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ECOSYSTEM NATURAL CAPITAL ACCOUNT - LAND COVER ACCOUNT V.1

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We use this protocol and it's working

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Abstract

Land cover is an observable image of the many processes taking place on the land surface. It reflects land occupation by various natural, modified or artificial systems, and, to some extent, the way land is used by such systems. Land-cover cartographic and statistical information therefore plays a central role in the description and quantification of the interactions between the economy and nature by providing



Extraction of gridded (raster, grid) land cover data

- 1 **Defining the area of interest:** Identify the boundaries of the target country
- 2 **Spatial clipping:** Extract only the data corresponding to the country using a geographic mask.
- 3 **Exporting results:** Save the extracted data in a usable format for further analysis

Production of the land cover change matrix

- 4 **Data preparation :** In gridded files (raster, grid), individual cells are assigned a number that can be either a code or a value. In the land cover raster/grid files produced in the previous steps, these numbers are explicit codes reflecting the hierarchical nomenclature used. This is convenient for visualization but not very practical for calculations. In particular, a different coding is required to produce the change matrix, simply replacing the explicit land cover (LC) codes with rank values.
- 5 Change Matrix create with cross-tabulation tools

Matrice de calcul des changements de couverture des terres 2000-2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total 2000
	10 - Urban/ artificiel	21 - Terres arables agricoles	22 - Cultures permanentes	23 - Zones agricoles hétérogènes	30 - Forêts	41 - Pâturages et prairies naturelles	42 - Broussailles	43 - Zones naturelles mixtes, transitions	44 - Zones de végétation claustrées	51 - Terre nue, roches, sable	52 - Neige permanente et glaciers	61 - Zones humides couvertes	62 - Eaux intérieures	63 - Eaux côtières et de transition	
1 10 Urban/ artificiel	216499	0	0	0	28	0	0	0	0	0	0	0	0	0	216527
2 21 Terres arables agricoles	19356	2088016	0	0	10090	0	0	0	0	0	0	0	0	0	2117462
3 22 Cultures permanentes	1427	0	51579	0	200	0	0	0	0	0	0	0	0	0	53206
4 23 Zones agricoles hétérogènes	4044	0	0	242397	5889	0	0	0	0	0	0	0	0	0	252330
5 30 Forêts	262	15720	0	1717	230025	288	0	610	0	0	0	10	86	0	248718
6 41 Pâturages et prairies naturelles	1323	0	0	0	5660	385723	0	0	0	0	0	0	0	0	392706
7 42 Broussailles	598	0	0	0	260	0	33334	0	0	0	0	0	0	0	34192
8 43 Zones naturelles mixtes, transitions	112	0	0	0	4124	0	0	15164	0	0	0	0	0	0	19400
9 44 Zones de végétation claustrées	0	0	0	0	0	0	0	0	27	0	0	0	0	0	27
10 51 Terre nue, roches, sable	24	0	0	0	0	0	0	0	0	1496	0	0	0	0	1520
11 52 Neige permanente et glaciers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 61 Zones humides couvertes	1	0	0	0	4	0	0	0	0	0	0	3536	0	0	3541
13 62 Eaux intérieures	389	0	0	0	395	0	0	0	0	0	0	0	50344	0	51128
14 63 Eaux côtières et de transition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 2015	244035	2103736	51579	244114	256675	386011	33334	15774	27	1496	0	3546	50430	0	3390757

Example of a confusion matrix for Moldova between 2000 and 2015 using ESA CCI data

Analysis of changes and production of the column table ("flat matrix") of land cover flows

6 **About the land cover flow:** With only 14 classes, the change matrix includes $(14 \times 14 = 196) - 14 = 182$ possible transitions. With the 44 classes of the European CORINE Land Cover, it can include up to 1,892 transitions.

In order to summarize these large numbers of changes and to be able to name them more easily, the land cover account groups individual changes into **land cover flows**. Flows are defined according to land use processes and are further distinguished into Consumption (of land cover of the initial year) and Formation (of new land cover in the final year). As compared to the Matrix of change, for a given land cover type SUM of Flows of Consumption = SUM of Output (losses, negative changes...) while SUM of Flows of Formation = SUM of Inputs (gains, positive changes.)

Land cover flows	
If1	Artificial development
If2	Agriculture extension
If3	Internal conversions, rotations
If4	Management and alteration of forested land
If5	Restoration and development of habitats
If6	Changes of land-cover due to natural and multiple causes
If7	Other land cover changes n.e.c. and reclassification
If0	No observed land-cover change

The 7 land cover flows

The definition of land cover flow according to *Weber 2014 : The ecosystem natural capital account a quick start package*

- **If1 – Artificial development** Artificial development includes sprawl or extension of urban and associated areas, transport infrastructures, economic activity areas, and associated areas such as green urban areas and sports facilities, and mines, quarries and waste landfills.
- **If2 - Agriculture extension** Agriculture extension includes conversion of forests, and natural and semi-natural land to agriculture. Conversion from small-scale agriculture, with associations of crops, mosaics and small linear features, to homogeneous cropland (farmland restructuring).
- **If3 – Internal conversions and rotations** Internal conversions and rotations (If3) are changes which can be observed within land-cover classes: artificial, urban, forest and other types. They require observation of detailed land-cover classes.
- **If4 Management and alteration of forested land** Forest management refers to long time-spans with a succession of steps. Depending on the frequency of accounting, all steps are described (annual accounts) or intermediate steps are consolidated. Also, forests are socio-ecological systems that include areas with foresttree cover (LCF06)

and other areas that are managed by foresters and are considered as part of forests in a land-use sense. This distinction is reflected in land-cover accounts. Processes involving forests are recorded in all land-cover aggregated flows.

- **If5 – Restoration and development of habitats** Restoration and development of habitat groups represents flows resulting from anthropogenic processes.
- **If6 – Changes of land cover due to natural and multiple causes** In many cases, land-cover flows cannot be clearly allocated to a particular human activity. This is the case with change driven by climate change regarding temperature, rainfall regime and hazards such as storms. For managed forests, damage is classified as If4 (management and alteration of forested land) and development as If5 (restoration and development of habitats).
- **If7 Other land-cover changes not elsewhere classified (n.e.c.) and revaluation** This class records unlikely changes such as conversion of urban areas, and permanent snow and glaciers to agriculture or forest. Revaluation is also recorded in If7. It corresponds to changes in classification due to errors in the initial database. As long as the initial database is not revised and upgraded, such false change is recorded as revaluation. Once revision is done, revaluation will be reclassified, generally as no observed change.

- 7 The land-cover flow classification is produced from analysis of the transition matrix. Changes are grouped according to processes. It is important that the standard computation matrix produced by the GIS is modified slightly to produce the correct accounting matrix. In the standard computation matrix, the diagonal is devoted to no change, with the consequence that this amount varies according to the level of detail of the land-cover classifications used, increasing when aggregating. In the accounting matrix (cf. next fig.), actual no change is separated from changes which are internal to a given class. Technically, the solution is to extract no change (If0) from the diagonal and record it as an additional item in rows and columns.



Year T1		Year T0																	
		Urban and associated developed areas	Homogeneous herbaceous cropland	Agriculture plantations, permanent crops	Agriculture associations and mosaics	Pastures and natural grassland	Forest tree cover	Shrubland, bushland, heathland	Sparsely vegetated areas	Natural vegetation associations and mosaics	Barren land	Permanent snow and glaciers	Open wetlands	Inland water bodies	Coastal water bodies and inter-tidal areas	Sea (interface with land)	Total Consumption of land cover	No Change	TOTAL t1
Year T0		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15		99	
Urban and associated developed areas	01	If3	If7	If7	If7	If7	If7	If7	If7	If7	If7	If7	If7	If1	If6	If6		If0	
Homogeneous herbaceous cropland	02	If1	If3	If3	If5	If5	If5	If5	If5	If5	If6	If7	If5	If1	If6	If6		If0	
Agriculture plantations, permanent crops	03	If1	If3	If3	If5	If5	If5	If5	If6	If5	If6	If7	If5	If1	If6	If6		If0	
Agriculture associations and mosaics	04	If1	If2	If2	If3	If5	If5	If5	If6	If5	If6	If7	If5	If1	If6	If6		If0	
Pastures and natural grassland	05	If1	If2	If2	If2	If3	If5	If5	If6	If5	If6	If7	If5	If1	If6	If6		If0	
Forest tree cover	06	If1	If2	If2	If2	If4	If3	If4	If4	If4	If4	If7	If4	If1	If6	If6		If0	
Shrubland, bushland, heathland	07	If1	If2	If2	If2	If6	If5	If3	If6	If6	If6	If7	If6	If1	If6	If6		If0	
Sparsely vegetated areas	08	If1	If2	If2	If2	If2	If5	If6	If3	If6	If6	If7	If6	If1	If6	If6		If0	
Natural vegetation associations and mosaics	09	If1	If2	If2	If2	If2	If5	If6	If6	If3	If6	If7	If6	If1	If6	If6		If0	
Barren land	10	If1	If2	If2	If2	If2	If5	If6	If6	If5	If3	If7	If6	If1	If6	If6		If0	
Permanent snow and glaciers	11	If1	If6	If6	If6	If6	If6	If6	If6	If6	If6	If3	If6	If6	If6	If6		If0	
Open wetlands	12	If1	If2	If2	If2	If2	If5	If6	If6	If6	If6	If7	If3	If6	If6	If6		If0	
Inland water bodies	13	If1	If2	If2	If2	If2	If5	If6	If6	If6	If6	If7	If6	If3	If6	If6		If0	
Coastal water bodies and inter-tidal areas	14	If1	If6	If6	If6	If6	If5	If6	If6	If6	If6	If7	If6	If6	If3	If6		If0	
Sea (interface with land)	15	If1	If6	If6	If6	If6	If6	If6	If6	If6	If6	If6	If6	If6	If6	If3		If0	
Total Formation of land cover																			
No Change	99	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0	If0			
TOTAL t2																			

The transition matrix

Production of the cross-tabulation of LEAC stock and flow accounts for a country



- 8 The production of a complete LEAC can be carried out for any geographical division, such as regions, districts, river basins, or protected areas, as long as raster (grid) data is available.

Managing the land-cover accounts database can be done with the tools available in the organization in charge of accounting. Cloud computing is likely to be an option for the future – although there is as yet no experience.

To obtain the Consumption matrix : Land cover Y1 * land cover flow

The formation matrix : Land cover Y2 * land cover flow