KANGARÉ ENCA: ECOSYSTEM NATURAL CAPITAL ACCOUNTS OF A FICTITIOUS COUNTRY
Accounting Manual v.01

by Jean-Louis Weber

This manual is supplemented by **fiches** describing the various exercises, **spreadsheets with accounts templates** and **data sets** to be used with the recommended software package.

The manual refers to the CBD Report TS 77 for contents issues: *Jean-Louis Weber (2014). Ecosystem Natural Capital Accounts: A Quick Start Package, Technical Series No. 77, Secretariat of the Convention on Biological Diversity, Montreal, 248 pages.*

A typical software package needed for the Kangare ENCA Tutorial has been developed by by *Cédric Lardeux (ONFI, France)*. The tutorial software package is covered by a CeCILL freeware licence. It is made of a suite of programs based on open source freeware packages:

- QGIS
- LibreOffice
- Linux Unbuntu

QGIS and LibreOffice and the Kangare ENCA tutorial software package can be operated as well from MS Windows.

As long as data formats are standard or easily convertible, the Kangare ENCA tutorial can be converted to be used with other software packages, including commercial ones.

Step 1: Discovering the tools and the data infrastructure

1.1 Discovering the tools

The software packages: QGIS, LibreOffice

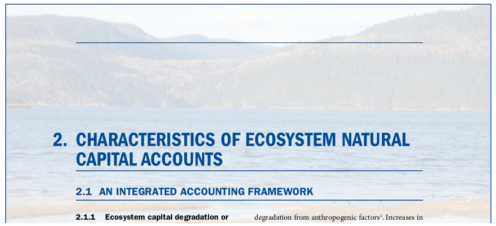
The Documentation

The Datasets

Presentation of the standard QSP software package:

G:\KANGARE_ENCA_Tutorial\PresentationQuickStratPackage.odp by Cédric Lardeux (The tutorial software package in CeCILL Licence – Open access)

1.2 Discovering the data infrastructure (TS77 Chap. 2 & 3)


2. CHARACTERISTICS OF ECOSYSTEM NATURAL CAPITAL ACCOUNTS

2.1 AN INTEGRATED ACCOUNTING FRAMEWORK

2.1.1 Ecosystem capital degradation or degradation from anthropogenic factors[1]. Increases in


3. THE DATA INFRASTRUCTURE

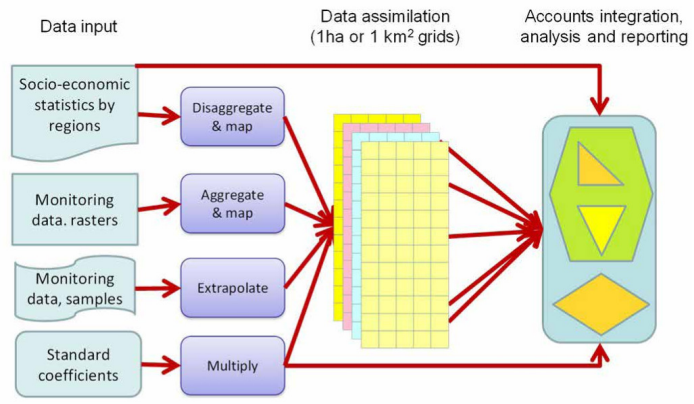
3.01 The SEEA-ENCA Quick Start Package (QSP) aims at starting to implement ecosystem natural capital accounts without delay. The first step will be a double test: of the relevance of the accounts for stakeholders, and of their feasibility for the institution(s) in charge of their production.

3.05 It is important to note that the primary user of these guidelines is the person involved in the production of ENCAs, who may not be a specialist in the data and their processing. Make a quick start is therefore in the hands of the accountant, who, ideally, will try to establish partnerships with specialists in the various domains

1.2.1 The ENCA data model

- accounts are produced from various data and statistics
- accounts are compiled by accounting units of various types and shapes
- data and statistics are assimilated to a common grid which allows easier compilations

Figure 2.07: The ENCA Data Model: Main data flows for compiling accounts



1.2.2 Ecosystem Accounting Units

The country and other administrative and other geographical reporting units:

- administrative regions, districts and municipalities
- bio-geographical regions management zones (e.g. coastal zones, mountain areas) and conservation areas, parks etc.

A - The ecosystem analytical units :

- Land cover ecosystem units
- River basins (or catchments) and sub-basins
- Socio-ecological landscape units (SELU)
- Rivers and Homogeneous stream reaches

Figure 2.04: River basins, rivers and homogeneous stream reaches

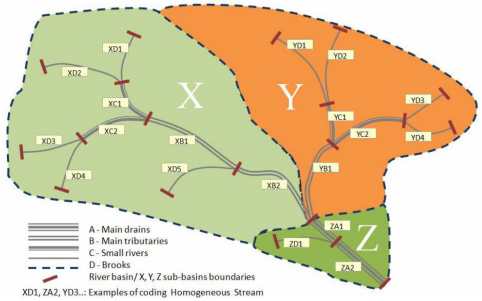
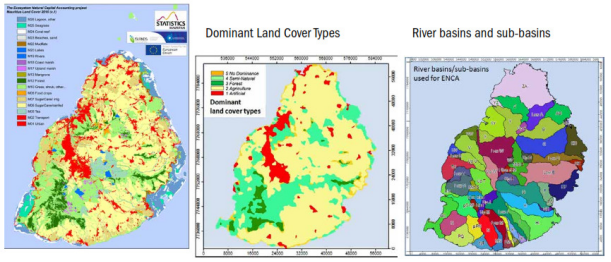
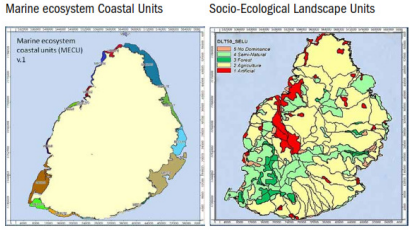


Figure 2.06: The production of the SELU map and directory for ENCA Mauritius (preliminary version 2013)

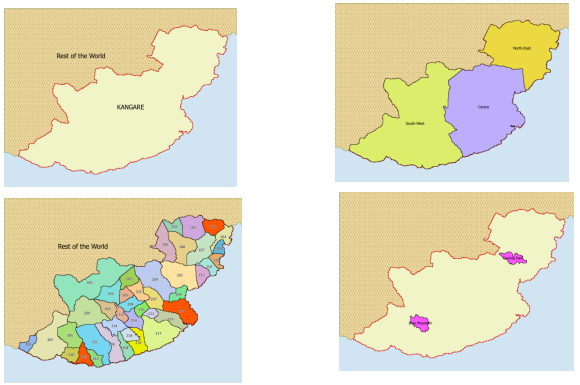


In the case of the Mauritius test accounts, only dominant land-cover types and river sub-basin limits have been used for defining SELUs. Dominant land cover has been compiled in the 1 ha grid, using the >50% criteria with five classes: artificial, agriculture, forest, semi-natural and natural land and no Land cover dominance. Additional zoning according to relief has still to be included. Marine coastal ecosystem units (MCUs) and their composition according to seabeds have been extracted directly from the land-cover map.



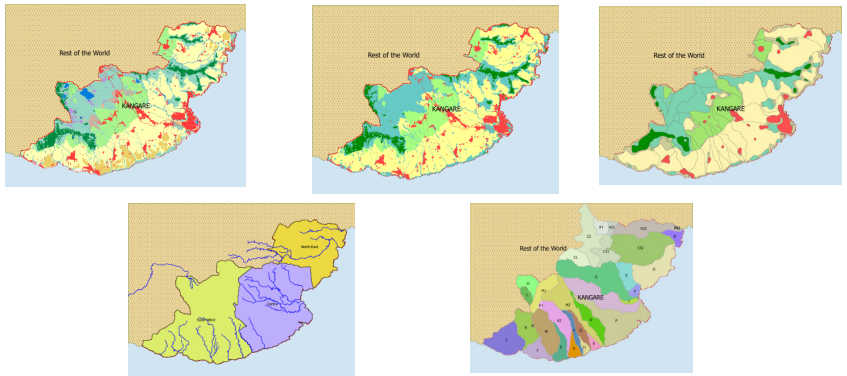
B - Discovering the Ecosystem Accounting Units of Kangare

The administrative reporting units



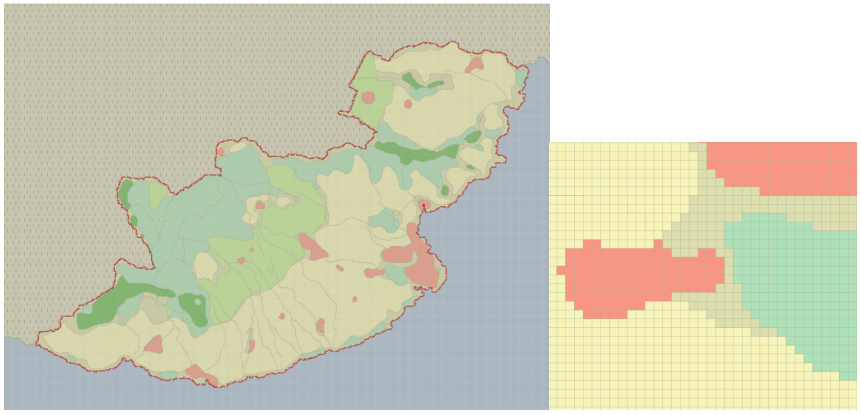
The ecosystem analytical and reporting units:

- The land cover ecosystem units 2010 map, detailed level (16 classes) and its aggregation to five classes
- Rivers and river basins
- Creating the SELU map and directory



C - The EAU datasets:

- Shapefiles : original resolution and 100 m generalisation
- Raster files : 10 m and 100m resolution
-
- **<u>The reference grid (100m x 100m cells) for data assimilation</u>**



Step 2 : The Land Cover Account

4. THE LAND COVER ACCOUNT

4.1 LAND-COVER MAPS, STOCKS AND CHANGES

4.1.1 Specific role(s) of land-cover accounts in the ENCA framework

4.01 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

"other change in volume" of non-financial assets) one of the bases of ecosystem accounts.

4.02 If enough data and maps exist in various organizations in charge of cadastre, transport, agriculture,

2.1 Presentation of the land cover account

- Land cover ecosystem units classification
- Land cover change: consumption and formation of land cover
- Land cover flows : consumption and formation of land cover by processes

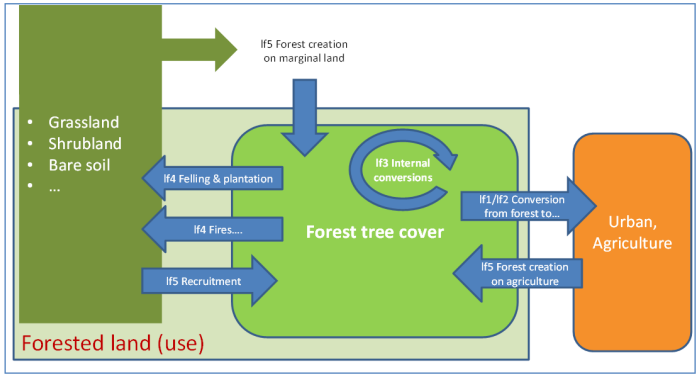
4.13 The LCEU classification produced on this basis has 14 classes (plus sea):

Class	Label
01	Urban and associated developed areas
02	Homogeneous herbaceous cropland
03	Agriculture plantations, permanent crops
04	Agriculture associations and mosaics
05	Pastures and natural grassland
06	Forest tree cover
07	Shrubland, bushland, heathland
08	Sparsely vegetated areas
09	Natural vegetation associations and mosaics
10	Barren land
11	Permanent snow and glaciers
12	Open wetlands
13	Inland water bodies
14	Coastal water bodies and inter-tidal areas
	Sea (interface with land)

Box 4.18 Aggregated land cover flows (provisional) classification (lf)

Land cover flows	
lf1	Artificial development
lf2	Agriculture extension
lf3	Internal conversions, rotations
lf4	Management and alteration of forested land
lf5	Restoration and development of habitats
lf6	Changes of land-cover due to natural and multiple causes
lf7	Other land cover changes n.e.c. and reclassification
lf0	No observed land-cover change

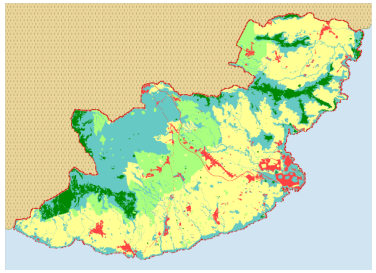
n.e.c: non-elsewhere classified



Example of land cover flows assessment for forests

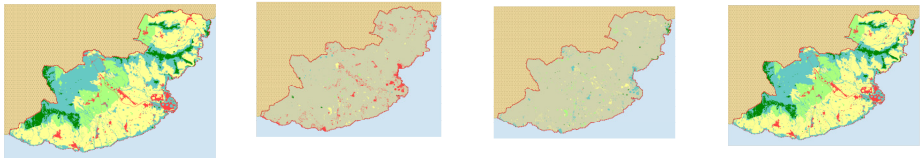
2.2 Production of the land cover map 2000 for Kangare

- Example with 5 land cover classes, starting from land cover 2010

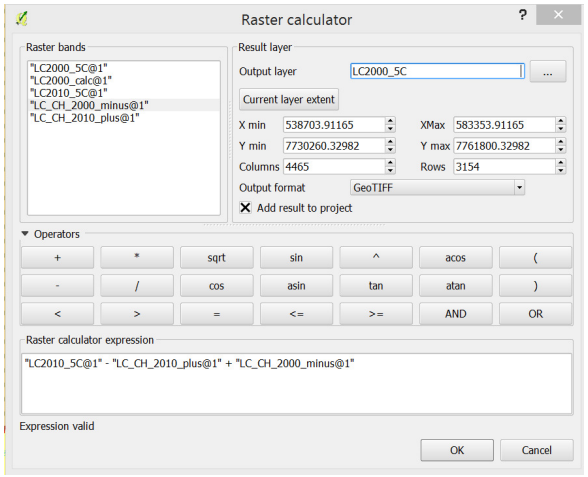


_ENCA_Kangare_Tutorial/Kangare_Land_Cover/Input_LCV_data/SAGA_sgrids/LCV_10m_grids/LC2010_5C.sdat

- Methodology: use the land cover 2010 and the formation and consumption layers



- **LC2010 – Formation + Consumption = LC2000**

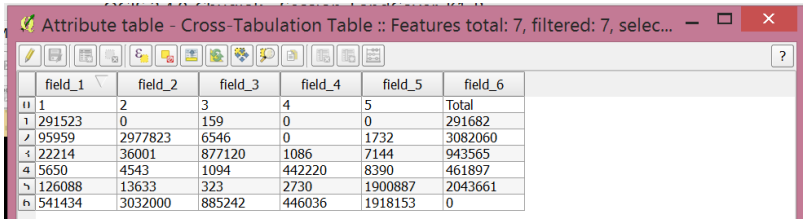


2.3 Extraction of land cover data

2.3.1 Matrix of land cover change

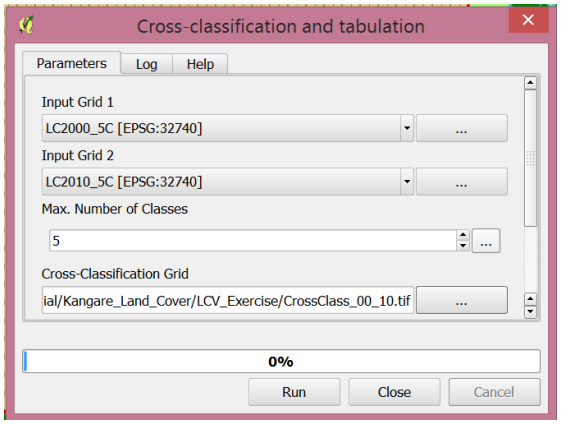
Input: LC2000_5C and LC2010_5C

Extraction of the matrix using the QGIS/SAGA Cross classification and tabulation tool.



	field_1	field_2	field_3	field_4	field_5	field_6
0	1	2	3	4	5	Total
1	291523	0	159	0	0	291682
2	95959	2977823	6546	0	1732	3082060
3	22214	36001	877120	1086	7144	943565
4	5650	4543	1094	442220	8390	461897
5	126088	13633	323	2730	1900887	2043661
6	541434	3032000	885242	446036	1918153	0

Save the cross-tabulation table as .dbf file. This the calculation matrix, not the accounting matrix. Save it again as a .ods spreadsheet. The table is copied into the worksheet "LC_AccountingMatrix" of the workbook called:
D:_ENCA_Kangare_Tutorial\Kangare_Land_Cover\LCV_Exercise



2.3.2 Basic land cover account and Land cover accounts of Regions by Dominant Land Cover Type

The accounts present data on land cover stocks 2000 and 2010 and on land cover flows, formation and consumption

A - Attribution of EAU codes to the 100m x 100m reference grid:

- Regions_ID, Municipalities_ID, Catchments/Sub-Catchments_ID, SELU_ID, SELU_DLCT type and Park_ID
- Use EAU 100m raster files (tif or sdat) with QGIS/SAGA tool "Add grid values to shapes" (the codes will be added to the cells of the reference grid...)

B - Extraction of statistics to the reference grid:

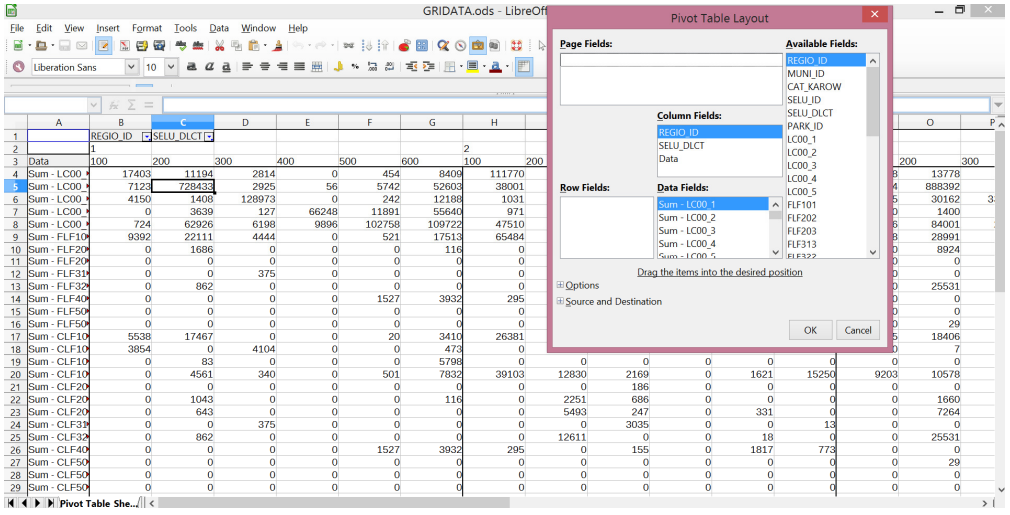
- DATA: LC2000 (LC00) and LC2010 (LC10), classes 1,2,3,4,5 and individual land cover flows, formation and consumption, coded

F_lf and C_lf and a number. Short names needed as .dbf accepts only 8 digits and truncates arbitrarily the names.

- Use the new reference grid with EAU codes.
- Use the QGIS/SAGA tool “Grid statistics for polygons”; unclick all options, keep only SUM. [NB: As the input data have a resolution of 10m x 10m, the calculation results will have to be divided by 100 to make hectares.]
- Save the attribute table as GRIDATA.dbf table, open it with a spreadsheet package and save is in spreadsheet format (.ods or .xls). Pre-filled version GRIDATA.ods and GRIDATA.xls are available at D:_ENCA_Kangare_Tutorial\Kangare_Land_Cover\Intermediate_Tables

C - Cross-tabulation of the GRIDATA table

- The GRIDATA.dbf table can be easily imported into a DBMS (database management system) such as MSAccess, PostGRES, MySQL, SQLite, Oracle etc... or directly processed from QGIS with PostGIS. There, SQL queries allow easy production of the accounts. THE USE OF DBMS WILL NOT BE ADDRESSED IN THIS SESSION.
- Tabulation with a spreadsheet's pivot table: Open GRIDATA.ods with LibeOffice Calc. Go to data, Pivot Table. WARNING: the default line “data” has to be deleted from the Columns Fields. In the column are the EAU (alone or combined). In the box for Data Fields, drag and drop the various land cover datasets, one by one. And that's it. To modify the Pivot Table (e.g. replace regions by municipalities in columns, sort by rows.....), right click a cell and use the command “Edit Layout” and change Columns and Rows, keeping the long list of data unchanged [don't forget to delete again “data” in the Columns Fields].



D - Producing and presenting the land cover accounts

Exercise: Fill the Land Cover Basic Account and the Land Cover Account Region-DLCT

Support:
D:_ENCA_Kangare_Tutorial\Kangare_Land_Cover\LCV_Exercise\LandCover_Account_KA_EXO.ods
The worksheet “Input to LC_Basic_and_REGIO-DLCT” is connected to the final accouting tables. On the Pivot table REGIO/SELU-DLCT produced at Step 3, unclik on the top boxes the Zero fields of REGIO_ID and SELU_DLCT (a few small mismatches between layers on Kangare's border). The copy the whole array of data (not the headings...) and paste it into the box framed in red of the worksheet “Input to LC_Basic_and_REGIO-DLCT”. It's done...

Comment the land cover accounts

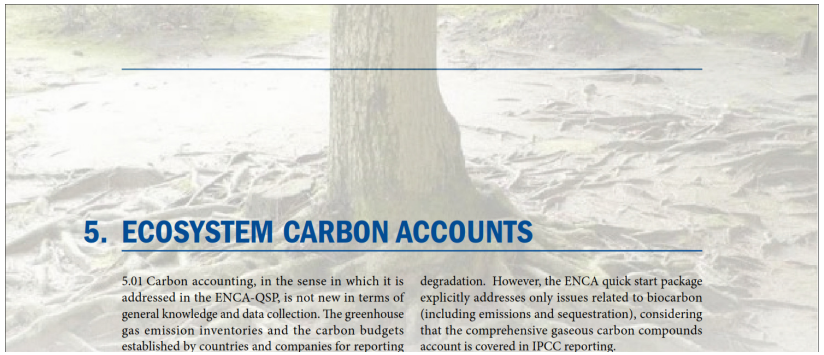
Ecosystem Natural Capital Accounts: Land Cover Stocks and Flows Account

Unit : hectare

Land Cover Ecosystem Units Classes (LCEU)		K1	K2	K24	K30	K42	TOTAL
Land cover stocks and flows		Artificial/ Urban	Homogeneous agriculture	Permanent crops	Mosaic agriculture & pastures	Mangroves	
	Opening Stock	2915.4	30819.6	9434.1	4612.7	20329.7	68111.5
F_lf10	Artificial development	2785.9					2785.9
F_lf20	Agriculture extension		199.2	18.7			217.9
F_lf31	Conversion from mixed agriculture and pastures to homogeneous			73.1			73.1
F_lf32	Conversion from homogeneous to mixed agriculture		392.5				392.5
F_lf40	Management & alteration of forested land					98.0	98.0
F_lf50	Restoration & developement of habitats				40.2	98.3	138.5
F_lf60	Other changes						
	Total formation of land cover	2785.9	591.7	91.8	40.2	196.3	3705.9
C_lf10	Artificial development		1187.1	284.9	62.1	1251.7	2785.9
C_lf20	Agriculture extension	1.9			63.7	152.4	217.9
C_lf31	Conversion from mixed agriculture and pastures to homogeneous		73.1				73.1
C_lf32	Conversion from homogeneous to mixed agriculture			392.5			392.5
C_lf40	Management & alteration of forested land				98.0		98.0
C_lf50	Restoration & developement of habitats		19.6	89.5		29.5	138.5
C_lf60	Other changes						
	Total consumption of land cover	1.9	1279.8	766.9	223.8	1433.6	3705.9
	Net change in land cover (formation - consumption)	2784.0	-688.1	-675.1	-183.6	-1237.2	0.0
	Closing Stock	5402.1	30319.2	8851.3	4455.0	19083.9	68111.5
lf00	*No observed land cover change*	*2616.2*	*29727.5*	*8759.5*	*4414.8*	*18887.6*	*64405.6*

Jean-Louis Weber, 2014

Step 3 : The Ecosystem carbon accounts



5. ECOSYSTEM CARBON ACCOUNTS

5.01 Carbon accounting, in the sense in which it is addressed in the ENCA-QSP, is not new in terms of general knowledge and data collection. The greenhouse gas emission inventories and the carbon budgets established by countries and companies for reporting degradation. However, the ENCA quick start package explicitly addresses only issues related to biocarbon (including emissions and sequestration), considering that the comprehensive gaseous carbon compounds account is covered in IPCC reporting.

3.1 Structure of the ecosystem carbon accounts

Figure 5.01 The ENCA-QSP ecosystem carbon account structure

I. Ecosystem Carbon Basic Balance	Stocks Primary and secondary production of biocarbon Withdrawals Natural perturbations	*Total inflow of biocarbon* *Net Ecosystem Carbon Balance*
II. Accessible Resource Surplus	Total inflow of biocarbon Accessible stock carried over Restrictions of use Other accessibility corrections	*Net Accessible Resource Surplus*
III. Total Uses of Ecosystem Bio and Geo-Carbon	Total use of biocarbon Imports/biocarbon commodites contents Imports/ embedded biocarbon Direct use of fossil carbon Fossil carbon embedded into commodites	*Direct use of biocarbon Biocarbon requirement* *Total carbon requirement*
IV. Table of Indexes of Intensity of Use and Ecosystem Health	Sustainable intensity of ecosystem carbon use Composite ecosystem biocarbon health index	*Biocarbon ecological internal unit value*

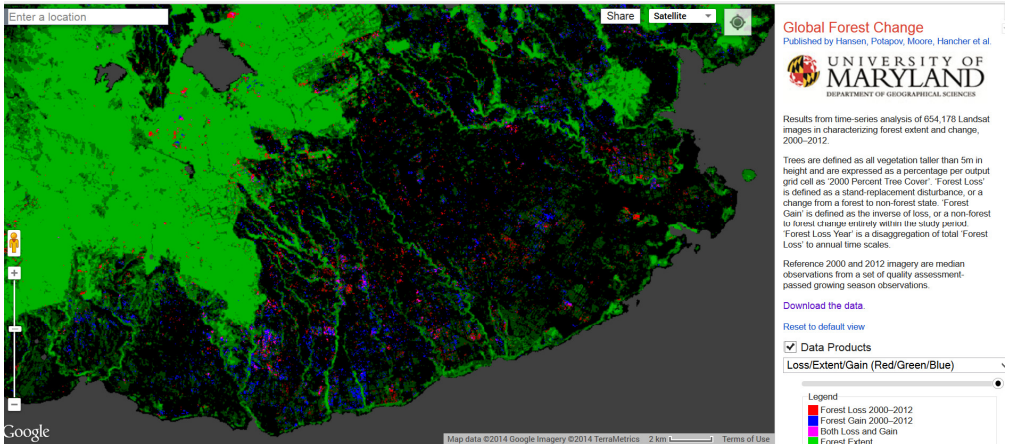
3.2 Browsing the ecosystem carbon accounts tables [folder Accounting Tables]

3.3 Exercice: Download data on biomass stocks and flows from the internet – the example of the Global Forest Change

http://earthenginepartners.appspot.com/science-2013-global-forest

How such data can be used?
How to download the data?
How to visualise and process the data in QGIS?

Other data from satellite: Forest/trees, NPP...



3.4 Discussion of data needed to produce the ecosystem carbon account:

Forestry and agricuture statistics,

Soil

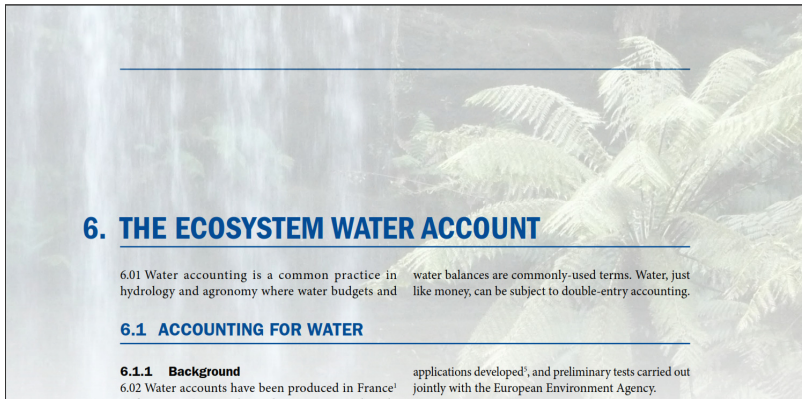
CO2,

Fisheries...

National resources

FAO, IPCC, others...

Step 4: The ecosystem water account



6. THE ECOSYSTEM WATER ACCOUNT

6.01 Water accounting is a common practice in hydrology and agronomy where water budgets and water balances are commonly-used terms. Water, just like money, can be subject to double-entry accounting.

6.1 ACCOUNTING FOR WATER

6.1.1 Background

6.02 Water accounts have been produced in France[1] applications developed[2], and preliminary tests carried out jointly with the European Environment Agency.

4.1 Structure of the Ecosystem Water Account

Figure 6.01 The ENCA-QSP water account structure

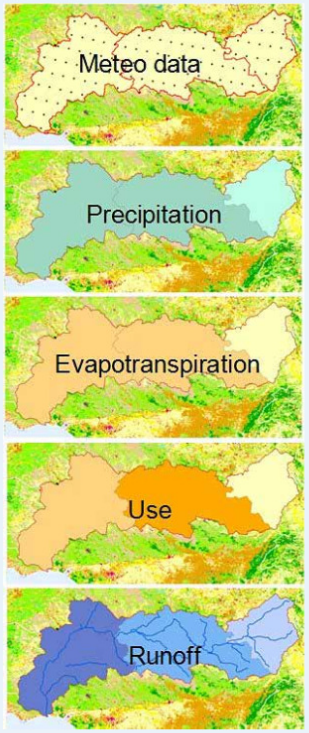
I. Ecosystem Water Basic Balance	Stocks Primary and secondary production of water Transfers between water bodies and basins Actual Evapotranspiration Abstraction of water, supply and use Returns to waste water and losses	*Total inflow of water* *Net Ecosystem Water Balance*
II. Accessible Resource Surplus	Total renewable water resources Accessible stock carried over Restrictions of use Other accessibility corrections	*Net Accessible Water Resource Surplus*
III. Total Uses of Water	Total use of ecosystem water: blues, grey & green water Imports/water commodities contents Imports/ embedded water	*Total use of ecosystem water* *Direct use of water* *Total water requirement*
IV. Table of Indexes of Intensity of Use and Ecosystem Health	Sustainable intensity of ecosystem water use Composite ecosystem water health index	*Water internal ecological unit value*

4.2 Browsing the ecosystem water accounts tables [folder Accounting Tables]

4.3: Exercise: Fixing issues [1] How to produce a balanced water account for a river basin with incomplete data?

The "Guadiana" example.

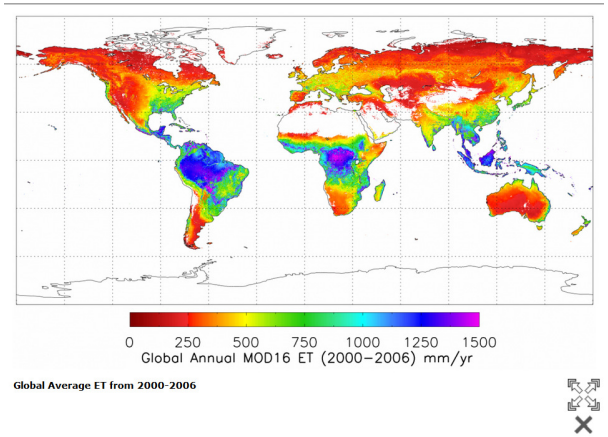
Box 6.08 A quick method for estimating river runoff by river sub-basin



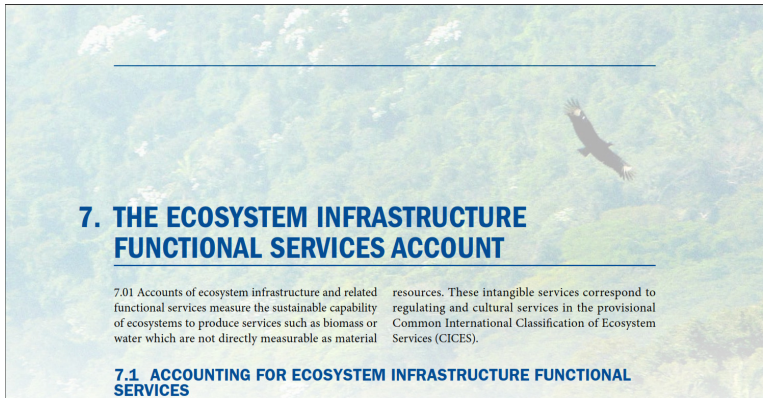
A simplified theoretical sequence for a quick estimate would be the following. If actual data on river runoff are available, they can be used to calibrate the account.

Precipitation*
- spontaneous Actual EvapoTranspiration**
- net infiltration to soil/subsoil***
+ inflows from upstream runoff
+ returns of used water & irrigationμ
= Available surface water resource
- use of water by activities and householdsμ
- evapotranspiration by activities μ
= River basin runoff

Sources:
* Meteo
** Modelling from meteo data, land cover & NDVI (vegetation index)
*** Hydrogeological modelling
μ Estimation from land cover and socio-economic statistics
Bold Ital: accounting balances

Fixing issues [2] Evapotranspiration (actual) : from where can we download data when they are not availble in the country? An example **http://www.ntsg.umt.edu/project/mod16**	
4.4: Fixing issues [3] How to downscale water use statistics. The example of households water consumption **Tentative exercise: calculation of households water consumption by the 100m x 100m accounting grid** **Data input:** • Water use per capita • Population by municipalities • Urban land cover • Proprotional breakdown of household water consumption by 100m x 100m cells.	

Step 5: The ecosystem infrastructure functional services account



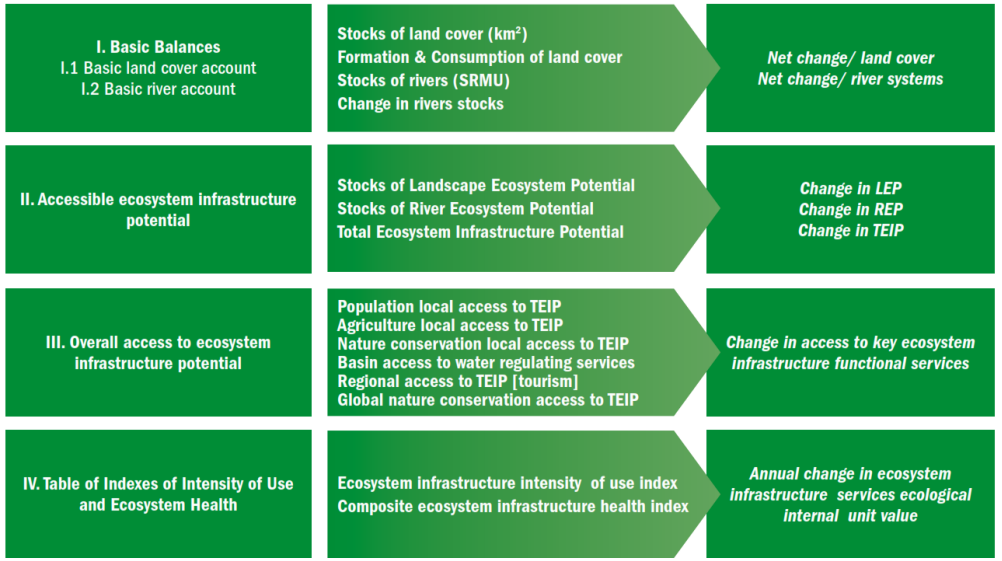
7. THE ECOSYSTEM INFRASTRUCTURE FUNCTIONAL SERVICES ACCOUNT

7.01 Accounts of ecosystem infrastructure and related functional services measure the sustainable capability of ecosystems to produce services such as biomass or water which are not directly measurable as material resources. These intangible services correspond to regulating and cultural services in the provisional Common International Classification of Ecosystem Services (CICES).

7.1 ACCOUNTING FOR ECOSYSTEM INFRASTRUCTURE FUNCTIONAL SERVICES

5.1 Structure of the ecosystem infrastructure functional services account

Figure 7.01 the ENCA-QSP ecosystem infrastructure functional services

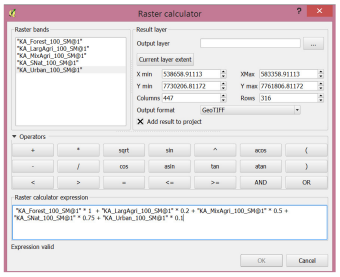


5.2 Browsing the ecosystem water accounts tables [folder Accounting Tables]

5.3 Exercise: Calculating the Net Landscape Ecosystem Potential (NLEP)

A - Calculating GBLI, the Green Background Landscape Index

Choice of the weighting factors, discussion
GBLI 2000 and 2010
Integration of landscape fragmentation by roads
Quick calculation of NLEP



*"KA_Forest_100_SM@1" * 1 + "KA_LargAgri_100_SM@1" * 0.2 + "KA_MixAgri_100_SM@1" * 0.5 + "KA_SNat_100_SM@1" * 0.75 + "KA_Urban_100_SM@1" * 0.1*

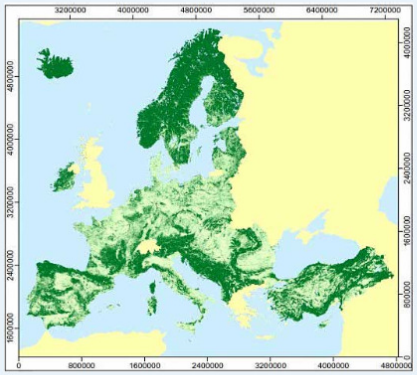
B - Discussion:

- other elements which could be incorporated in NLEP
- NREP (for rivers)

Box 7.06 Examples of scoring tables for GBLI calculation

EEA member countries

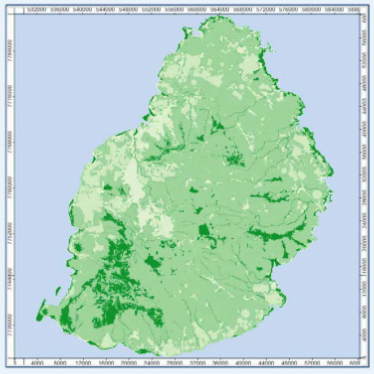
The GBLI calculation for Europe (EEA member countries) is based on an aggregation of land cover in 7 classes. The data have been computed on a 1 km² grid and smoothed with a radius of 5 km. The scores on a 0 to 1 grid are:
Artificial Areas: 0.1
Broad agriculture: 0.2
Mosaic agriculture and pastures: 0.75
Forest: 1
Natural and semi-natural land: 1
Wetlands: 1
Water bodies: 1



Data source: GBLI2006, EEA 2011 (missing data for Greece and the UK)

Mauritius

The GBLI calculation for the Mauritius test accounts is based on an aggregation of land cover in 8 classes. Data have been computed on a 1 ha grid and smoothed with a radius of 1 km. The provisional scores on a 0 to 1 grid are:
Urban/ artificial: 0.1
Sugar Cane/Irrigated: 0.2
Sugar Cane/Rainfed: 0.4
Food crops: 0.4
Tea: 0.6
Grassland and Shrubs: 0.8
Forest: 0.8
Natural land: 1

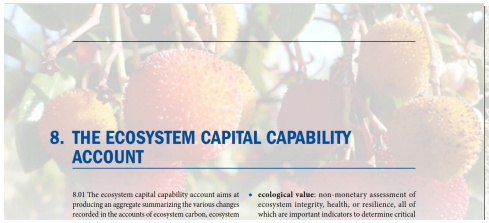


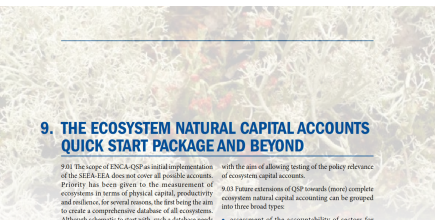
Data source: GBLI 2010, Statistics Mauritius and J.-L. Weber, 2013

5.4 Discussion on the use of species and habitats biodiversity in the ecosystem health diagnosis

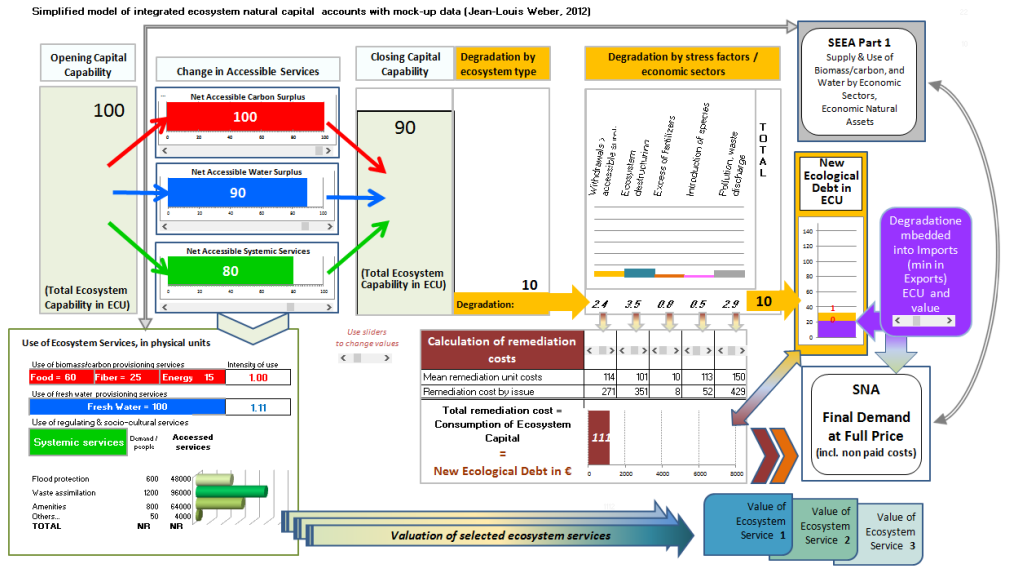
- Required properties of good biodiversity indicators
- Spatial generalisation of in situ monitoring data
- Data and expert judgements

Step 6 : Accounts integration and QSP extension (TS77 Chap. 8 and 9)





6.1 Manipulation of the ENCA simplified interactive demonstration model



6.2 Discussion

Jean-Louis Weber, 2014

Step 7 A roadmap to implement ENCA QSP

Discussion of CBD TS77 T*able 1.01: Five steps for producing ecosystem natural capital accounts* (pp. 28, 29)

Objective	Datasets/ Accounts	Tasks for the accountant
Step 1: Create the data infrastructure needed for accounting		
Collect reference geographical datasets and create the database of Ecosystem Accounting Units	Geographical features/zonings 1. Physical boundaries (coastline, river basin and sub-basin limits, climate zoning, elevation classes) 2. Administrative boundaries (municipalities, districts, regions) 3. Transport network 4. Hydrological network, rivers, aquifers 5. Sea/fisheries zoning(s) 6. Regular grid(s) for accounting (1 ha and 1 km^2)	Collect from relevant organisations the basic geographical layers that will structure the physical accounts. Check their consistency (geometry, projection). Produce a set of regular grids (based on official geographical standards). Create the database of Ecosystem Accounting Units (EAUs) for terrestrial ecosystems, rivers, marine coastal units and other sea accounting units. (N.B. it requires using a land-cover map for the baseline year).
Step 2: Collect the basic datasets		
Collect the basic datasets for ecosystem natural capital accounting: monitoring data and statistics	7. Land-cover change (including marine coastal areas) 8. Meteorological data 9. Hydrological data 10. Soil data 11. Data on forest stocks and growth 12. Population data 13. Regular agriculture, forestry and fishery statistics 14. Data/statistics on water use 15. Indicators on species and systems biodiversity	Produce a consistent multi-annual (10–20 year) land-cover map/database using satellite images and other sources available (forest maps, cadastre, buildings and roads...). Collect and organize the various sets of data needed for accounting. Official data sources are given priority: official statistics, meteorological data, hydrological data...where available, accounts produced for IPCC reporting, REDD+, SEEA Water... are important inputs. Satellite data sometimes as second best.
Step 3: Produce the core accounts		
Produce the core ecosystem natural capital accounts, measure total ecosystem capability, assess degradation or enhancement	Land-cover change account 16. Ecosystem carbon account 17. Ecosystem water account 18. Ecosystem integrity and functional services accounts 19. Ecosystem overall capability account (including exchanges between ecosystems)	Compile the accounts with basic data collected at Step 2, additional data for specific items and physical data modelling. Geo-process datasets. Estimate missing data. Integrate the accounts.

Objective	Datasets/ Accounts	Tasks for the accountant
Step 4: Functional accounts in physical units		
Functional analysis of ecosystem capital and services in physical units	20. Accountability of economic sectors for ecosystem capital degradation / enhancement 21. Ecosystem degradation embedded in trade 22. Ecological Balance Sheet (in ECU) 23. Social demand for ecosystem services (by ecosystem units, municipalities, regions...)	Targeted, detailed analysis to be carried out with statistical offices, planning agencies, environment agencies, the research sector etc. Compilation of the ecological balance-sheet. Mapping and assessing ecosystem services.
Step 5: Functional accounts in monetary units		
Functional analysis of ecosystem capital and services in monetary units: measurement of unpaid degradation costs; valuation of ecosystem services	**24. Unpaid remediation costs:** 25. accountability of economic sectors for ecosystem capital degradation/ enhancement 26. Ecosystem degradation embedded in trade 27. Ecological Balance Sheet in money terms 28. Adjustment of Final Demand from unpaid costs 29. **Monetary value of key ecosystem services** 30. Total (direct and indirect) value added by ecosystem services (agriculture, forestry, fishery, water, tourism etc.	Economic analysis of remediation costs (restoration works, alleviation, opportunity costs of reducing pressure on ecosystems etc..). Economic analysis of ecosystem services monetary value. Input/Output analysis of Value Added induced by ecosystem services; sustainability assessment
Steps 1 to 3 have to be done for all ecosystems and sectors. Steps 4 and 5 can focus on one particular ecosystem, service or economic sector.		