Land cover maps:
  - Used as input to compile land accounts as tables as well as maps (e.g. land cover change map)
  - Built using geospatial data, i.e. data that is associated to a geographic location
- Geospatial data representation:
  - Vector: points, lines, polygons
  - Raster: gridded cells

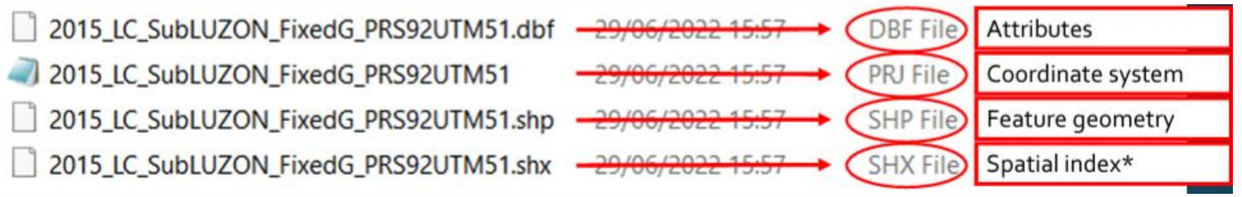
Geospatial data representation



Source: Blanca Perez-Lapena, https://seea.un.org/sites/seea.un.org/files/day1_workshop_sessiongis_bperezlapena_final_pdf.pdf

Vector data

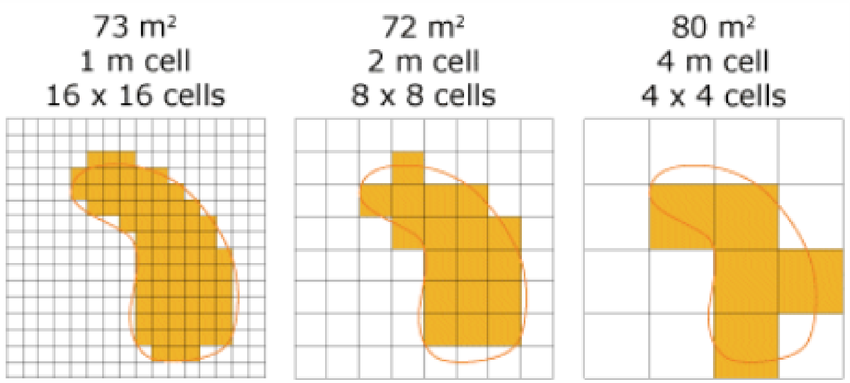
- Points, lines and polygons
  - > Discrete data points/features
  - > Linear features
  - > Areas
- Shapefiles are a common format for storing vector data
  - > Store non-topological vector data with attribute data
  - > One shapefile consists of several files with the same file name, but different file extensions

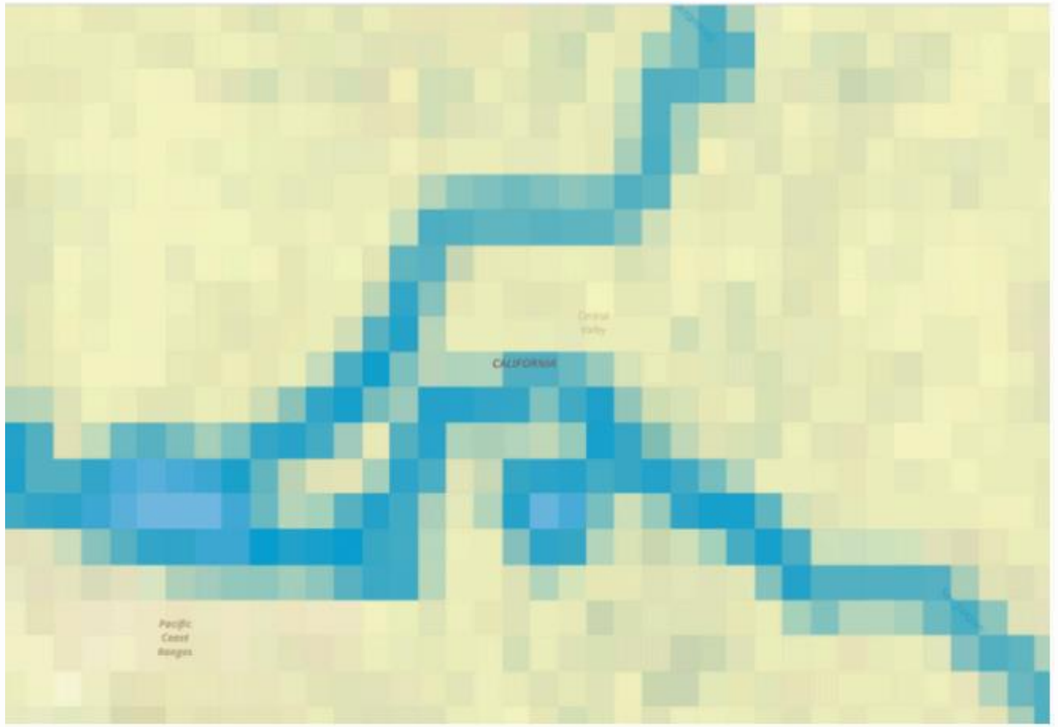


Source: https://www.gislounge.com/geodatabases-explored-vector-and-raster-data/#:~:text=Vector%20data%20represents%20geographic%20data,set%20is%20the%20same%20cell; Blanca Perez-Lapena, https://seea.un.org/sites/seea.un.org/files/day1_workshop_sessiongis_bperezlapena_final_pdf.pdf

Raster data

- Data associated to gridded cells identified by row and column
- Discrete and continuous rasters are possible
- File format: Various, but often a GeoTIFF, or some other file format which has georeferencing info embedded within the file
- Raster data can have different resolutions





SEEA

Source: https://www.gislounge.com/geodatabases-explored-vector-and-raster-data/#:~:text=Vector%20data%20represents%20geographic%20data,set%20is%20the%20same%20cell; https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/cell-size-of-raster-data.htm

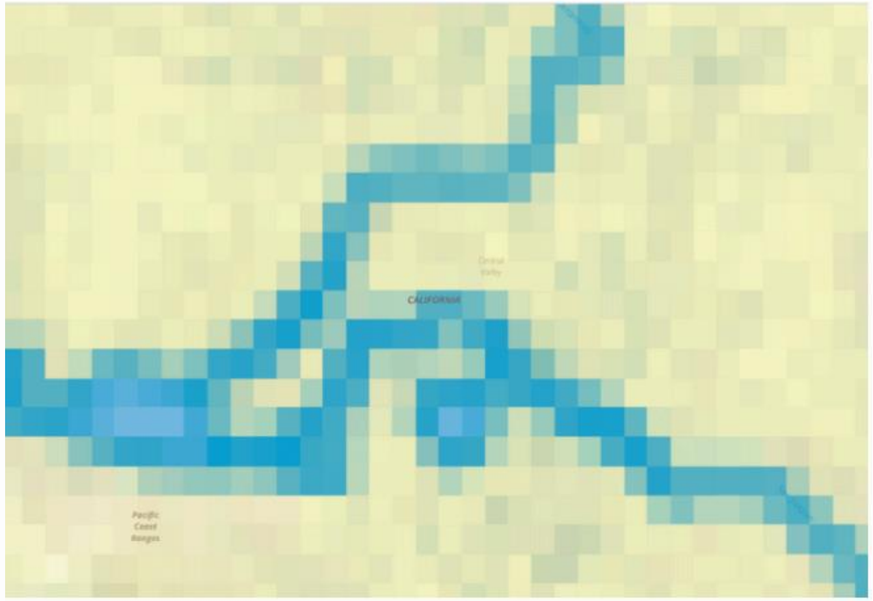
Vector vs raster data

VECTOR

- Represents data using points, lines, polygons
- Precise representation of shapes and boundaries
- Complex operations may be computationally demanding

RASTER

- Represents data as a grid of pixels or cells
- Detail depends on the raster resolution (cell size)
- Simplifies some spatial analyses



SEEA

Source images: https://www.gislounge.com/geodatabases-explored-vector-and-raster-data/#:~:text=Vector%20data%20represents%20geographic%20data,set%20is%20the%20same%20cell; https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/cell-size-of-raster-data.htm

Input data requirements for compilation

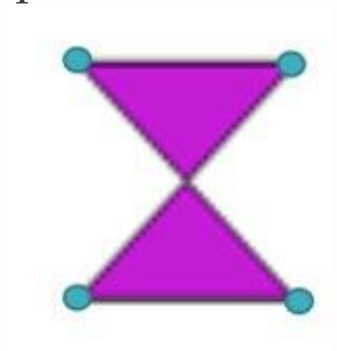
- At minimum, input data should have consistent boundaries and LC classes
  - Some exceptions can be worked around, particularly around inconsistent boundaries
- Either raster or vector data can be used
- Methods and data sources used do not need to be the same over time (though it is ideal)
  - Can use different satellites (e.g. Landsat, Sentinel)
  - Can have different initial resolutions
  - If different methods/data sources are used, it's important to provide explanations/implications

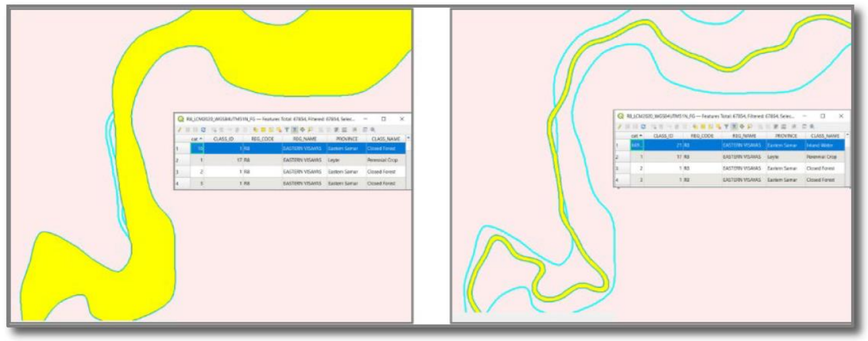
General workflow

- Step 1: Preliminary data corrections for land cover maps
- Step 2: Create land cover change accounts (e.g. additions/reductions)
  - > Can be done in a semi-automated way
- Step 3: Examine land cover change matrix for quality assurance
  - > Check for “improbable changes”
- Step 4: Further investigate problematic polygons and make adjustments as needed
- Step 5: Run final land cover accounts

Step 1: Preliminary data corrections

- Three main areas to check: Geometry errors, overlaps and gaps
  - > Geometry errors: Invalid polygons (e.g. self-intersecting polygons)
  - > Overlap issues: causes issues when vector is converted to raster. Which land cover class is assigned to a pixel?
  - > Gaps: Converting from vector to raster can result in pixels with “NoData” values
- What do these data corrections help ensure?
  - > Correct data processing; each pixel has only one associated land cover class; comprehensive in scope





Step 2/3: Create land cover accounts and matrices

- Can be done fairly easily, if you undertake preliminary data corrections
  - > Conversion to raster
  - > Raster overlay and counting pixels times the area of the cell
- Land cover change map/matrix provides a way to do quality assurance
- Change matrix is useful for detecting “improbable changes”
  - > Important to sit down with ecologists to determine what constitutes an “improbable change”
  - > Helpful to create a “master list” with explanations which can be referred to over time

Sl.No	Land cover class
1	Snow and Glacier
2	Agriculture Land
3	Built up
4	Shrubs
5	Forests
6	Landslides
7	Water Bodies
8	Sandy Bank
9	Meadows
10	Non Built up
11	Moraines
12	Rocky Outcrops
13	Alpine Scrubs

Step 4: Further investigate problematic polygons and make adjustments as needed

- Importance of taking a spatial point of view
- Should not just look at an aggregate land cover matrix as a guide for what needs to be investigated
  - > Need to know underlying statistics/distribution of improbable transition
  - > Is the large number in change matrix of urban→forest one large polygon or many small little polygons?
  - > Establishing a threshold—strike a balance between quality and practicality
  - > Helps prioritize where to investigate
- Mapping authority may check improbable transitions in a variety of ways—looking again at source data; making comparison to Google Earth; ground truthing
- If necessary, mapping authority should modify the land cover class associated with the polygon(s) where you see the improbable transition

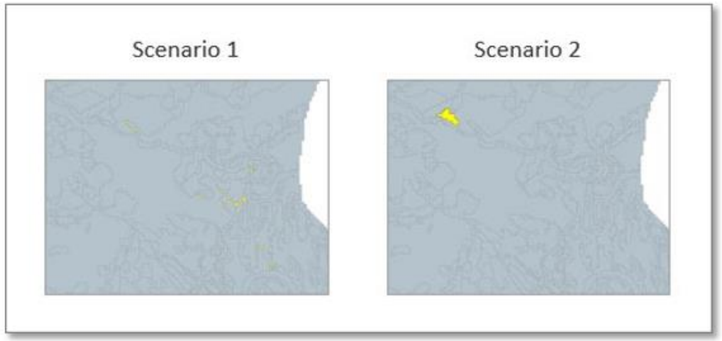


Figure 12 Scattered small polygons (left) and a large polygon (right) having a particular improbable transition.

Source: Blanca Perez-Lapena

Step 5: Run final land cover accounts

- Disseminating both “regular” land cover account and change matrix / map is extremely useful
- Process often improves the input data and provides value added, even if the base product is already high-quality.
  - Accounting requires consistency over time
  - Needs and mandate of NSO are different

Institutional collaboration

- Land cover accounts require close collaboration with the national mapping authority or custodian of official land cover maps and NSO
- Usually mapping agency or custodian has complete authority over basic land cover maps
  - > More flexibility with derivative maps
- Even if you have high quality land cover maps, the creation of the accounts can help detect inconsistencies/areas for improvement
- Helpful for NSO to have some basic familiarity with GIS terminology and systems (either ArcGIS or QGIS)