ANTHROPOCENE CURRICULUM & ANTHROPOCENE CAMPUS

November 14-22, 2014

Haus der Kulturen der Welt (HKW), Berlin

Valuing Nature: Beyond The Vital Balance Sheet

A Seminar by Sabine Höhler, Natalie Jeremijenko, and Ioan Negrutiu with Adrian Lahoud

Introduction to ecosystem natural capital accounting

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Because national accounts are based on financial transactions, they account for nothing in nature, to which we don't owe anything in terms of payments but to which we owe everything in terms of livelihood." Bertrand de Jouvenel, Arcadie, 1968

"The same rule of self-destructive financial calculation governs every walk of life. We destroy the beauty of the countryside because the unappropriated splendors of nature have no economic value. We are capable of shutting off the sun and the stars because they do not pay a dividend." John Maynard Keynes, 'National Self-Sufficiency,' The Yale Review, Vol. 22, no. 4 (June 1933), pp. 755-769

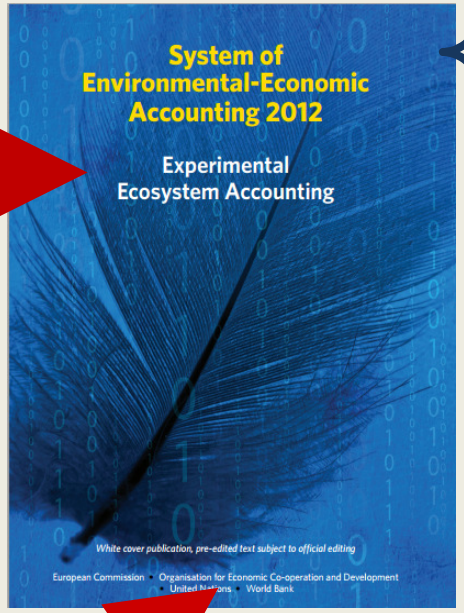
International statistical context: SNA and SEEA volumes 1 & 2

The System of Environmental-Economic Accounts "Central Framework" (SEEA-CF) adopted by the UN Statistical Commission in 2012 as an international statistical standard on par with the System of National Accounts (SNA 2008). 12) has been supplemented in 2013 by a volume on "Experimental Ecosystem Accounting" (SEEA-EEA). While the SEEA-CF is recommended for implementation, the SEEA-EEA which is a conceptual framework is now tested in various projects for which additional methodologies need to be defined. The CBD TS77 ENCA-QSP is a contribution to the development of such tests.

SNA

SEEA volume 1 "Central Framework"

SEEA volume 2 "Experimental Ecosystem Accounting"



SEEA-EEA Experiment

XXX

SEEA-EEA Experiment

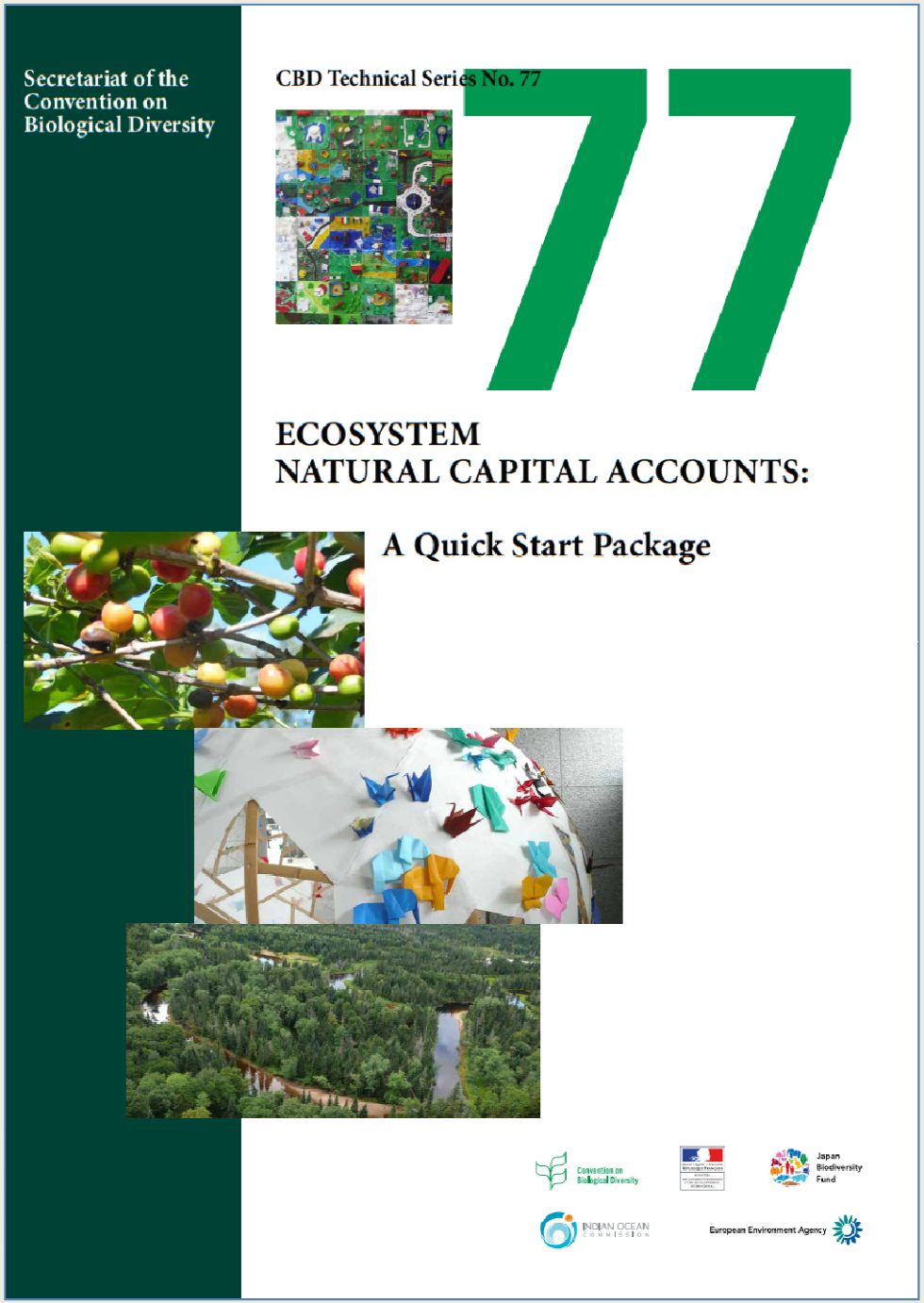
EU: ECA & MAES

Ecosystem Capital Accounts Mapping and Assessment of Ecosystem Services

SEEA-EEA Experiment

ENCA-Mauritius

Ecosystem/ Natural Capital Accounts

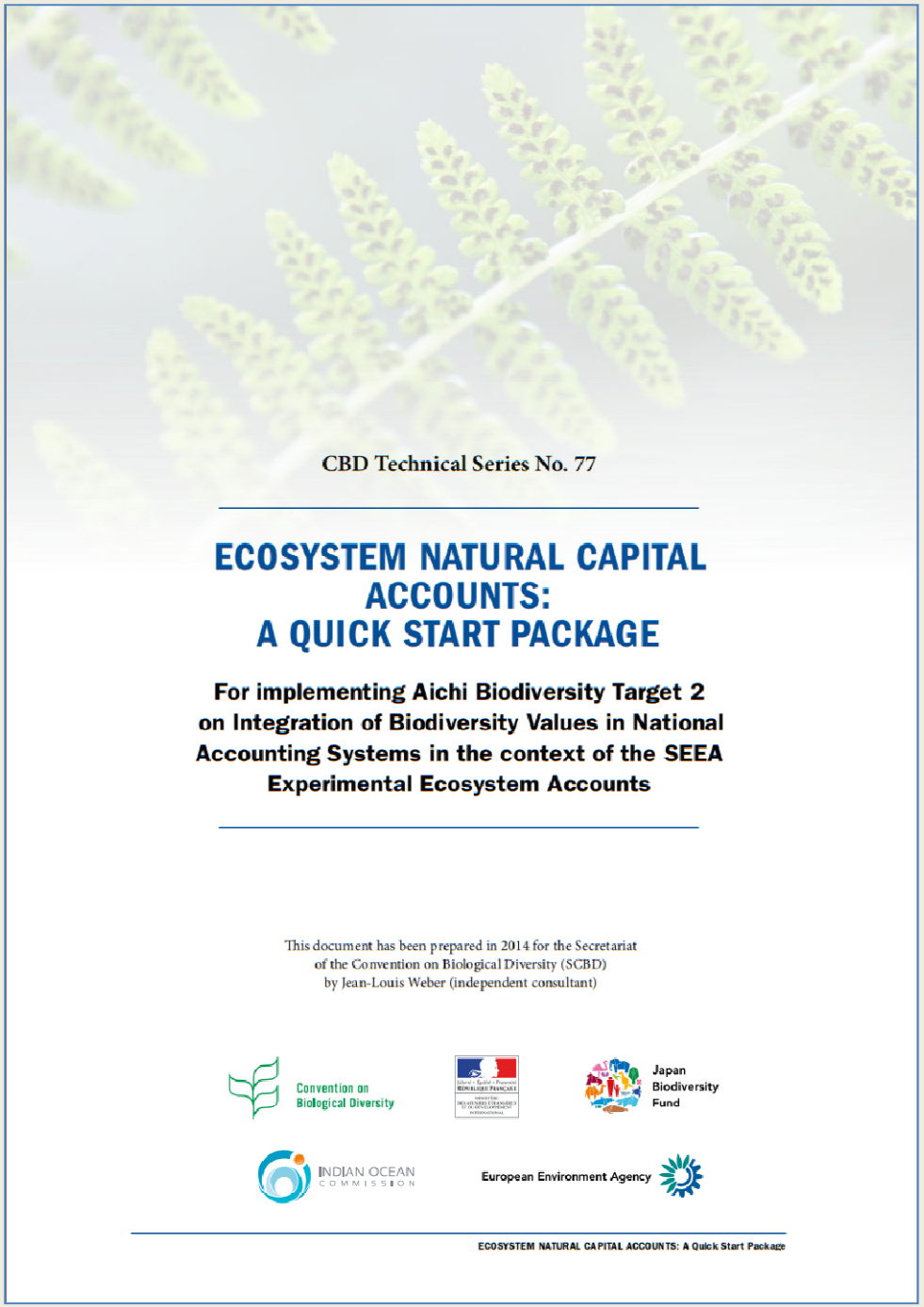


"In 2010, Parties to the CBD adopted Aichi Biodiversity Target 2, which calls for incorporating, as appropriate and by 2020 at the latest, biodiversity values into national accounting. This target is crucial to implementing the Strategic Plan for Biodiversity 2011-2020 and thereby addressing the underlying causes of biodiversity loss, in order to achieve its vision that "*by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people*".

This edition of the CBD Secretariat's Technical Series n°77 "*Ecosystem Natural Capital Accounts: A Quick Start Package*" provides the technical nuts and bolts for getting started in implementing this goal. Using existing data, countries can begin ecosystem accounting in accordance with the rules of national accounting and biodiversity data and indicators."

FOREWORD

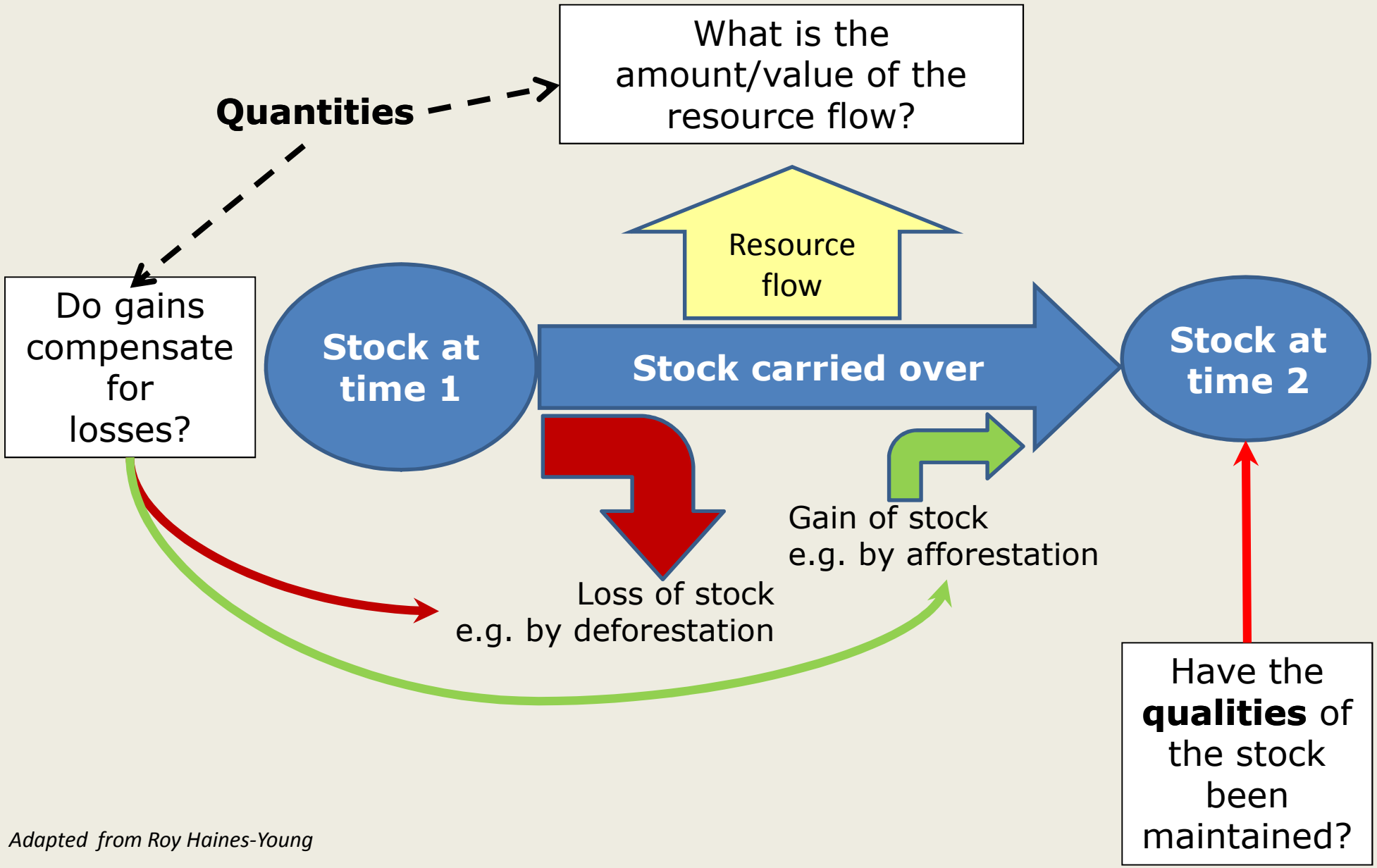
Braulio Ferreira de Souza Dias
Executive Secretary,
Convention on Biological Diversity



ENCA: a Quick Start Package

- Meet an **urgency**
- **Focus on core accounts in physical units** and calculation of ecosystem capability and degradation or enhancement.
- **Fast track implementation** with existing data; learning by doing
- **First test accounts**:
  - ➔ involvement of producers, data holders and stakeholder.
  - ➔policy relevance of results discussed with stakeholders.
  - ➔identification of data gaps and framing of an action plan for regular implementation
- In the **last chapter, further steps** are described : liability of economic sectors and ecological balance-sheet, restoration costs, valuation of services...

Ecosystem Natural Capital Account: an attempt to respond to basic questions



Adapted from Roy Haines-Young

Value is not just about money

…but maintaining an asset may have a cost

Paid maintenance/ restoration costs

Estimated cost of repairs (not yet paid) = Measurement of asset depreciation

Invaluable asset ➔ no monetary value… but a huge socio-cultural value

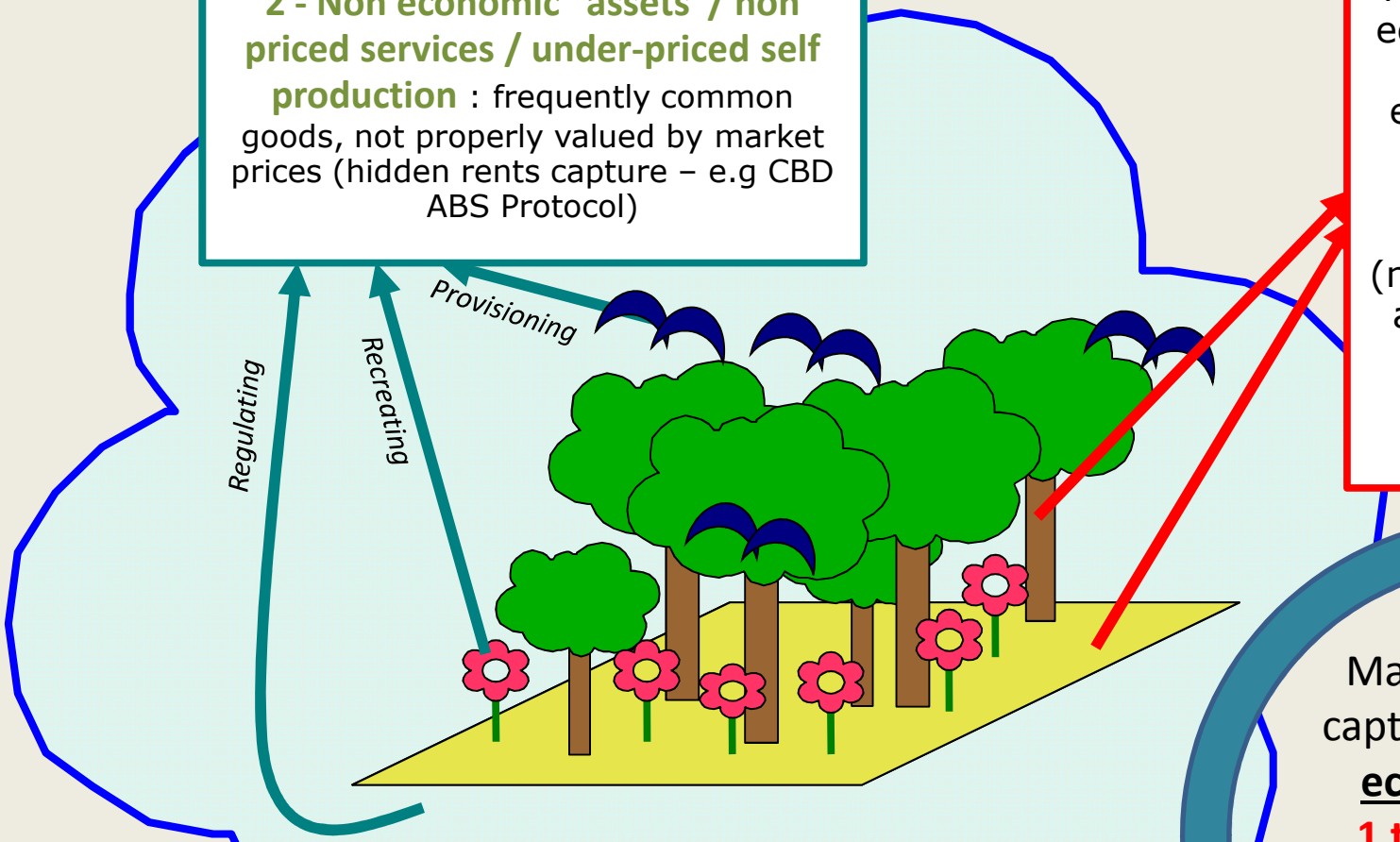
Cultural services, may generate income

Ecosystems assets and services : 3 “values” in 1

1 – SNA commodities and assets:
The value of ecosystem economic assets, goods and services is entangled into market values…

It includes all goods (not all services) for self account recorded at a production price of similar goods

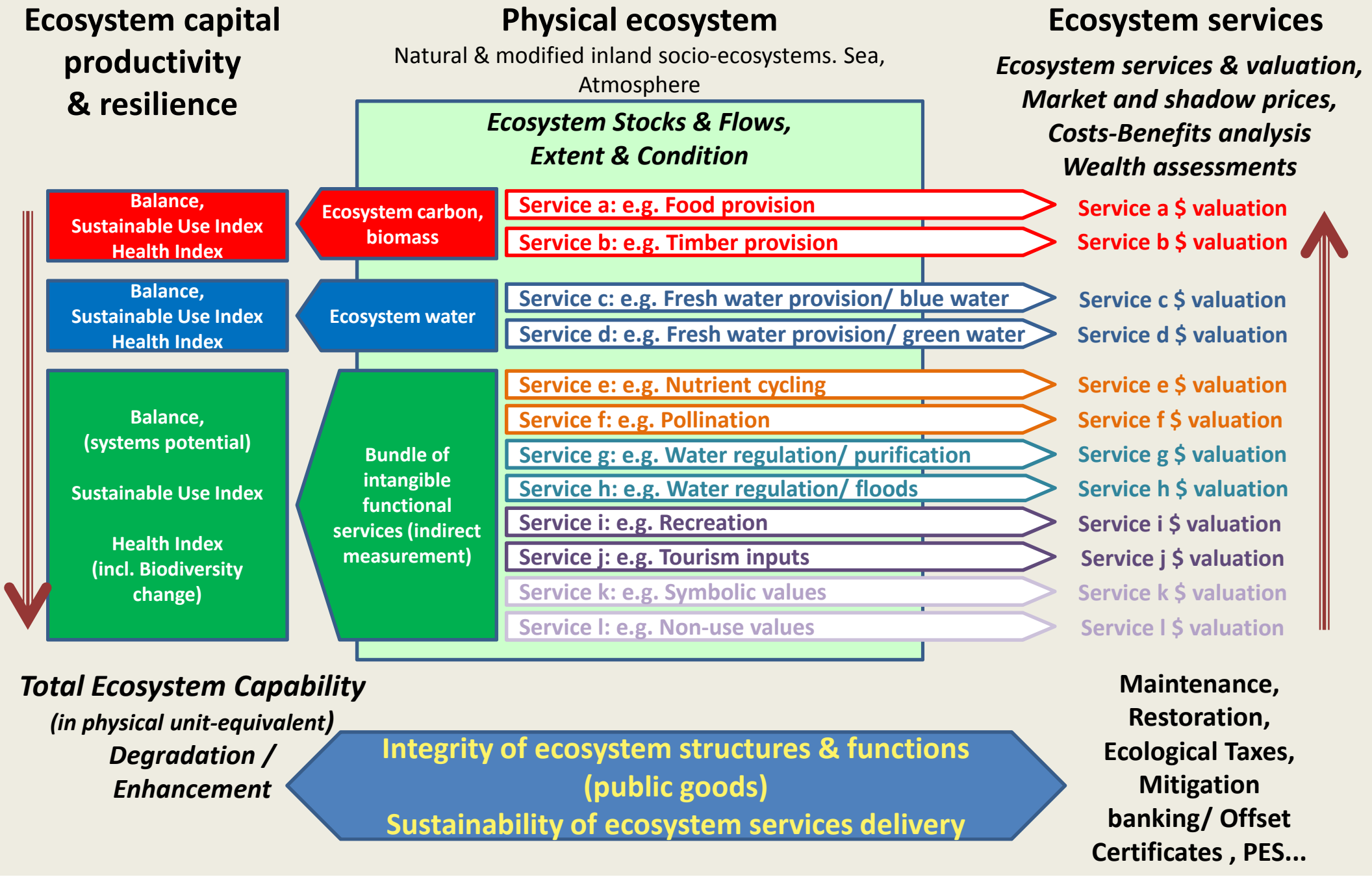
2 - Non economic “assets”/ non priced services / under-priced self production : frequently common goods, not properly valued by market prices (hidden rents capture – e.g CBD ABS Protocol)



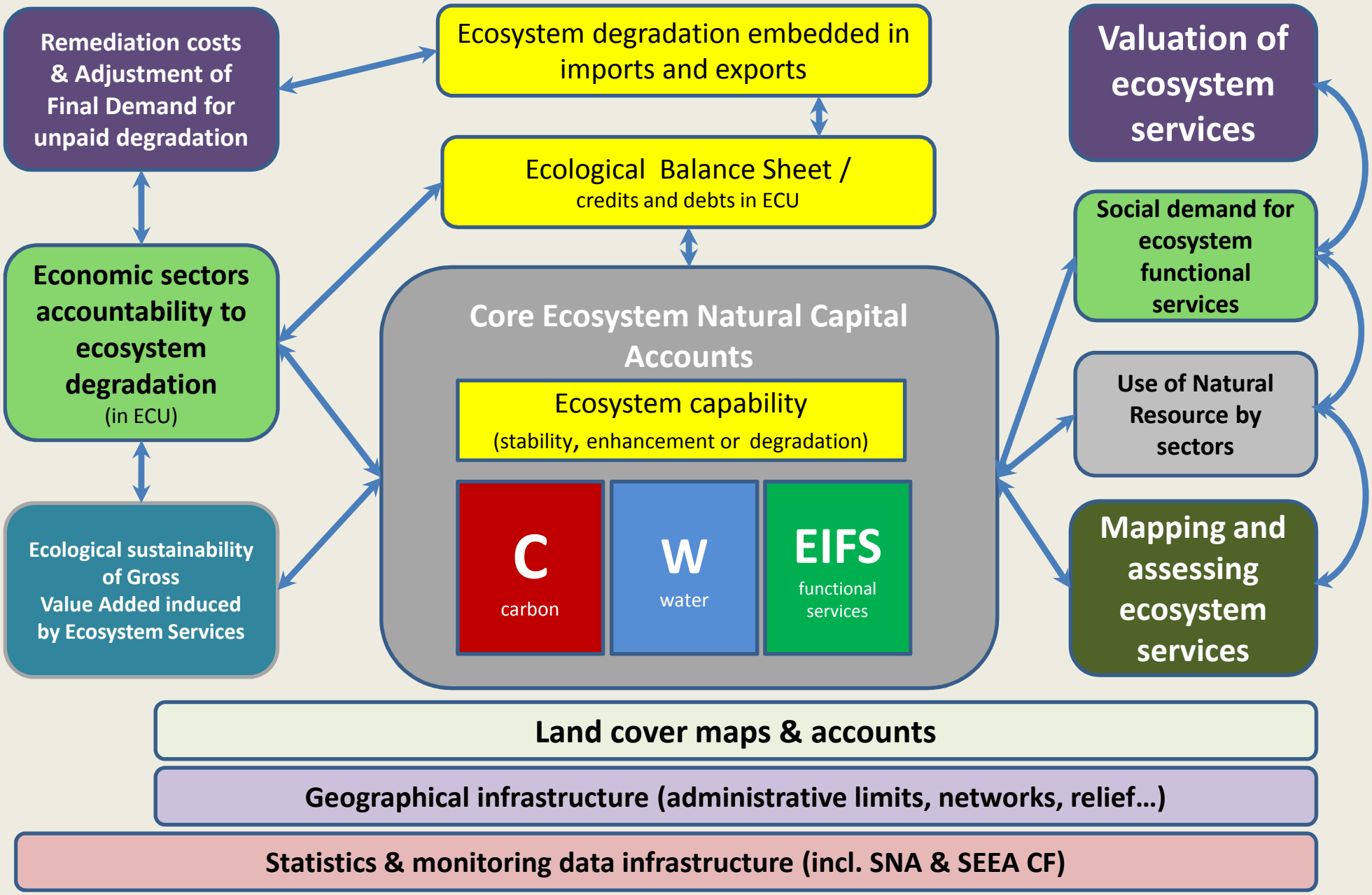
Market value don’t capture the complete **ecosystem value**:
1 to some extent,
2 imperfectly and
3 very poorly ➔
need of a different currency

3 – Ecosystem health: public good, non-rival, non-exclusive use, long term “value”, non-transferable ownership rights. It can be maintained (environmental expenditures, green taxes, offset certificates, PES…) or degraded.
Degradation is an Unpaid Cost

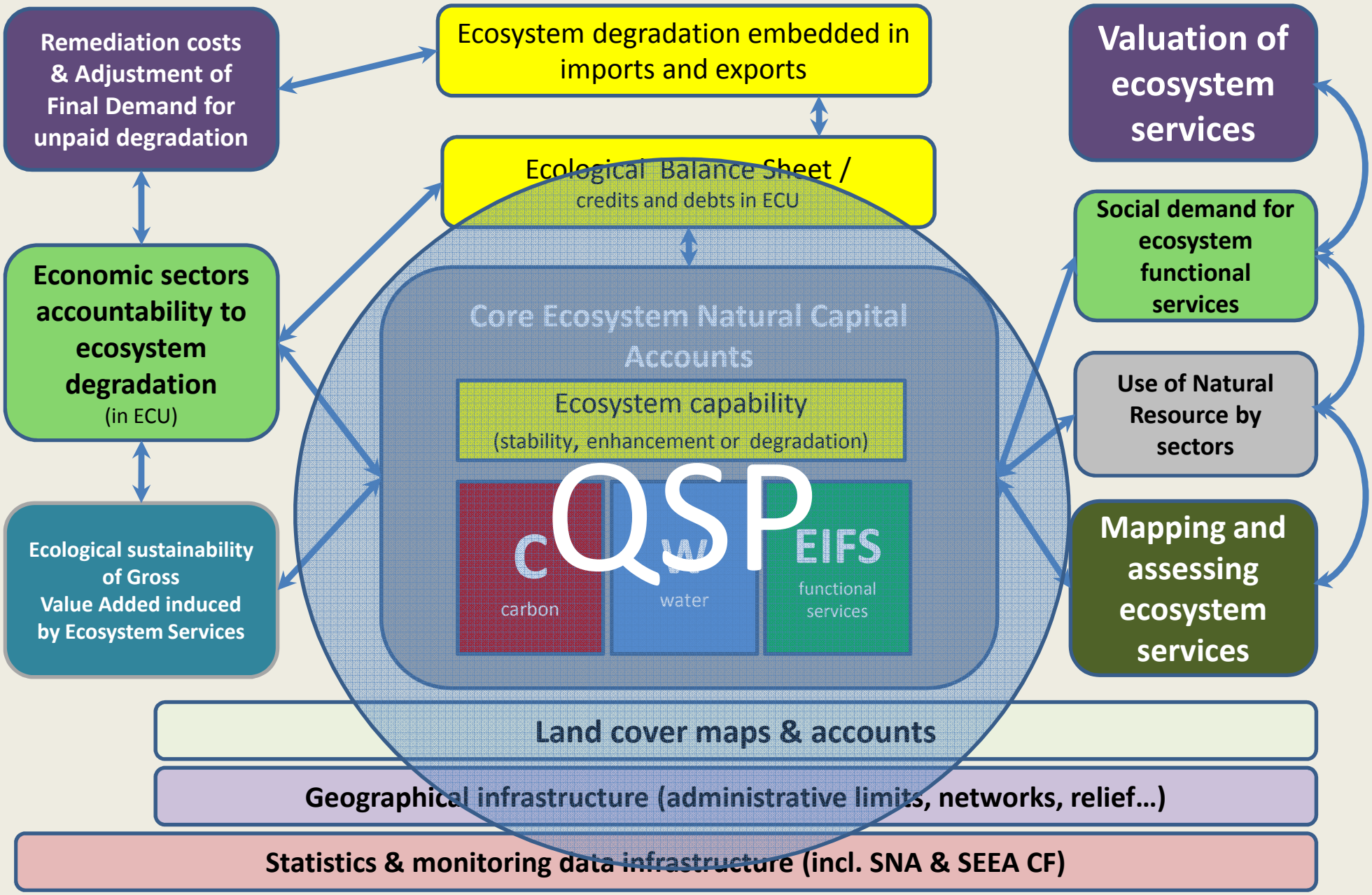
Two possible approaches to ecosystem accounting



Structure of Ecosystem Natural Capital Accounts



Structure of Ecosystem Natural Capital Accounts



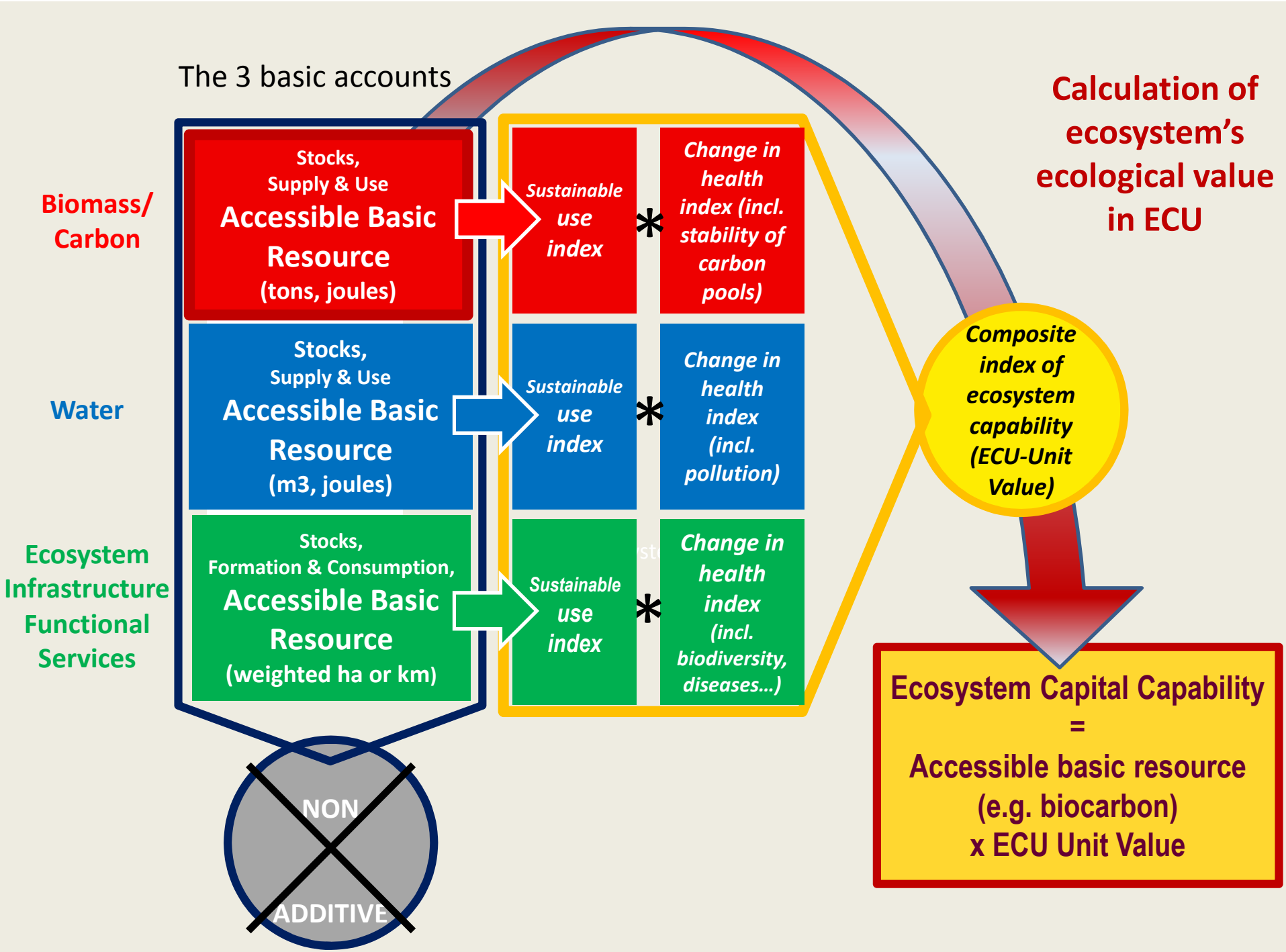
All ecosystems are addressed in ENCA

- Natural, semi-natural, managed, even urban ecosystems; the soil ecosystem is accounted as a sub-system of each surface ecosystem; the atmosphere is also an ecosystem...
- In the context of the CBD ENCA-QSP, priority is given to inland ecosystems and sea coastal ecosystems.
- Programmes on oceans and atmosphere can be started if sufficient involvement of the respective scientific communities can be found; linkages with IPCC are indispensable.

Need of a common unit for accounting

- Without a common unit, accounts aggregation is not possible.
- Simple physical units don't do the job...
- Climate change: **CO_2-equivalents** to measure contributions to global warming
- Green Growth: **tons (-equivalents)** to measure resource use efficiency
- Ecosystem/biodiversity: **Ecosystem Capability Unit (ECU)** to measure total ecosystem performance in delivering ecosystem services, now and in the future; stability, degradation or enhancement

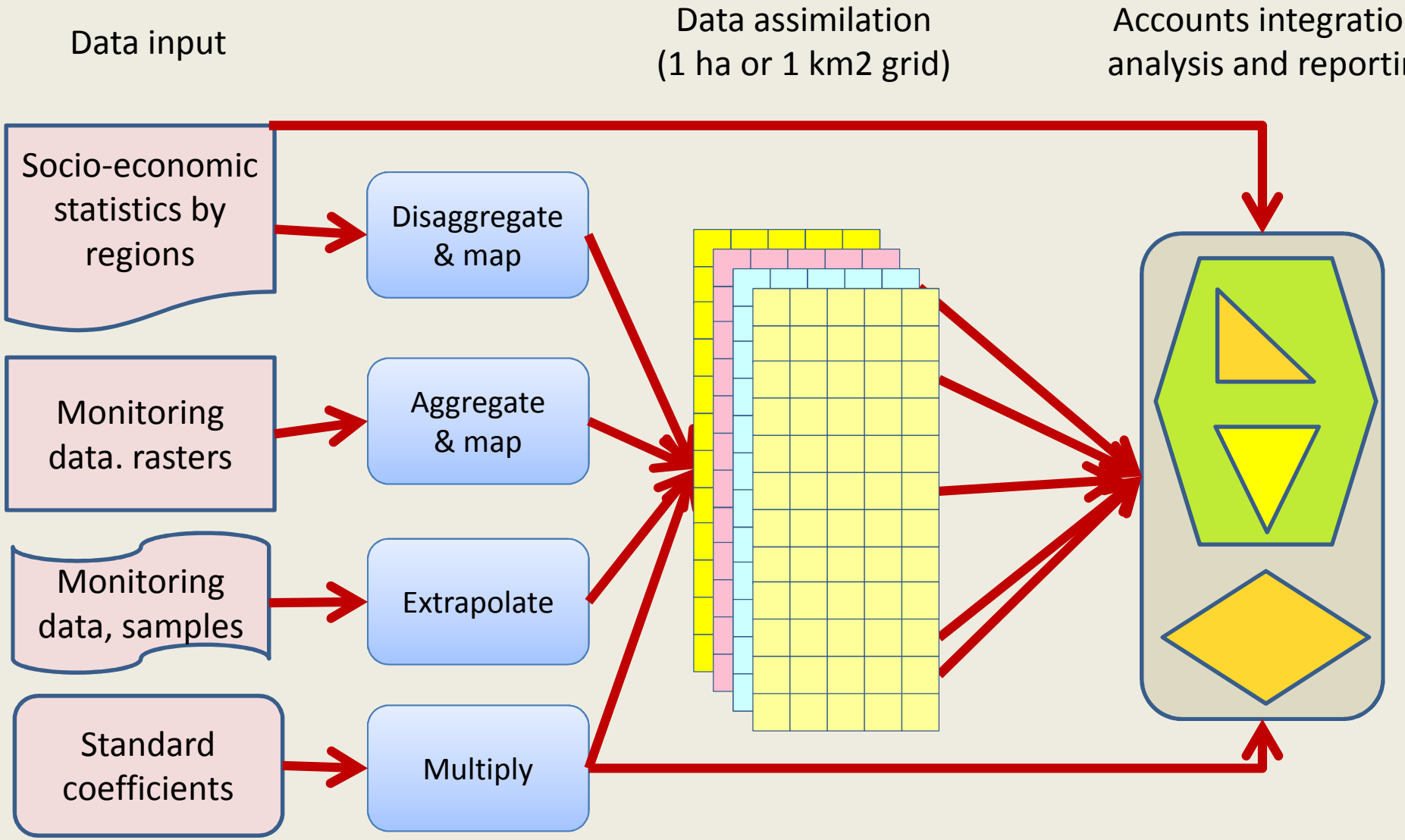
➔ Ecological value (in ECU) vs. Economic value (in $)


The 3 basic accounts
Biomass/ Carbon
Water
Ecosystem Infrastructure Functional Services
Stocks, Supply & Use Accessible Basic Resource (tons, joules)
Stocks, Supply & Use Accessible Basic Resource (m3, joules)
Stocks, Formation & Consumption, Accessible Basic Resource (weighted ha or km)
Sustainable use index
Change in health index (incl. stability of carbon pools)
Sustainable use index
Change in health index (incl. pollution)
Sustainable use index
Change in health index (incl. biodiversity, diseases...)
NON
ADDITIVE
Composite index of ecosystem capability (ECU-Unit Value)
Calculation of ecosystem's ecological value in ECU
Ecosystem Capital Capability
=
Accessible basic resource (e.g. biocarbon)
x ECU Unit Value

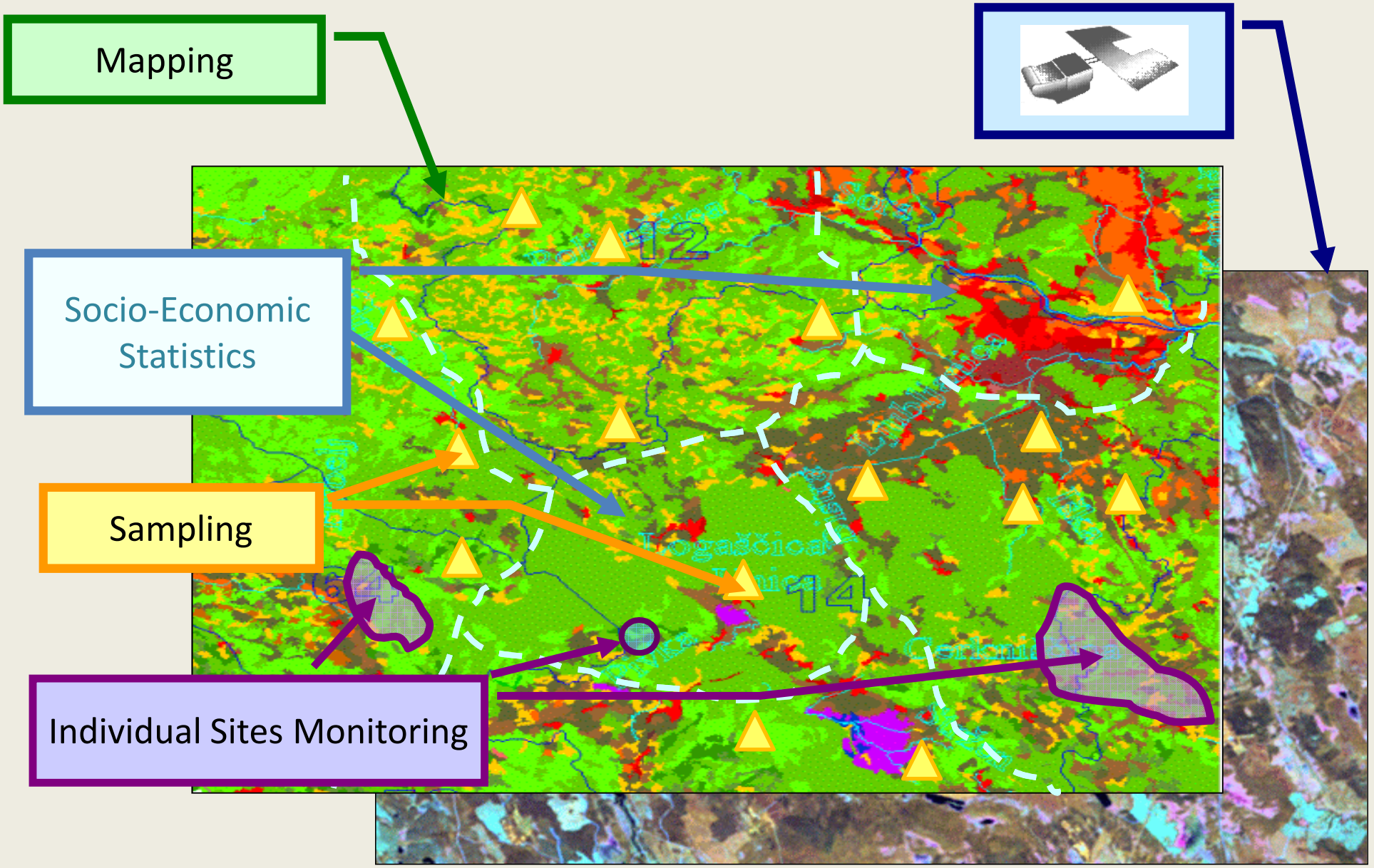
ENCA: An integrated accounting framework

- ENCA_simpl_model_jlw2014.xls

Main data flows to compile ecosystem capital accounts



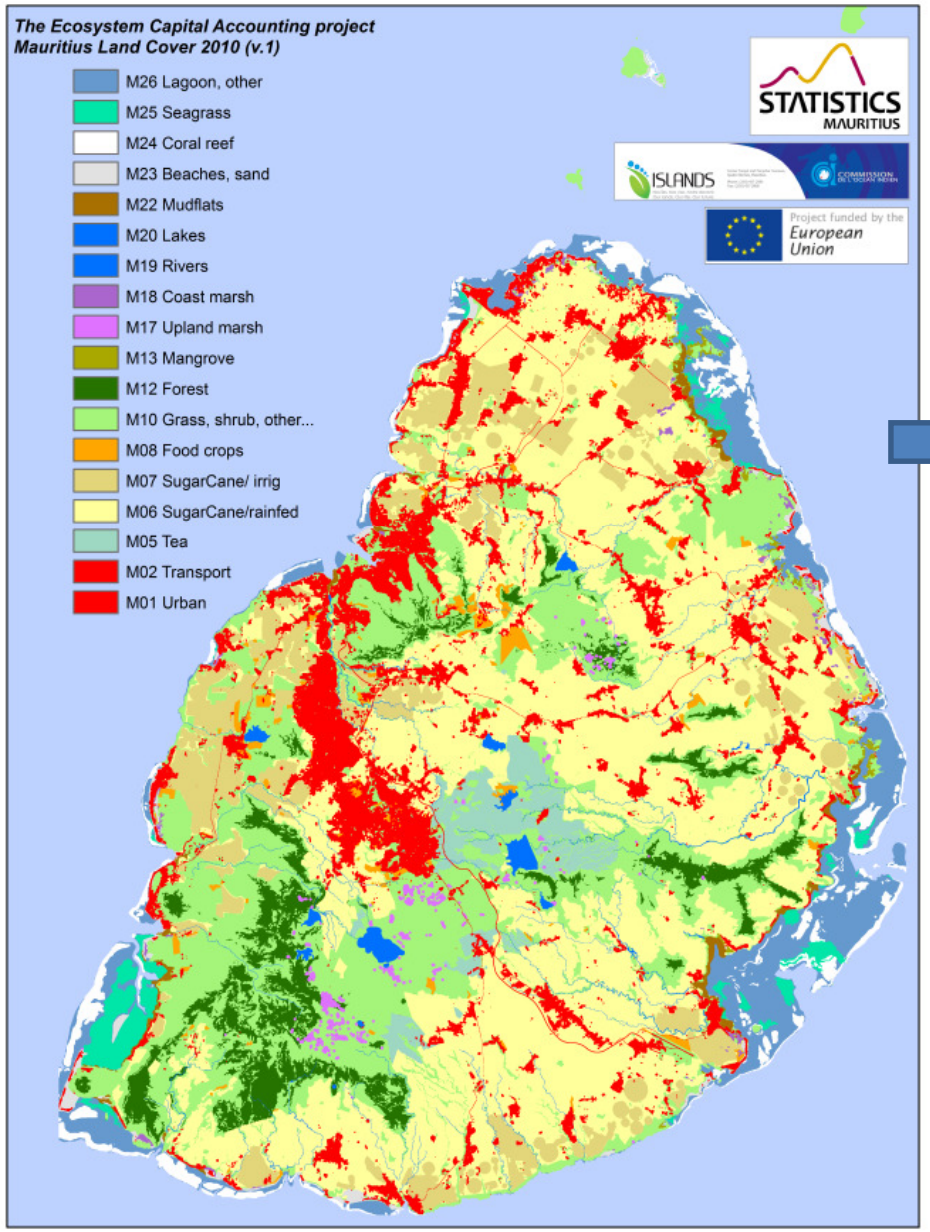
Spatial Integration of Environmental & Socio-Economic Data



Example of (experimental) ENCA for Mauritius

SEEA-ENCA Mauritius preliminary results :

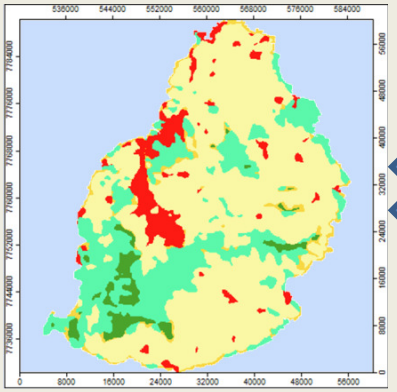
Creation of Ecosystem Accounting Units



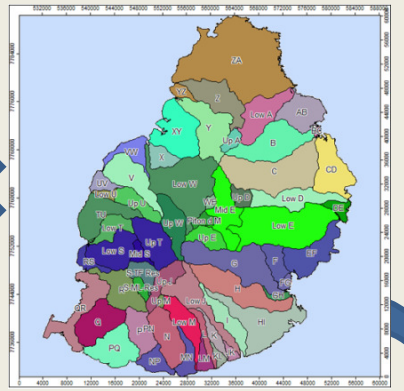
A land cover map has been produced from the start for:

1. **Defining statistical units for accounting (EAU) and**
2. **Computing the land cover account (next slide)**

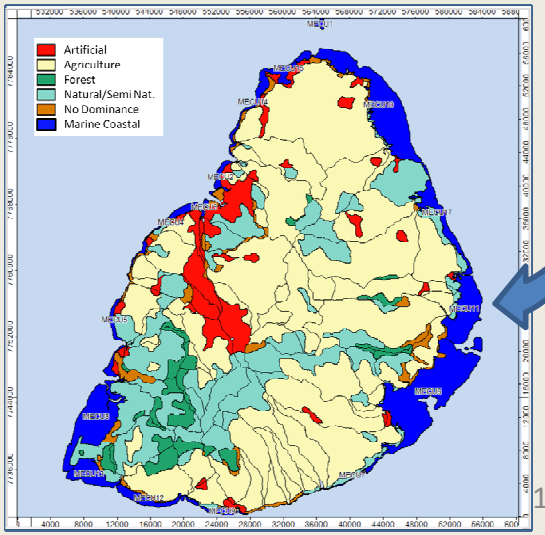
Dominant land cover types (>50%)



River sub-basins

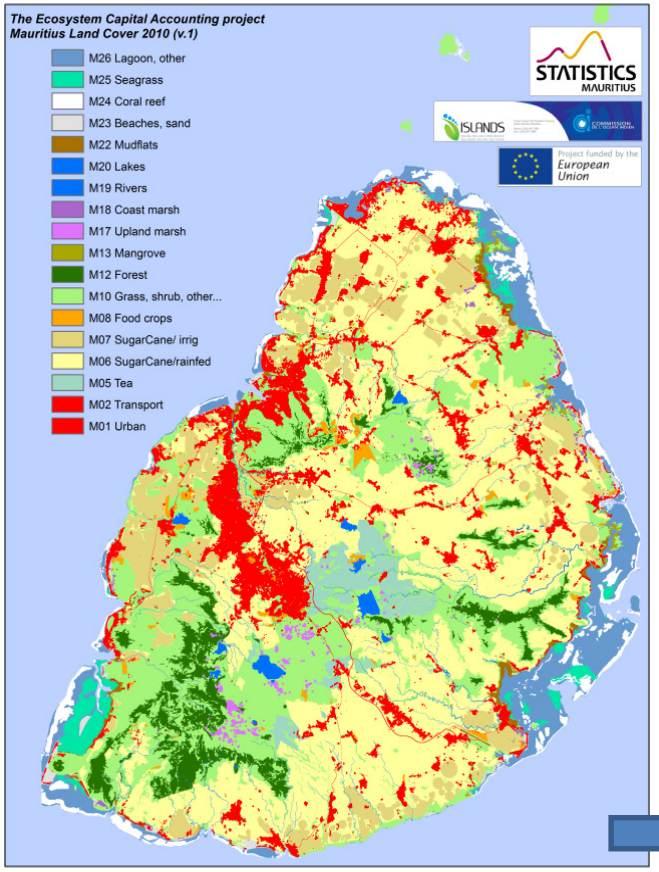


Socio-ecological landscape units (SELU) & Marine Coastal Units (MCU)



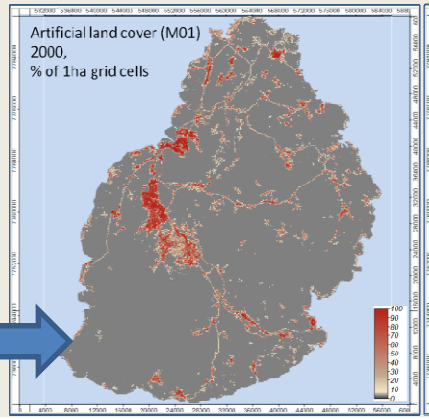
SEEA-ENCA Mauritius preliminary results :

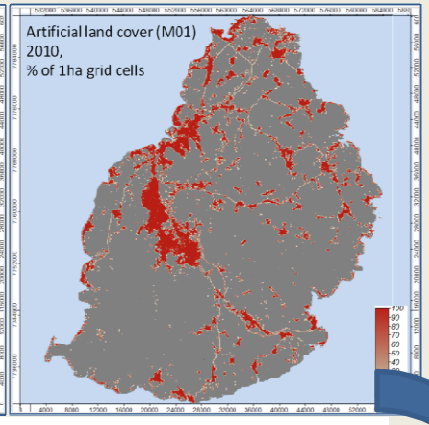
Land cover and change from 2000 to 2010



The land cover data are stored using geographical datasets which use grids (10m x 10m and 100m x 100m) at the most detailed level.

Urban land cover 2000 & 2010





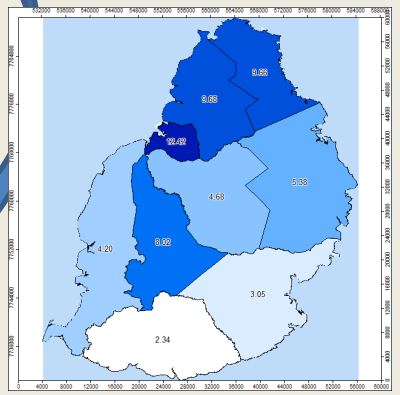
These grids allow computing statistics and producing ecosystems/natural capital accounts for various statistical units such as municipal and village council areas, districts, coastal zones, river basins, socio-ecological landscape units and any relevant zoning.

Land cover stock and change account/ urban sprawl **2000 2010 - km2**

Provisional

	Rivière du Rempart	Pamplemousses	Flacq	Moka	Grand Port	Plaines Wilhems	Black River	Savanne	Port Louis	TOTAL
District AREA SQKM	14703	18019	29826	23512	26134	19839	25558	24758	3976	186325
M01 Urban land cover 2000 v0	747	705	405	282	406	2060	334	266	2667	7872
M01 Urban land cover 2000 v1, adjusted	1225	1172	667	510	549	2456	542	379	3284	10782
lf1 Urban sprawl	478	467	263	228	143	396	208	112	616	2911
M01 Urban land cover 2010	1704	1639	930	738	691	2852	749	491	3900	13693

Urban sprawl 2000-2010 by Districts



SEEA-ENCA Mauritius preliminary results :

The biomass-carbon account

Carbon Accounts show the capacity of the ecosystems to produce biomass and the way it is used by crops harvests and trees removal or sometimes sterilised by artificial developments or destroyed by soil erosion or forest fires (in line with IPCC guidelines).

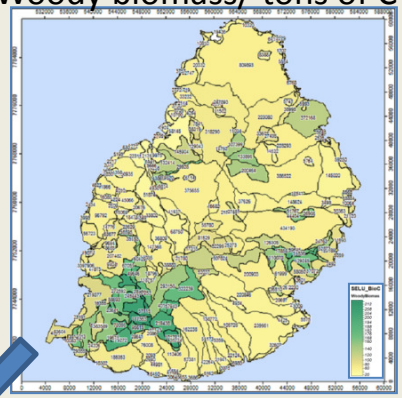
Accounts are compiled using various sources such as products based on earth observation by satellite (e.g. MODIS NPP), on in situ monitoring (for IPCC-LULUCF, FAO/soil, FRA2010) and official statistics .

Simplified bio-carbon accounts by districts, 2010 — **Tons of carbon**

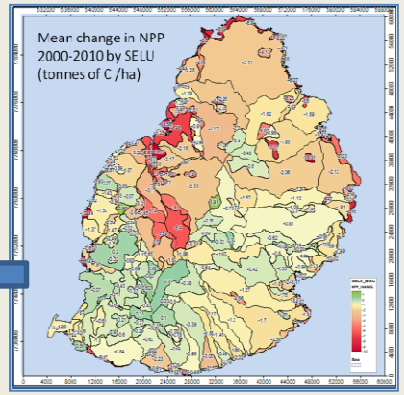
Provisional

2010	Riviere du Rempart	Pamplemousses	Flacq	Moka	Grand Port	Plaines Wilhems	Black River	Savanne	Port Louis	Tot
Initial stock 2010	**1457955**	**2101934**	**4135543**	**4165122**	**2855365**	**3327114**	**3173857**	**3196601**	**432317**	**24845808**
Woody biomass	873403	1137222	2068571	1744337	1796040	1643485	2224653	2409579	265193	**14162483**
Topsoil organic carbon	584551	964712	2066972	2420785	1059325	1683629	949204	787022	167124	**10683324**
Flows/inputs	**335582**	**417954**	**819601**	**675923**	**736068**	**454057**	**642970**	**739278**	**68922**	**4890354**
Net Primary Production	335582	417954	819601	675923	736068	454057	642970	739278	68922	**4890354**
Flows/outputs and decrease	**349143**	**448659**	**870542**	**708508**	**725853**	**481532**	**650835**	**744290**	**74976**	**5054339**
Removals, harvests	65446	90345	108405	56498	90172	35596	87914	81900	1698	**617974**
Wood removals										**0**
Sugarcane	*63718*	*86585*	*104230*	*52531*	*87208*	*31984*	*83773*	*80223*	*912*	**591165**
Food crops	*1727*	*3759*	*4175*	*3656*	*2918*	*3565*	*4141*	*1633*	*786*	**263**
Other cops	*0*	*0*	*0*	*311*	*46*	*46*	*0*	*44*	*0*	**447**
Decrease due to land use change	4102	4761	5762	3629	3240	5216	2881	2290	1388	**33269**
Other decrease (fire, erosion…)	14580	21019	41355	41651	28554	33271	31739	31966	4323	**248458**
Soil/decomposers respiration v2	265016	332534	715020	606730	603888	407449	528301	628133	67567	**4154638**
Net Ecosystem Carbon Balance 1 (flows)	***-13562***	***-30705***	***-50941***	***-32585***	***10215***	***-27475***	***-7865***	***-5012***	***-6054***	**-163985**
Statistical adjustment	16597	28379	33235	15034	-29421	11163	-19714	-15632	6178	**45819**
Net Ecosystem Carbon Balance 2 (stocks)	***3035***	***-2326***	***-17706***	***-17551***	***-19206***	***-16312***	***-27579***	***-20644***	***123***	**-118166**
Final Stock 2010	**1460990**	**2099608**	**4117837**	**4147571**	**2836159**	**3310802**	**3146278**	**3175957**	**432440**	**24727642**
Woody biomass	876438	1134896	2050865	1726786	1776835	1627173	2197074	2388935	265316	**14044318**
Topsoil organic carbon	584551	964712	2066972	2420785	1059325	1683629	949204	787022	167124	**10683324**
Net accessible bio-carbon resource 2010	**73600**	**83094**	**86875**	**51642**	**112974**	**30296**	**87089**	**90500**	**1479**	**617550**
Change in stocks in the previous year	3035	-2326	-17706	-17551	-19206	-16312	-27579	-20644	123	**-118166**
Flows/inputs (+)	335582	417954	819601	675923	736068	454057	642970	739278	68922	**4890354**
Soil/decomposers respiration v2 (-)	265016	332534	715020	606730	603888	407449	528301	628133	67567	**4154638**
Index of intensity of use of bio-carbon 2010	**112**	**92**	**80**	**91**	**125**	**85**	**99**	**111**	**87**	**100**

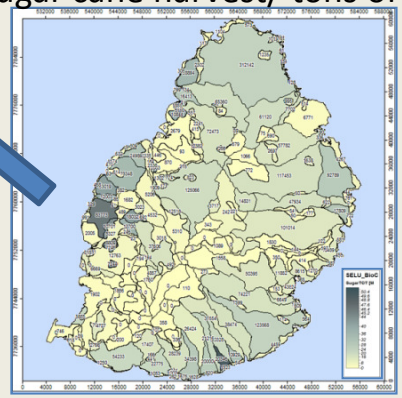
Woody biomass/ tons of C



Change in NPP/ tons of C



Sugar cane harvest/ tons of C

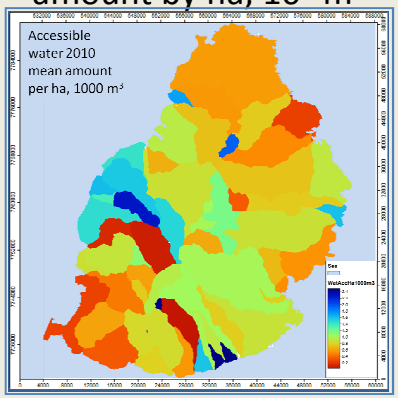


SEEA-ENCA Mauritius preliminary results :

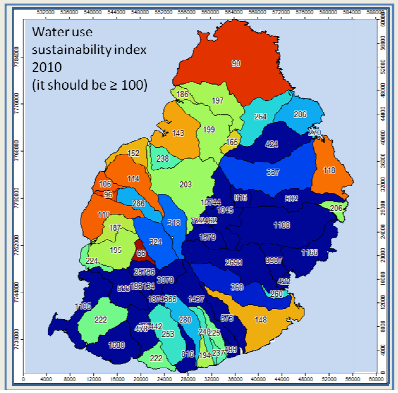
The ecosystem water account

The ecosystem water accounts follows the SEEA Water methodology and use preliminary results of the national water accounts. They are detailed by river basins and sub-basins where the hydrological system can be described consistently. Stocks of water are mainly aquifers and lakes/reservoirs, which play important role in Mauritius. Data have provided by the meteorological and water agencies. Water use by sub-basins is estimated from population census data and irrigation map. Satellite products have been used for evapotranspiration. The outcome is the calculation of the water really accessible for use and of an index of stress from water use intensity.

Accessible water, mean amount by ha, 10^3 m^3



Water use intensity stress index (stress when <100)



Simplified water accounts by Districts, 2010 — Mm3

Provisional

2010	Rivière du Rempart	Pamplemousses	Riviere	Moka	Grand Port	Plaines Wilhems	Black River	Savanne	Port Louis	Total
AREA_ha	*14703*	*18019*	*29826*	*23512*	*26134*	*19839*	*25558*	*24758*	*3976*	*186325*
Boreholes_nb	*105*	*164*	*100*	*83*	*110*	*146*	*131*	*30*	*12*	*881*
River runoff districts coeff	*35*	*20*	*150*	*150*	*100*	*100*	*80*	*100*	*20*	*755*
Lake 2010 ha	*0*	*103*	*0*	*468*	*41*	*511*	*109*	*19*	*0*	*1251*
Stocks	**3345**	**5231**	**3189**	**2681**	**3510**	**4687**	**4183**	**961**	**383**	**28170**
Aquifers	3343	5222	3184	2643	3503	4649	4171	955	382	28052
Lakes/reservoirs	0	7	0	32	3	35	7	1	0	86
Rivers	2	2	5	6	5	3	4	4	1	32
Soil/vegetation										
Net Inflows	**75**	**176**	**292**	**342**	**355**	**293**	**155**	**353**	**12**	**2052**
Rainfall	173	236	579	633	629	484	302	603	49	3688
EvapoTranspitation (actual), total	155	199	367	290	338	224	308	326	40	2247
EvapoTranspitation (actual), spontaneous	109	115	310	268	294	207	167	269	40	1779
Net transfers surface - groundwater	11	14	23	18	20	15	20	19	3	143
Transfers between basins		41		-41						0
Abstraction and Uses	**63**	**109**	**80**	**36**	**63**	**83**	**152**	**69**	**23**	**678**
Municipal Water Production	17	23	23	13	18	64	11	11	22	202
Use of water	*8*	*12*	*11*	*7*	*9*	*32*	*5*	*6*	*11*	*101*
Loss of water in distribution	*8*	*12*	*11*	*7*	*9*	*32*	*5*	*6*	*11*	*101*
Irrigation	46	85	57	22	44	17	141	57	0	468
Other	1	1	1	1	1	3	0	0	1	8
Waste water to rivers	**6**	**8**	**8**	**5**	**6**	**22**	**4**	**4**	**8**	**70**
Outflow to the sea	**78**	**46**	**324**	**318**	**217**	**212**	**172**	**213**	**50**	**1632**
Rivers runoff	74	42	318	318	212	212	170	212	42	1602
Waste water to the sea	4	4	6	0	5	0	2	1	8	30
Induced ETA, Evaporation	**46**	**85**	**57**	**22**	**44**	**17**	**141**	**57**	**0**	**468**
Net Flows	-103	-52	-156	-29	41	2	-304	19	-46	-626
Closing stocks	**3242**	**5179**	**3034**	**2652**	**3551**	**4690**	**3879**	**980**	**337**	**27544**
Accessible renewable water	**83**	**124**	**217**	**200**	**219**	**187**	**228**	**213**	**36**	**1507**
Water use intensity (1): Average/ha	**132**	**114**	**270**	**561**	**345**	**224**	**150**	**310**	**155**	
Water use intensity (2): 1st decile	**90**	**90**	**118**	**203**	**148**	**114**	**110**	**222**	**143**	

SEEA-ENCA Mauritius preliminary results :

The functional services account (depending from integrity and biodiversity)

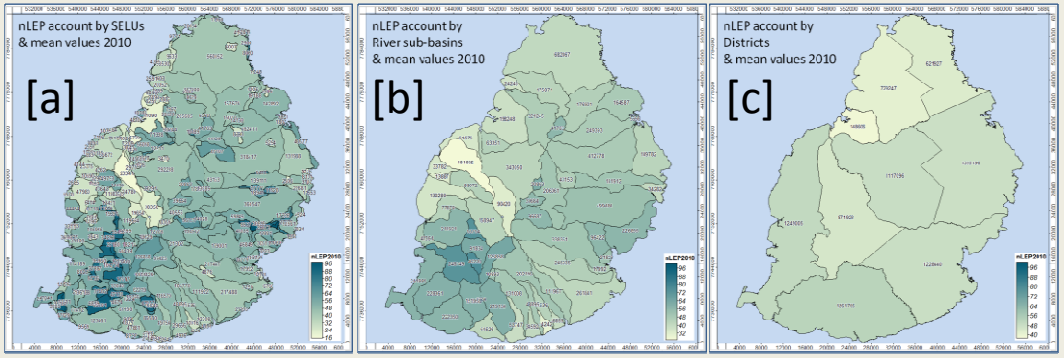
The biodiversity of systems and species account is made of two accounts which describe the state of ecosystems green infrastructure (landscapes, rivers and sea coastal zones) on the one hand and changes in species biodiversity on the other hand.

The NLEP index combines the green character of ecosystems and their fragmentation by roads which may alter their good functioning. Land cover is then weighted with NLEP.
Highest NLEP values can be found where forests, shrubs, grass and natural habitats are predominant, in particular in mountainous and land coastal areas. Low NLEP values correspond to urbanised areas and intermediate score reflect agriculture dominated catchments.

Green Infrastructure Accounts

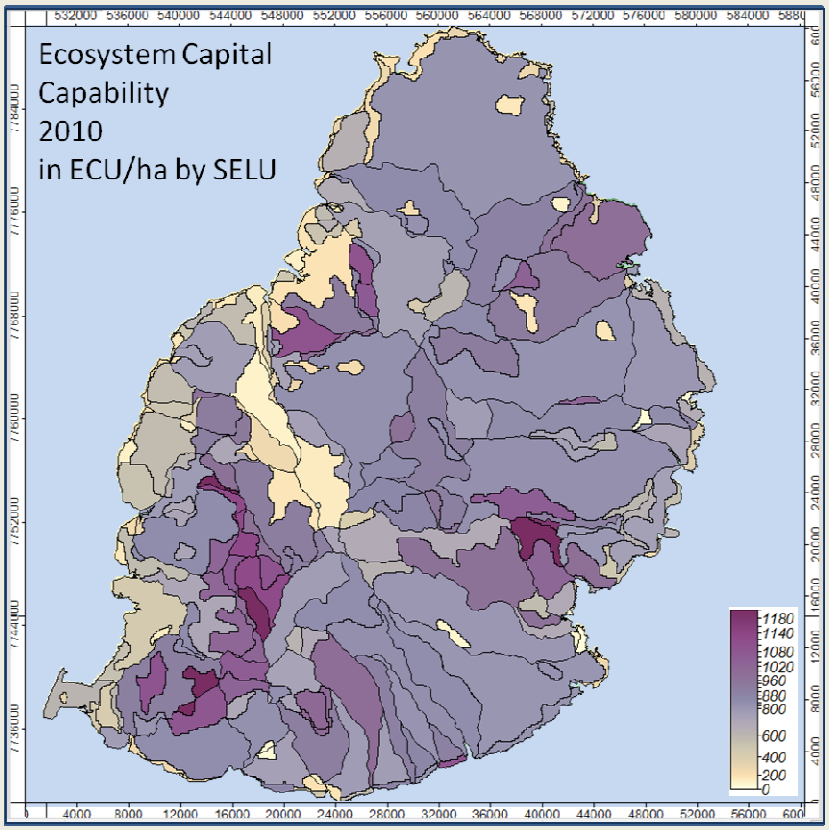
Provisional	*Riviere du Rempart*	*Pamplemousses*	*Flacq*	*Moka*	*Grand Port*	*Plaines Wilhems*	*Black River*	*Savanne*	*Port Louis*	**Total** */ Mean values*
AREA_ha	14703	18019	29826	23512	26134	19839	25558	24758	3976	186325
Indexes (0-100 value per ha)										
GBL 2000 index	*43.4*	*41.7*	*49.7*	*55.6*	*50.1*	*53.4*	*61.0*	*53.7*	*58.6*	*51.9*
Fragmentation index	*8.6*	*9.8*	*7.3*	*6.2*	*6.9*	*7.9*	*5.1*	*5.1*	*6.9*	*6.9*
nLEP 2000 index	*39.7*	*37.6*	*46.0*	*52.1*	*46.6*	*49.2*	*57.9*	*51.0*	*54.5*	*48.4*
Green Infrastructure Account										
GBL 2000 / weighted ha	638105	751152	1481482	1307506	1309039	1060139	1559660	1330151	232911	9670145
nLEP 2000 / weighted ha	583021	677761	1373059	1226033	1218167	976061	1479992	1262700	216727	9013521
Indexes (0-100 value per ha)										
GBL 2010 index	*42.0*	*40.6*	*49.2*	*55.1*	*49.8*	*52.4*	*60.5*	*53.5*	*50.7*	*51.1*
Fragmentation index	*8.6*	*9.8*	*7.3*	*6.2*	*6.9*	*7.9*	*5.1*	*5.1*	*6.9*	*6.9*
nLEP 2010 index	*38.4*	*36.7*	*45.6*	*51.6*	*46.4*	*48.2*	*57.4*	*50.8*	*47.2*	*47.7*
Green Infrastructure Account										
GBL 2010 / weighted ha	617999	732184	1468542	1294945	1301938	1039397	1547086	1324150	201660	9527900
nLEP 2010 / weighted ha	564651	660647	1361066	1214254	1211558	956963	1468060	1257003	187648	8881851
Change in nLEP 2000-2010	**-18370**	**-17114**	**-11993**	**-11779**	**-6608**	**-19097**	**-11932**	**-5697**	**-29079**	**-131670**
Change in nLEP index % 2000-2011	**-3.2**	**-2.5**	**-0.9**	**-1.0**	**-0.5**	**-2.0**	**-0.8**	**-0.5**	**-13.4**	**-1.5**

Net Landscape Ecosystem Potential (NLEP) 2010 by SELU [a], River basins [b] and Districts [c]

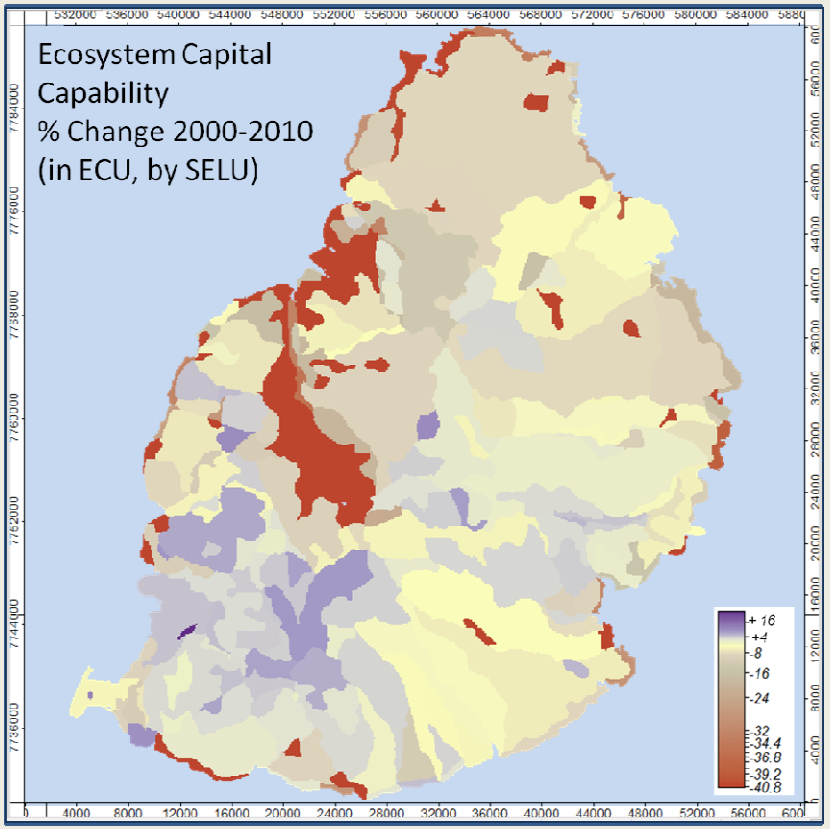


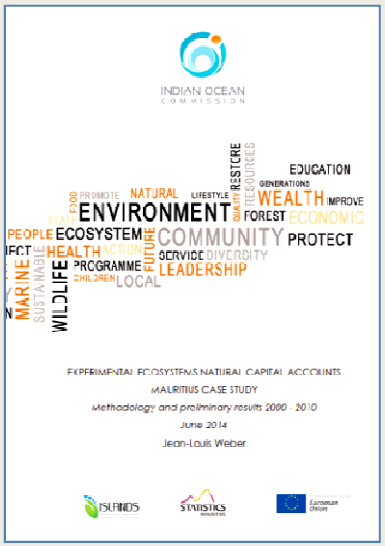
A first attempt to calculate Ecosystem Capital Capability (in ECU) for Mauritius

Ecosystem Capital Capability:
ECU value by Socio-Ecological Landscape Units, 2010



Ecosystem Capital Capability (inland):
Change in ECU value, % by Socio-Ecological Landscape Units, 2000-2010





Provisional results

Experimental ENCA, Mauritius Case Study (IOC, 2014)

Experimental ENCA for Berlin?

- Test feasibility with existing data
- Assess policy relevance
- Improve the accounting framework re specific urban issues

➔ Need of an inception study

- ❖ Screening of the issues addressed so far by existing sustainable development policies re Berlin as a urban ecosystem: priorities, gaps
- ❖ Screening of available data which could be used or reused for accounting

- ❖ ENCA Headings:
- ❑ Land cover/ land use change
- ❑ Ecosystem carbon, accessibility, use, qualitative aspects, footprint
- ❑ Water footprint, accessibility, use, qualitative aspects, footprint
- ❑ Ecosystem infrastructure functional services, accessibility, qualitative aspects, use, footprint
- ❑ Specific ecosystems services / quantity and value
- ❑ Ecosystem maintenance and restoration / quantity and costs, legal and economic instruments

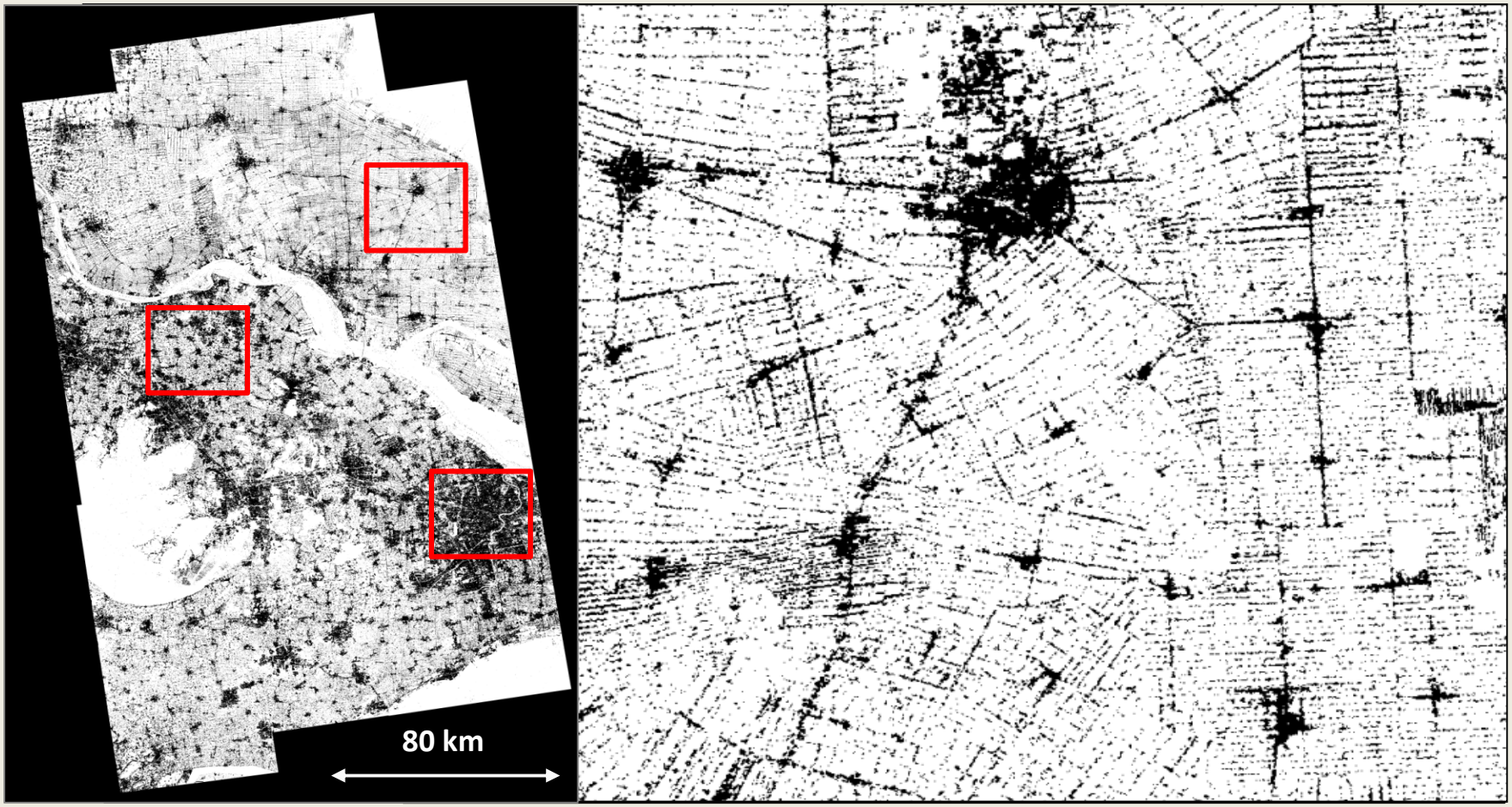
Simplified classifications of land cover types and land cover flows, to be detailed according to national/local conditions

Land cover types	
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)

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

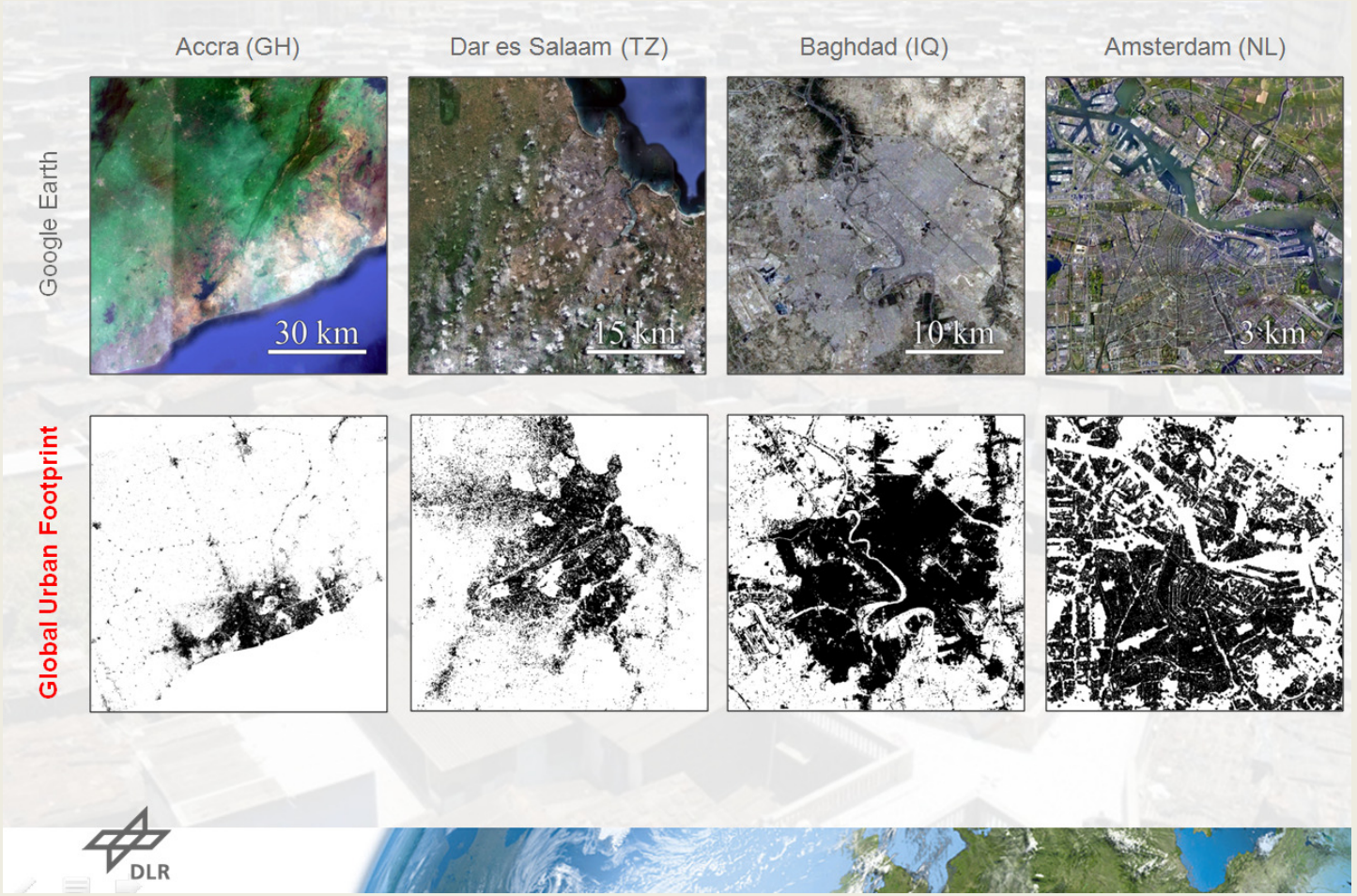
Land cover flows regroup elementary changes according to land use and natural processes

Global Urban Footprint by DLR



Shanghai (China)

Global Urban Footprint by DLR



M. Marconcini & T. Esch

German Aerospace Center (DLR)
German Remote Sensing Data Center (DFD)
Land Surface (LAX)
Urban Area and Land Management Team

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 under the UNFCCC Kyoto Protocol are accounts[1] Not all the information collected in following IPCC Guidelines is directly usable but a large part of it is a valuable input to ecosystem accounting. The IPCC principles take into account a variety of situations and propose an incremental approach. Regarding carbon, data availability therefore varies from one place to another. Since ENCA-QSP recommends using the best available data in countries, there is no one-fits-all solution. This variety of conditions is taken into account in this chapter.

5.02 An ecosystem carbon account records an ecosystem's sustainable capacity to produce biomass, measured as biocarbon, and the way this is used by crops, harvest and tree removal, sterilized by artificial developments, and destroyed by soil erosion or forest fires. It also records the carbon that is assimilated by the atmosphere and oceans. The account records, in tonnes of carbon, the stocks available in soil, below- and above-ground vegetation, and in water (fish and vegetal species), the flow of gross primary production (GPP) of biomass by natural and cultivated vegetation, and its use by crops and timber harvests as well as by nature itself. The secondary production of animal biomass is added to the primary production.

5.03 In addition to inland ecosystems, the accounts cover seas – fisheries, sea grass and algae, plankton and net accumulation of calcium carbonate ($CaCO_3$) produced by corals and other calcifying organisms, and sea-regulating capacity. The atmosphere's climate regulation ecosystem service is also considered here. For this, the capacity of the system to sequester carbon (in biomass) or to assimilate greenhouse gases (measured in carbon dioxide (CO_2)-equivalents) up to the agreed UNFCCC target[2] of a maximum increase of temperature of 2 °C defines the limits of total carbon use without ecosystem 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.

5.04 Formally, the biocarbon account is a development of SEEA and connects accordingly to the SNA. This consistency is improved by the use of official statistics on agriculture, forestry and fisheries. It includes a link to a calculation of the total use of carbon of biological and fossil origin, which corresponds to a subset of the material flows accounts commonly used to support strategies such as resource efficiency (European Union) or green growth (OECD). At the same time, ecosystem biocarbon accounts seek the maximum consistency with IPCC reporting, in particular regarding the LULUCF sector and agriculture, forestry and other land use (AFOLU)[3]. The ecosystem perspective is very specific compared to the economic management of natural resources and the objectives of mitigating greenhouse gas emissions to the atmosphere; but the consistency of ecosystem carbon accounts with national accounts and with the climate-change programme makes them tools easy to integrate into decision-making processes.

5.05 Accounts are compiled using various data sources available within countries or at the international level. They include various kinds of monitoring data and statistics on the environment and natural resources, meteorology, and official statistics, particularly on agriculture, forestry and fisheries. Earth observation by satellite is an important data source used together with *in-situ* monitoring and statistics. National data compiled for international programmes such as IPCC-LULUCF/AFOLU, FAO SoilBase and Forest FRA2010[4] inventories and FishStat are convenient sources to start implementing ENCA-QSP, although their data need

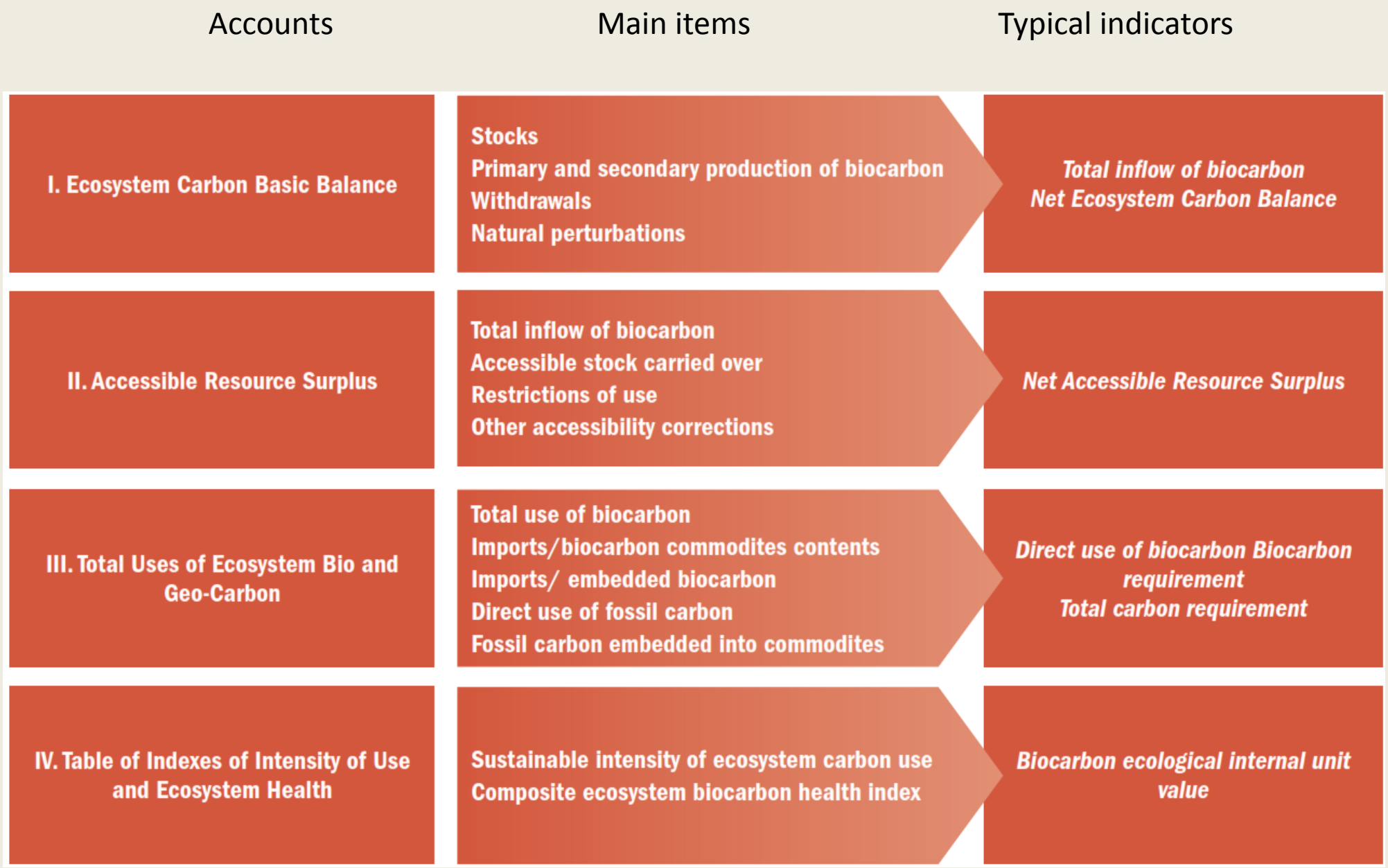
1 *Instead, the accounts established for the same convention relate to debits and credits established according to targets or commitments.*

2 *https://unfccc.int/essential_background/items/6031.php (accessed 14 July 2014)*

3 *Agriculture, forestry and other land use (AFOLU) is a term from the 2006 IPCC Guidelines describing a category of activities that contribute to anthropogenic greenhouse gas emissions. Used in national greenhouse gas inventories, the AFOLU category combines two previously distinct sectors – LULUCF and agriculture.*

4 *The Global Forest Resource Assessment (FRA) is carried out by FAO (with countries and other organizations) every five years.*

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***


Accounts
Main items
Typical indicators
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

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] and in Spain[2] since the early 1980s, using largely similar and complementary methodologies. Both accounts covered water quantity at the river-basin level and were aggregated nationally; the relationships between stocks and flows were described on the basis of systems analysis of the interaction between the water system itself, which includes natural assets and flows as well as in-stream uses, and a use system, defined restrictively in relation to water abstraction, transport and returns. Both applications considered both water quantity and quality. On the quality issue, while the French accounts attempted to use quality indicators of rivers, the Spanish accounts developed an approach based on thermodynamic measurements of water exergy losses, integrating quantity and quality aspects into one number. Both programmes included accounts of water expenditure. The water accounting methodology has been used in Chile[3] and Moldova[4]. Development of exergy-based water accounts has continued in Spain at the University of Zaragoza in the context of an overall approach to environmental accounting based on the calculation of exergy physical costs, with several regional applications developed[5], and preliminary tests carried out jointly with the European Environment Agency.

6.03 Water accounts have been implemented by the Australian Bureau of Statistics (ABS) since the early 1990s with a focus on the use of water by economic sectors. The ABS methodology follows the SEEA – ABS contributed to its development – and in particular SEEA-Water (see below). Water Account Australia (WAA) "*presents information on the supply and use of water in the Australian economy in 2011–12 in both physical (i.e. volumetric) and monetary terms. The focus of Water Account Australia (WAA) is on the interactions between users within the economy and the environment. The economy extracts water for consumption and production activities. The infrastructure to mobilize, store, treat, distribute and return water back to the environment forms part of the economy*"[6]. Water Account Australia (WAA) has been available since 1993 and has been updated annually since 2008[7].

1 *In Les Comptes du Patrimoine Naturel, CICPN, 1986, Les Collections de l'INSEE: 535-536. Série C, 137-138.*

2 *Spanish accounts were presented to the OECD (Pilot Study on Inland Waters, OECD, ENV/EC/SE (90) 24) in 1990 and published later in Spanish Water Accounts, by Jose Manuel Naredo in Environmental Economics in the European Union, Mesonada, C.S-J. (ed.). 1997. Mundi Prensa, Madrid.*

3 *Meza F., Jiliberto R., Maldini F. et al. 1999. Cuentas Ambientales del Recurso Agua en Chile. Documento de Trabajo N° 11, Serie Economía Ambiental, Pontificia Universidad Católica de Chile, Facultad de Agronomía y Ciencias Forestales, Santiago, Chile*

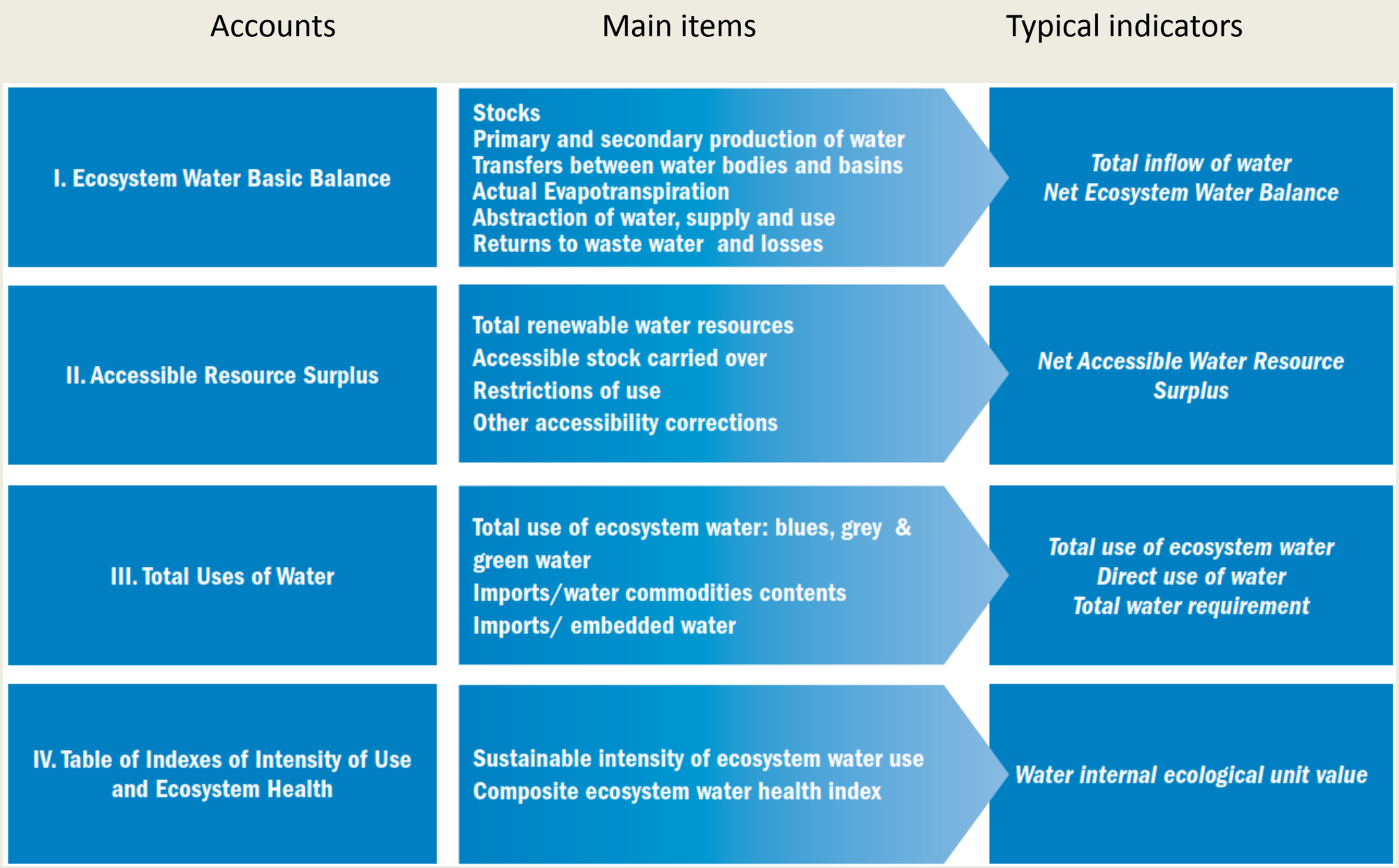
4 *Tiffi J. and Weber J.-L. 2000. Inland Water Accounts of the Republic of Moldova - Preliminary Results of Resource Accounts in Raw Quantities, 1994 and 1998. Technical report, Eurostat.*

5 *Valero A. et al. 2006 Physical Hydronomics: application of the exergy analysis to the assessment of environmental costs of water bodies. The case of the Inland Basins of Catalonia. http://teide.cps.unizar.es:8080/pub/publicir.nsf/codigospub/0436/$FILE/cp0436.pdf (accessed 14 July 2014).*

6 *http://www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0 (accessed 14 July 2014).*

7 *The Australian accounts from 1993 up to now are accessible at http://www.abs.gov.au/AUSSTATS/abs@.nsf/second+level+view?ReadForm&prodno=4610.0&viewtitle=~2011%9612~~&&tabname=Past%20Future%20Issues&prodno=4610.0&issue=2011%9612&num=&view=& (accessed 14 July 2014).*

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*


Accounts
Main items
Typical indicators
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

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

7.1.1 Physical flows of functional services cannot be measured directly because they are intangible.

7.02 Ecosystems are multifunctional and potentially deliver a bundle of material and intangible services which are used in various proportions according to the natural or socio-economic contexts. Services may be delivered directly to final users, protection from floods by forests, for example, or indirectly though intermediate inputs to services such as agricultural products or timber from managed forests. Uses can be either exclusive or synergetic. Uses can take place in the same ecosystem accounting unit (EAU: SELU, MCU or RSU[1]) as their generation, or in a different zone. In the absence of complete modelling of these interactions, including input-output analysis and imports-exports between EAUs, attempts to describe ecosystem capital capability by summing of ecosystem services would result in omissions and/or double counting.

7.03 The SEEA-EEA acknowledges the accounting issue in paragraph 3.45. "*if a choice is made to use an alternative boundary for the measurement of ecosystem services related to crops and other plants, then some adaptation of the CICES would be required. It is noted that if ecosystem services are measured using flows of harvested crops, then it is necessary to exclude flows relating to the growth of these plants such as pollination, abstraction of soil water, etc. Put differently, both pollination and harvested crops should not be combined in a measure of "final" ecosystem services. This would represent a "double count" in accounting terms*".

7.04 The ENCA-QSP approach to ecosystem services follows the option given in SEEA-EEA paragraph 3.45 where harvested crops are all included. This is done in the biocarbon account, where crops are considered as a joint economy-ecosystem outcome. This approach is consistent with the common definition of ecosystem services in the Millennium Ecosystem Assessment, in The Economics of Ecosystems and Biodiversity (TEEB)[2] or in the EU Mapping and Assessment of Ecosystems and their Services (MAES)[3] accounting project. As a consequence, no sum total of ecosystem services is presented – which would be difficult to achieve anyway in physical terms

1 *SELU: Socio-ecological landscape unit; MCU: Marine coastal unit; RSU: River system units.*

2 *The TEEB project is steered by UNEP. http://www.teebweb.org/ (accessed 14 July 2014)*

3 *MAES refers to the CICES 4.3 version. Provisioning services include "all material and biota-dependent energy outputs from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacture". Mapping and Assessment of Ecosystems and their Services (MAES), an analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Discussion paper – Final, April 2013 http://biodiversity.europa.eu/maes/ (accessed 14 July 2014)*

I. Basic Balances I.1 Basic land cover account I.2 Basic river account	**Stocks of land cover (km²)** **Formation & Consumption of land cover** **Stocks of rivers (SRMU)** **Change in rivers stocks**	***Net change/ land cover*** ***Net change/ river systems***
II. Accessible ecosystem infrastructure potential	**Stocks of Landscape Ecosystem Potential** **Stocks of River Ecosystem Potential** **Total Ecosystem Infrastructure Potential**	***Change in LEP*** ***Change in REP*** ***Change in TEIP***
III. Overall access to ecosystem infrastructure potential	**Population local access to TEIP** **Agriculture local access to TEIP** **Nature conservation local access to TEIP** **Basin access to water regulating services** **Regional access to TEIP [tourism]** **Global nature conservation access to TEIP**	***Change in access to key ecosystem infrastructure functional services***
IV. Table of Indexes of Intensity of Use and Ecosystem Health	**Ecosystem infrastructure intensity of use index** **Composite ecosystem infrastructure health index**	***Annual change in ecosystem infrastructure services ecological internal unit value***

Accounts	Main items	Typical indicators
I. Basic Balances I.1 Basic land cover account I.2 Basic river account	**Stocks of land cover (km^2)** **Formation & Consumption of land cover** **Stocks of rivers (SRMU)** **Change in rivers stocks**	***Net change/ land cover*** ***Net change/ river systems***
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