BioResources & Biodiversity 2015
Master BioSciences ENS de Lyon

ENS DE LYON

Tuesday 1 June 2015: Biodiversity, Ecosystems and economy

Ecosystem services and the social value of Nature 2

Ecosystem Natural Capital Accounts: towards an Ecological Balance-Sheet

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Outline

1. Principles and Framework

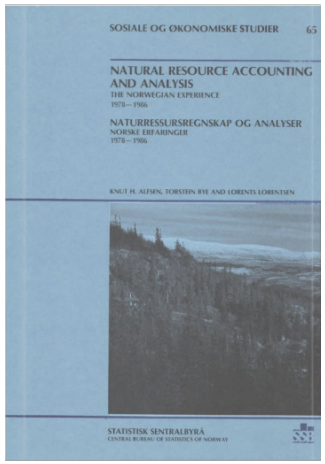
2. Presentation of ENCA-QSP

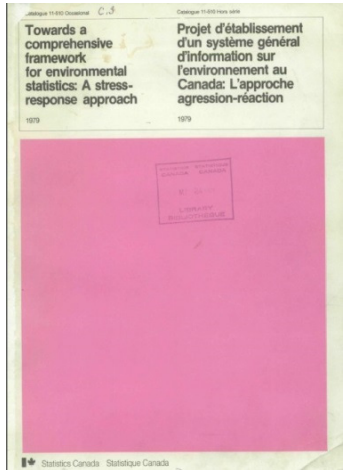
3. The making of ecosystem accounts and example of the Mauritius experimental accounts 2013

National Accounts:
Recurrent demands for improved economic indicators and aggregates

- Historical pioneer "green accounting" projects: Norway, Canada, France, Philippines, Indonesia, the Netherlands, Spain…
- Rio1992, Agenda 21
- UN SEEA1993 to "adjust" the UN System of National Accounts ("Green GDP"). SEEA revised in 2003
- New SEEA revision 2012/13, including now a second volume on experimental ecosystem accounting
- Recent initiatives:
  - Beyond GDP Conference 2008
  - Potsdam 2008 G8+5 initiative and TEEB
  - Stiglitz/ Sen/ Fitoussi report on the measurement of economic performance 2009
  - World Bank's new Global Partnership for "Green Accounting" and Ecosystem Valuation (WAVES)
  - CBD Aïchi-Nagoya Strategy 2010: demand for the inclusion of biodiversity and ecosystem value into national accounts and launch of CBD TS77 on Ecosystem Natural Capital Accounts – A quick Start Package at the CBD COP12 in South Korea, 2014.
  - References to environmental accounts for measuring progress in Green Economy, Green Growth, Resource Efficiency…
  - SDG: reference to the SEEA
- In Europe:
  - Regulation on Environmental Accounting: Eurostat, the economy-environment interface and
  - Natural Capital Accounts to support the EU Biodiversity Strategy: MAES by the JRC and ECA by the EEA (ecosystem capital accounts)

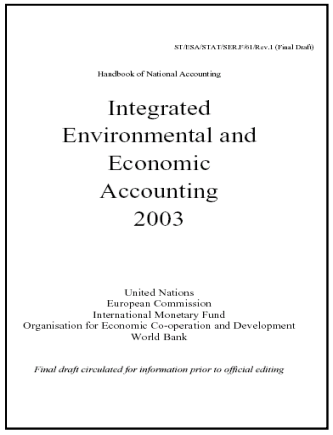
(very incomplete) history of early works…



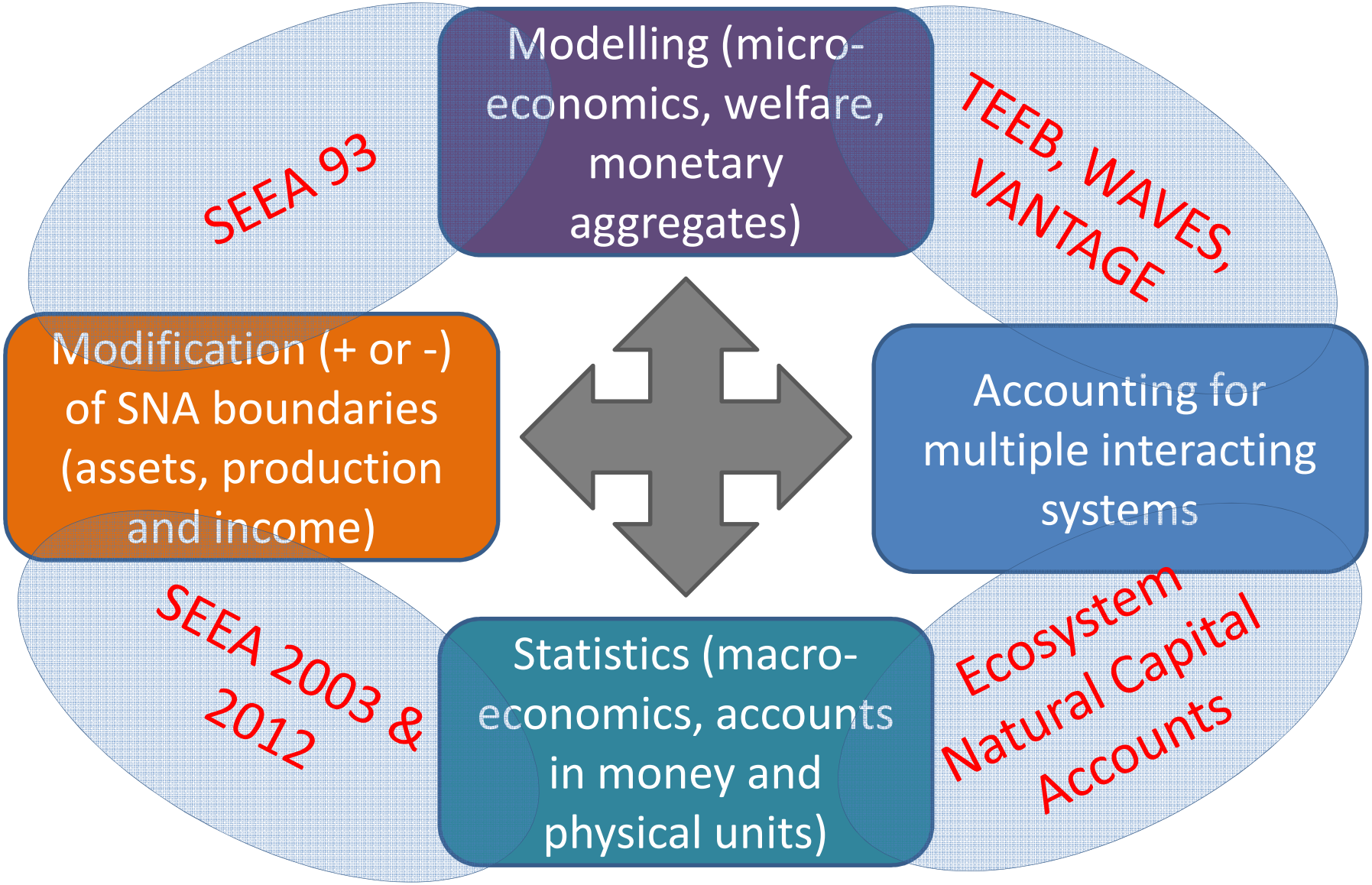


- Peskin ("accounting for environmental services")
- Ganarsjordet, Norway ("Natural Resource Accounts")
- El Serafy, WB ("User Cost")
- Repetto, WRI ("net market values")
- Hueting, NL ("distance to target")
    - David Rapport & Tony Friend, Canada ("Stress-Response System")
        - CICPN-France ("Les Comptes du Patrimoine Naturel")
- CICPN-Espagne (Naredo, water accounts in exergy/quantity-quality)
- Hamilton, WB, ("Genuine Savings")
- SEEA 1993
- SEEA 2003

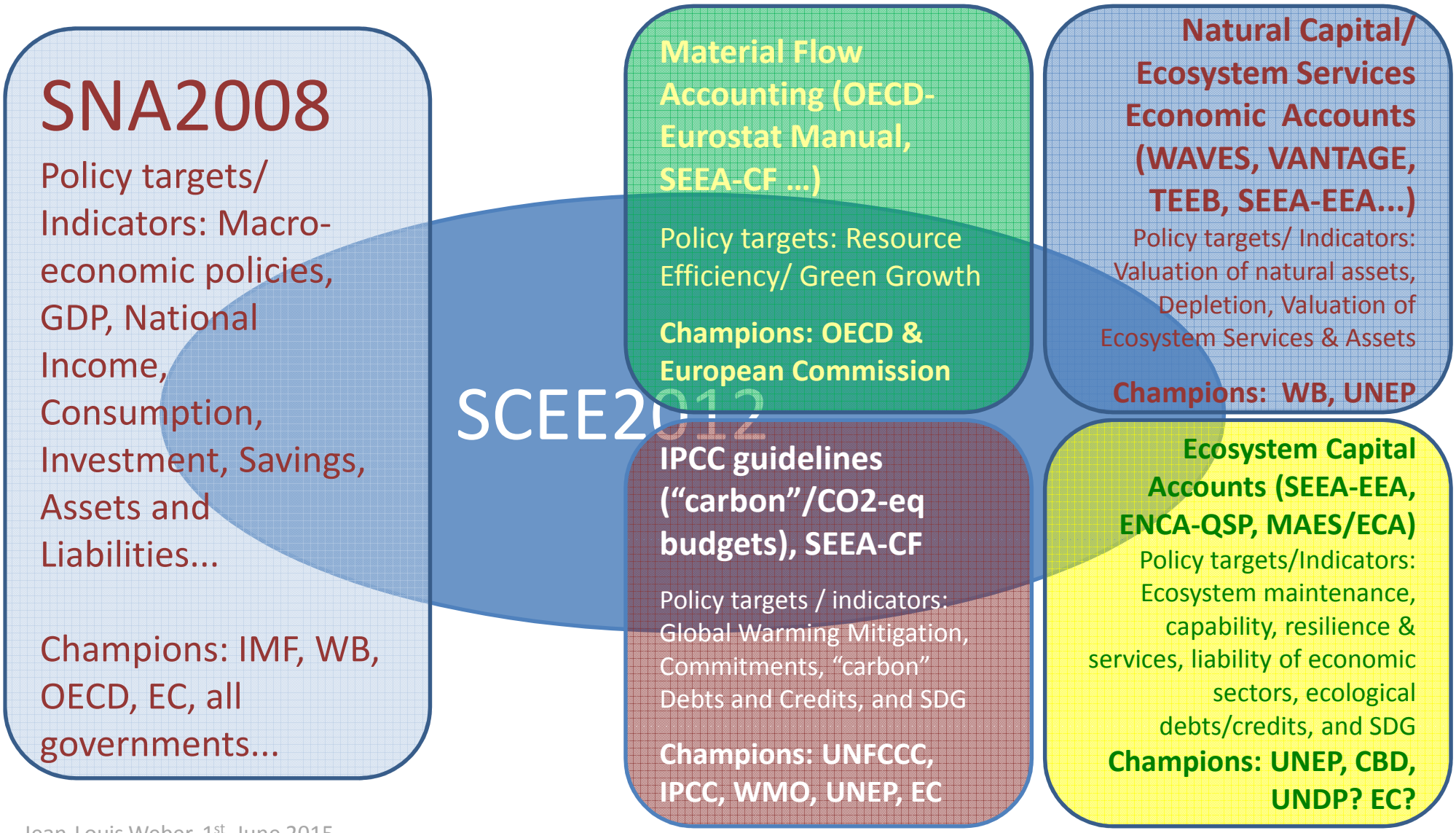
+ IPCC guidelines



Multiple approaches to environmental accounting



The SEEA and Related Accounting Frameworks



Why accounting for nature is important?

- Accounting = a technique to measure the "true" or net outcome of an activity, based on the complete recording of all entries and outcomes; double-entry accounting, cross-checking data
- Accounts' "balancing items" are key indicators, strictly defined and much used: profit or loss, net income, net savings, accumulation, net worth (assets minus debts)... GDP, National Income...
- Accounting standards allow comparisons between economic agents (International Financial Standards) and between countries (System of National Accounts) as well as the measurement of change (growth, depletion, degradation, time series...)
- Accounts feed models with reliable data and statistics; models outcomes can be compared to the picture of the past and presents situation given by accounts and support policy making
- Physical accounts can be connected to the National Accounts (and to corporate, government accounts...): "carbon/CO2-eq accounts" (IPCC), "material flow accounts" (OECD Green Growth)... now ecosystem accounts

➔**REMARK: Ecosystem accounts combine comprehensive and perennial base accounts with more specific and detailed assessments of hot issues**

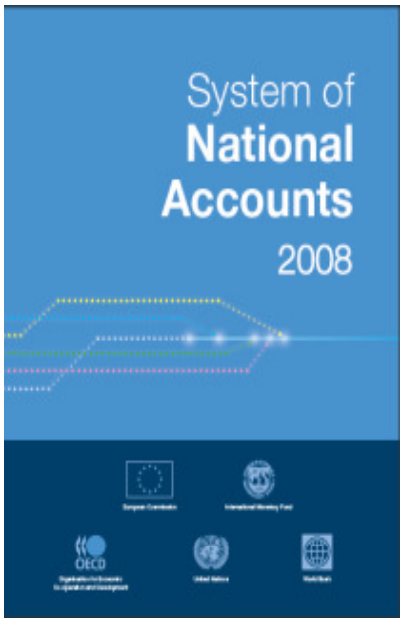
How are Ecosystem Services & Assets recorded in the SNA?

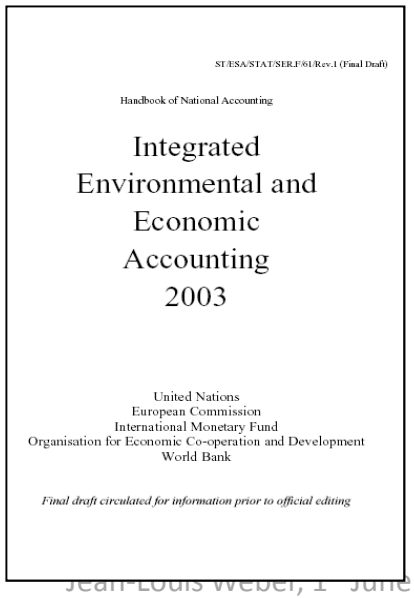
- ES are input to production of goods and services, valued at the purchase price; ES are part of an economy-nature joint production...
- SNA production includes all goods produced for own account (incl. picking up berries, mushrooms, deadwood etc...).
- SNA natural assets are only economic assets, owned and managed for profit; it includes assets owned by governments but excludes ecosystem functions that benefit to others and the public: they are not taken into account.

- **ISSUES: several prices are not rightly set.**
  - Ignored: the ecosystem functions which are not economic assets are not recorded (zero price).
  - Incomplete: unlike consumption of fixed capital, consumption of ecosystem capital is not included in purchasers' prices (because economic agents don't record it – it is for them an externality).
  - Values are not assigned to the right sectors because of rent extortion: Value Added of agriculture is very low, partly because value of food is recorded as Value Added of Agro-food industry and trade; the Value Added of molecules "discovered"via bio-prospecting is recorded as that of Pharmaceutical Industry, not of regions of origin (the ABS paradigm...)

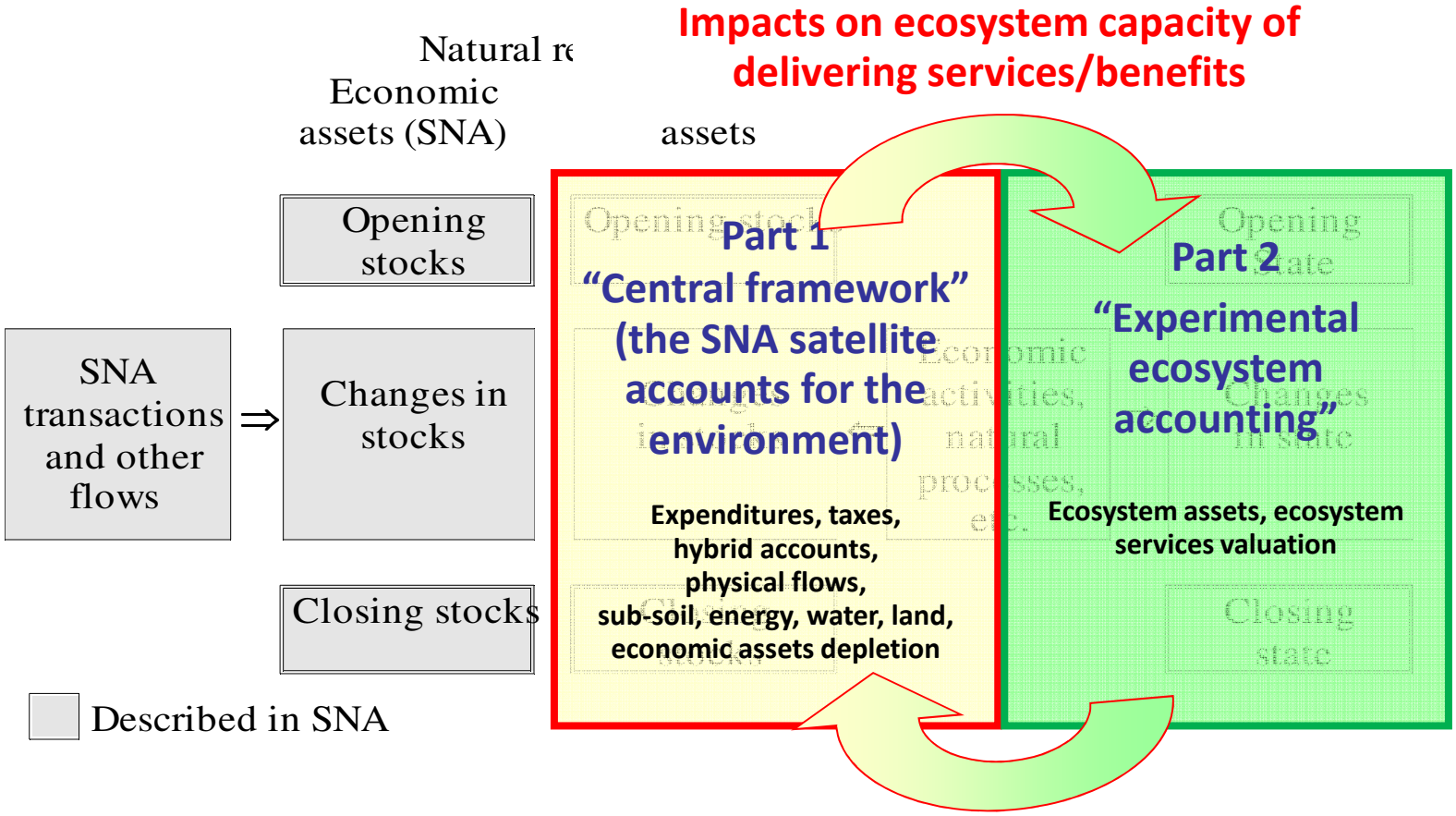
UN manual for environmental-economic accounting: **SEEA2012/13**

On par with the System of National Accounts (SNA) since February 2012





Revision of the SEEA2003 ➔ SEEA2012/13, steered by the UNCEEA

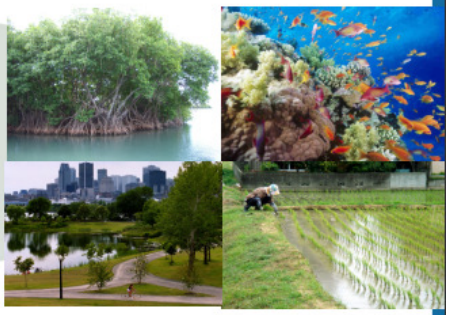


RM HASSAN - UN The System of Environmental and Economic Accounting
RANESA Workshop June 12-16, 2005 Maputo

What is ecosystem accounting?

What it is?

- Spatial
- Covering all ecosystems
- Combination of ecology and national accounting



How did it happen?

- Evolved over many years in academic and government agencies
- A rapidly evolving field

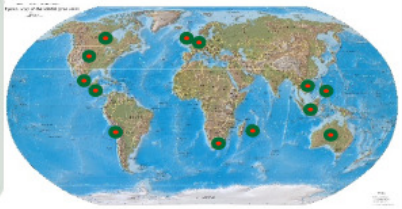
1953
1968
1993
2008

1993
2003
2012

2013

Where is it happening

- Several countries are developing ecosystem accounts

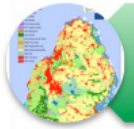


Source: Michael Vardon's presentation at the World Bank WAVES 1st Knowledge Exchange on Ecosystem Accounting, Manila, the Philippines, 23-27 February, 2015

Example: Mauritius – Experimental Ecosystems Natural Capital Accounts 2014

Key points

- A suite of accounts with land cover as a starting point
- It is complex but it can be done!
- Focuses on assets (e.g. natural capital) rather than services
- Learning by doing


Land cover


Water

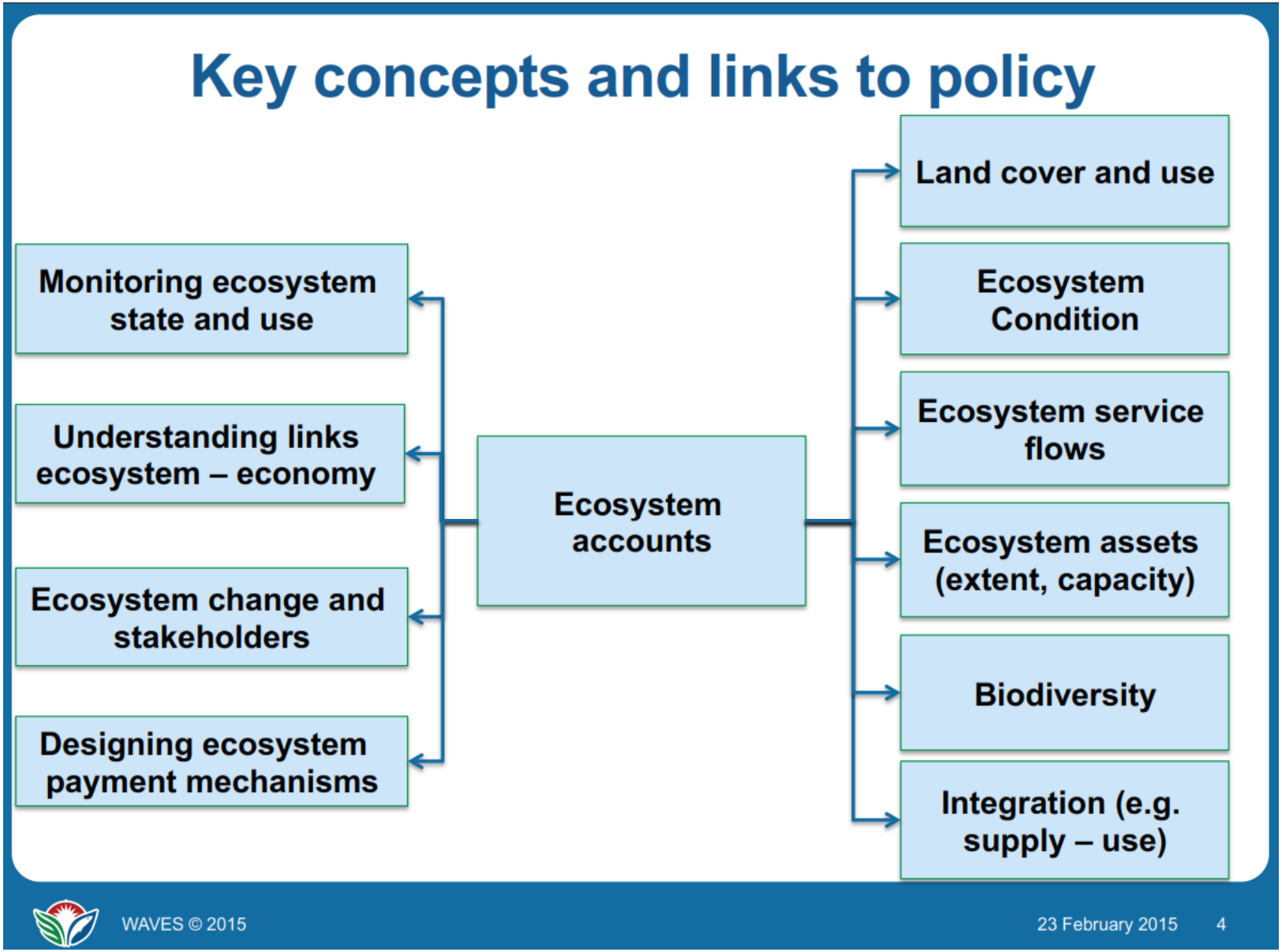

Biomass/Carbon


Biodiversity


Capability

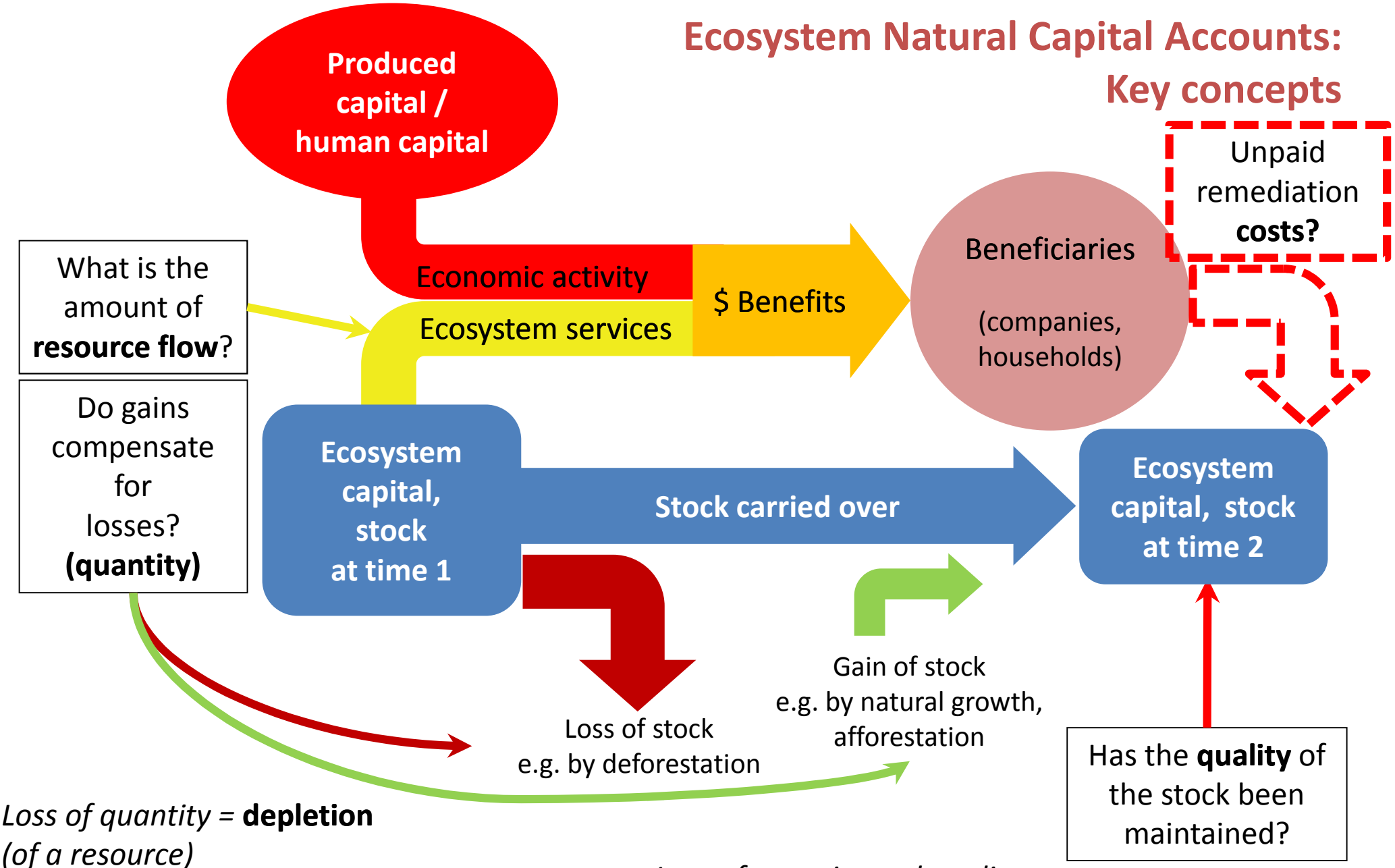
http://commissionoceanindien.org/fileadmin/resources/ISLANDSpdf/Experimental_Ecosystems_Natural_Capital_Accounts_Mauritius.pdf

Source: Michael Vardon's presentation at the World Bank WAVES 1st Knowledge Exchange on Ecosystem Accounting, Manila, the Philippines, 23-27 February, 2015



Source: Lars Hein's presentation at the World Bank WAVES 1st Knowledge Exchange on Ecosystem Accounting, Manila, the Philippines, 23-27 February, 2015

Ecosystem Natural Capital Accounts: Key concepts



Loss of quantity = **depletion** *(of a resource)*

Loss of quantity and quality = **degradation** *(of a system)*

Adapted from Roy Haines-Young, Michael Vardon and Lars Hein

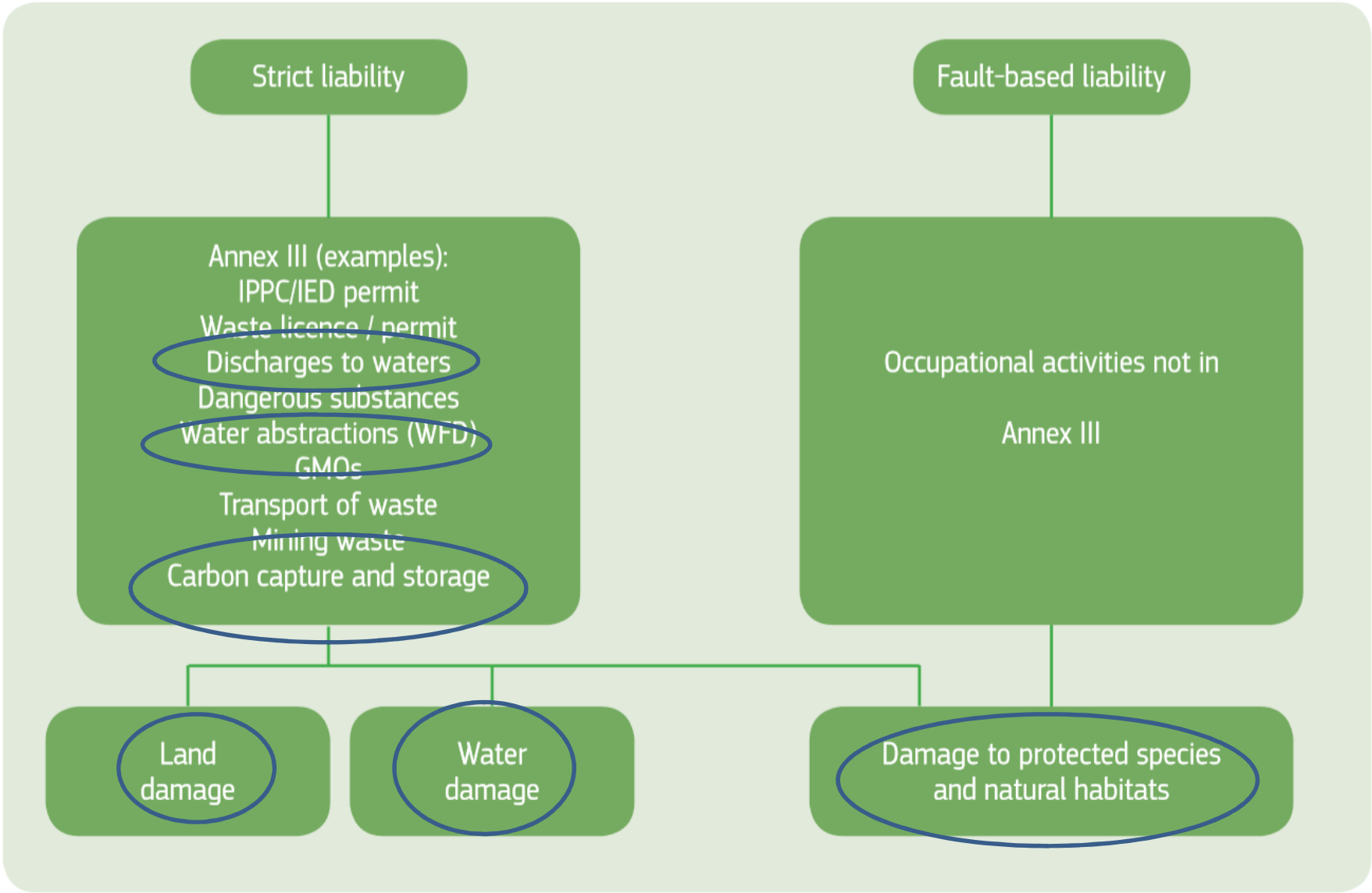
Importance of measuring degradation

Example of the EU Environmental Liability Directive of 2004 (ELD2004): the "Polluter Pays Principle" is enforced regarding environmental damages with 3 purposes:

1. Avoid degradation when possible
2. Repair or restore when 1 is not possible
3. Compensate the damage elsewhere for an equivalent amount when 1 and 2 are not possible

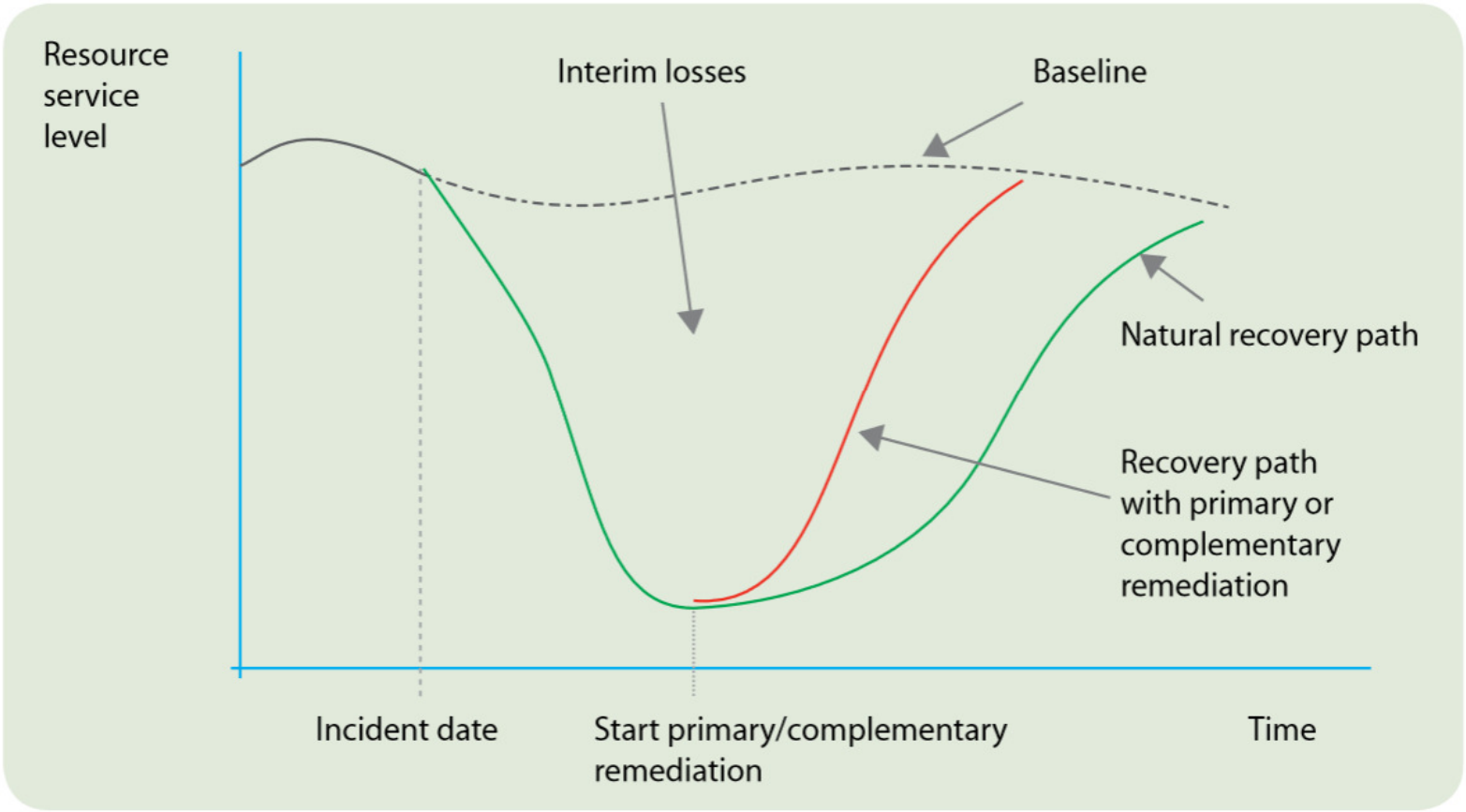
Scope of the ELD 2004 .. Similar to ecosystem accounts

Figure 2: Types of environmental liability and damage



The ELD 2004 “accounting” of damage and assessment of remediation

Figure 3: Illustrating baseline, initial damage, interim loss and remediation measures



Remediation measures are then converted into Euros

Examples of offset / cap & trade schemes

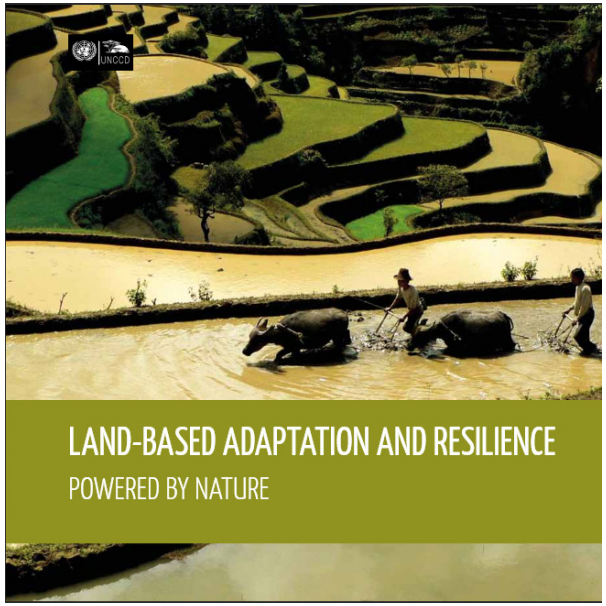
- ELD2004 is a Directive ➔ country regulations (Natura 2000 context)
- USA: wetlands mitigation banking schemes...
- UNFCCC / Clean Development Mechanism: “carbon” offset permits
- Various private initiatives

e.g. BBOP (Business and Biodiversity Offset Programme)

UNFCCD (Desertification): Land-Degradation Neutral World

The LDN concept was first introduced as “zero net land degradation” in a proposal tabled at Rio+20.

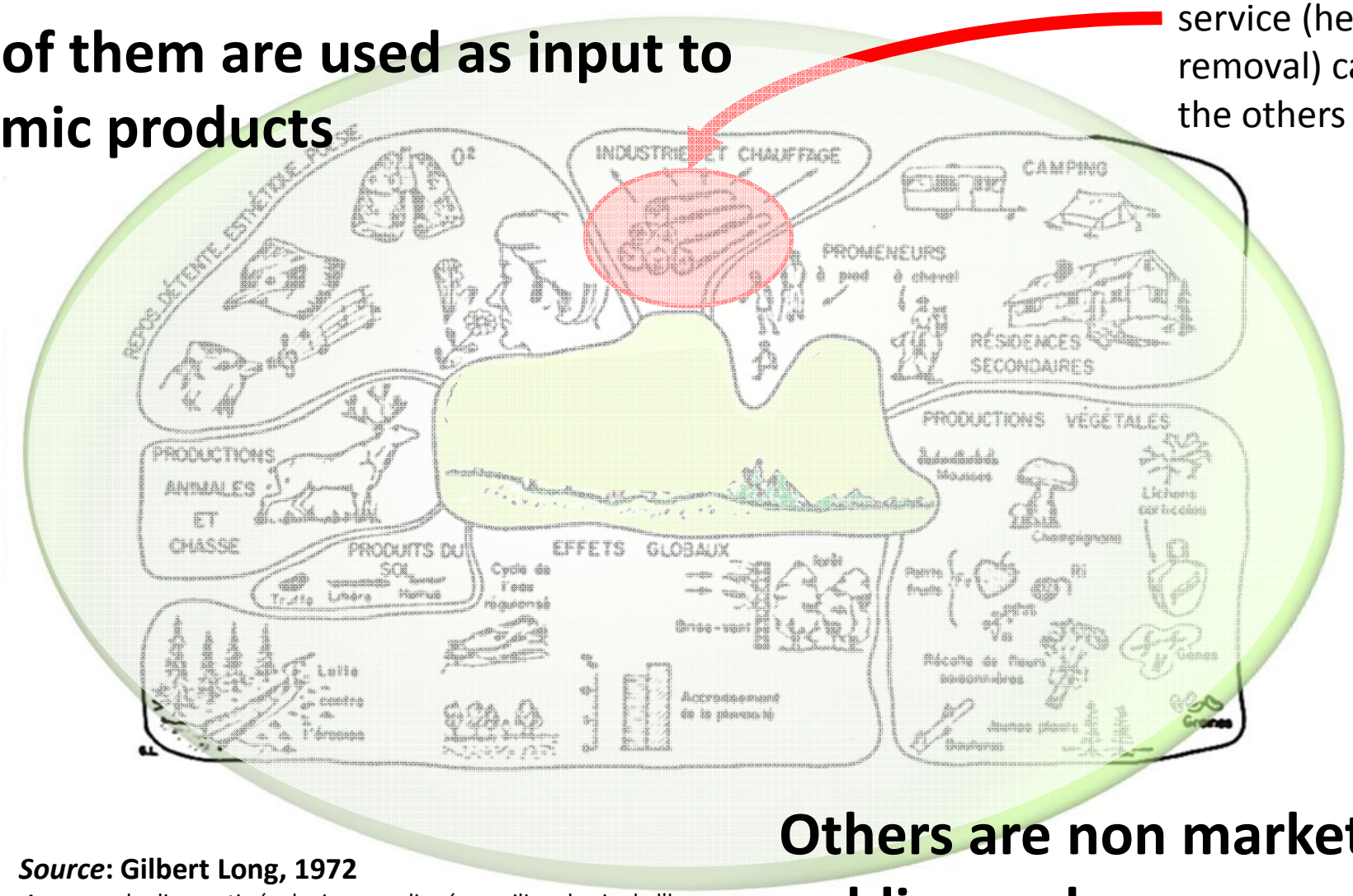
- *“In a land-degradation neutral world, the amount of healthy and productive land resources needed to support vital ecosystem services remains stable or increases in a given time and space.”*
- *“Restoring land at large scale improves watersheds and water drainage, refills aquifers, increases tree and plant cover, and helps to recover biodiversity and soil fertility.”*



Ecosystems deliver altogether **multiple services**

NOTE: Excessive extraction of 1 service (here wood removal) can ruin all the others

Some of them are used as input to economic products



Others are non marketed public goods

***Source*: Gilbert Long, 1972**
A propos du diagnostic écologique appliqué au milieu de vie de l'homme. Options Méditerranéennes, 13 , CHIEAM, Montpellier, Juin 1972

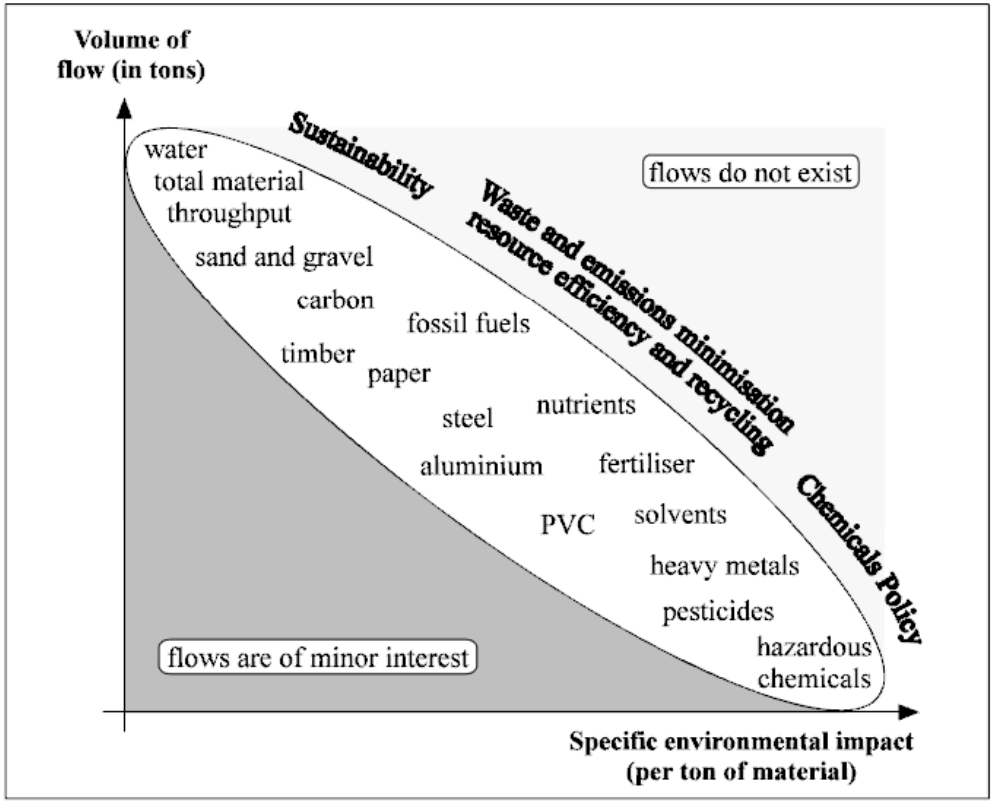
Accounts are about recording and summarizing values...

- Counts, inventories are limited, standalone “accounts”, issues in aggregating measurements done in physical units

Difficulty to Aggregate Physical Data

Ecosystem services in various units

Material flows in tons



Steurer (1996),[11] as developed with W. Radermacher (StBA) in 1995

Table 14. Available indicators for assessment of ecosystem services across different ecosystems.

Ecosystem services	Leader	Indicator	Marine systems
Cultivated crops	Agro	• Area and yields of food and feed crops	• Yield • Landings • Catch per unit effort (where applicable)
Reared animals and their outputs	Agro	• Livestock	
Wild plants, algae and their outputs	Forest	• Distribution of wild berries (modelling)	
Wild animals and their outputs	Forest	• Population sizes of species of interest	
Plants and algae from in-situ aquaculture	Water		
Animals from in-situ aquaculture	Water	• Freshwater aquaculture production	
Water (Nutrition)	Water	• Water abstracted	
Biomass (Materials)	Forest Agro	• Area and yield of fibre crops • Timber production and consumption statistics	
Water (Materials)	Water	• Water abstracted	
Plant-based resources	Forest	• Fuel wood statistics	
Animal-based resources			
Animal-based energy			
(Mediation of waste, toxics and other nuisances)	Forest	• Area occupied by riparian forests • Nitrogen and Sulphur removal (Forests)	• Nutrient load to coast • Heavy metals and persistent organic pollutants deposition • Oxyrisk
Mass stabilisation and control of erosion rates	Forest Agro	• Soil erosion risk or erosion protection	• Coastal protection capacity
Buffering and attenuation of mass flows			
Hydrological cycle and water flow maintenance			
Flood protection	Fresh	• Floodplains areas (and record of annual floods) • Area of wetlands located in flood risk zones	• Coastal protection capacity
Storm protection			
Ventilation and transpiration	Agro	• Amount of biomass	
Pollination and seed dispersal	Agro	• Pollination potential	
Maintaining nursery populations and habitats		• Share of High Nature Value farmland • Ecological Status of water bodies	• Oxygen concentration • Turbidity • Species distribution • Extent of marine protected areas
Pest and disease control			
Weathering processes	Agro	• Share of organic farming • Soil organic matter content • Ph of topsoil • Cation exchange capacity	
Decomposition and fixing processes	Agro	• Area of nitrogen fixing crops	
Chemical condition of freshwaters	Water	• Chemical status	
Chemical condition of salt waters	Marine		• Nutrient load to coast • HM and POP loading • Oxyrisk
Global climate regulation by reduction of greenhouse gas concentrations	Forest	• Carbon storage and sequestration by forests	• Carbon stock • Carbon sequestration • pH; • Blue carbon • Primary production
Micro and regional climate regulation	Forest	• Forest area	
Physical and experiential interactions	Forest Agro WaterMarine	• Visitor statistics	
Intellectual and representative interactions			
Spiritual and/or emblematic			
Other cultural outputs		• Extent of protected areas	

All services at CICES class level except services in italic at CICES group level. CICES Division indicated by brackets.

Accounts are about recording and summarizing values...

- Counts, inventories are limited, standalone “accounts”, issues in aggregating measurements in physical units

- Accounts or balances, integrated by double-entry rules are about **values**:
  - Assets value ➔ Wealth
  - Flows, receipts, expenditures ➔ Net Income

- Monetary value is important but it is not the only value that we acknowledge

Value is not just about money

…but maintaining an asset may have a cost

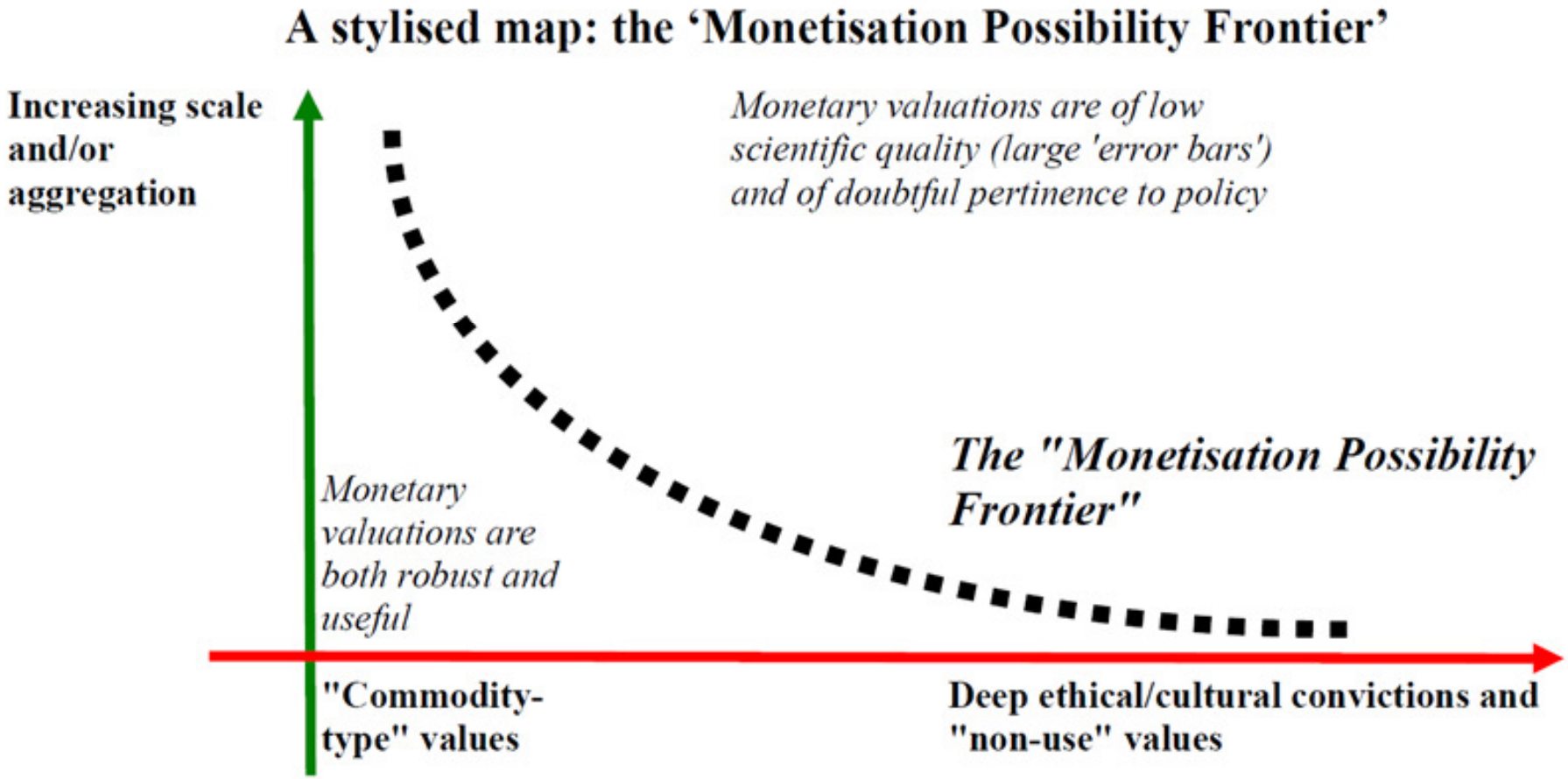
Paid maintenance/ restoration costs

Invaluable asset ➔ no monetary value…

Cultural services, may generate income

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

O'Connor and Steurer: The "Frontier of Monetisation" in Environmental Valuation, paper presented at the 6th meeting of the London Group on Environmental Accounting, Canberra November 1999



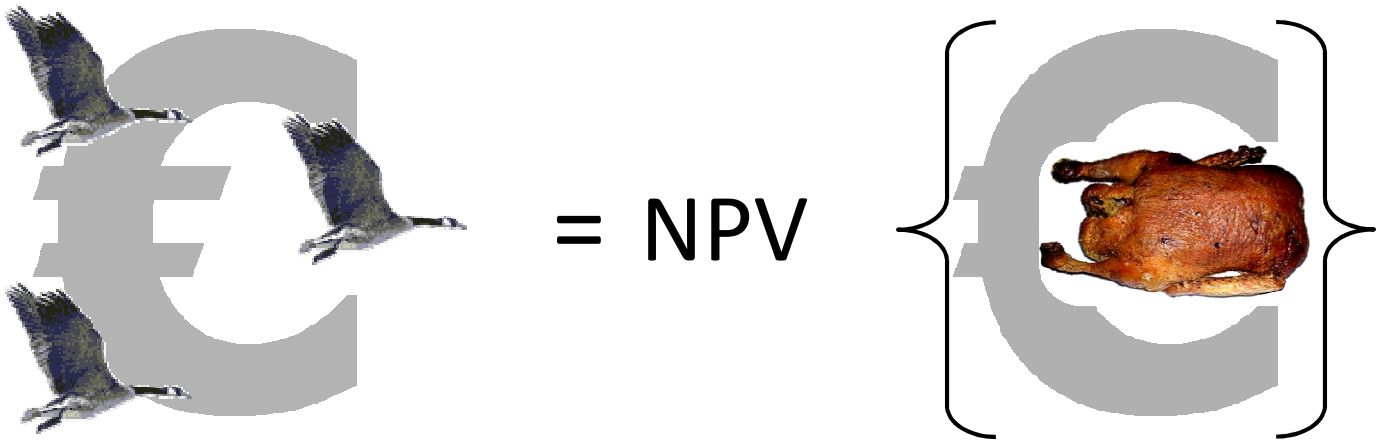
The conventional economic valuation of resource depletion is not appropriate for ecosystem degradation

Conventional economic theory:
Asset depreciation =

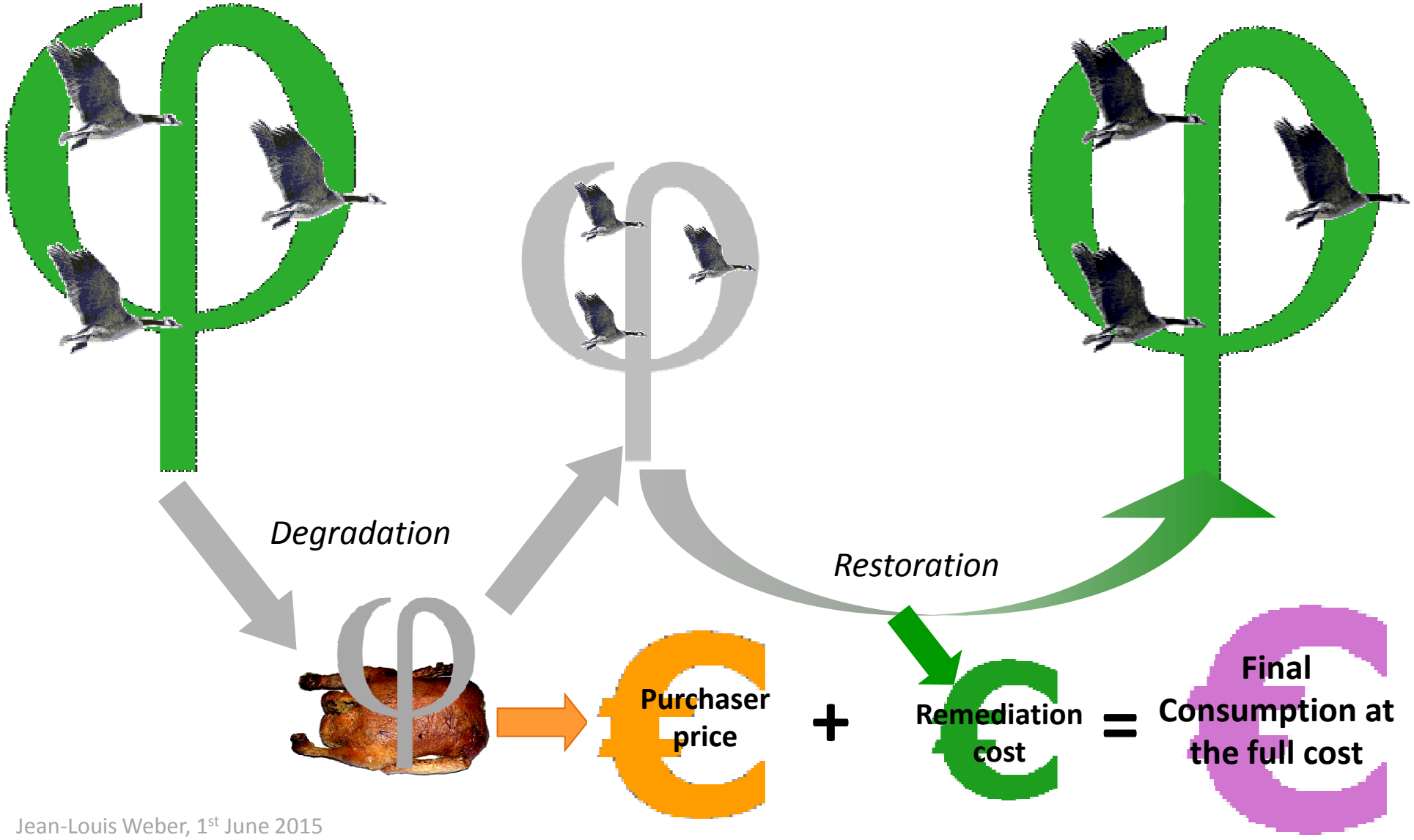
1. difference between asset values at two dates
2. cumulated loss of future benefits (financial approach, “Net Present Value”)

NB: 1. and 2. are assumed to be equivalent under the condition of “perfect market”

Financial value of natural assets = “Net Present Value” of expected future benefits



Ecosystem natural capital accounting: asset = "quantity*quality" (physical measurement)
only change is priced (imputed remediation costs)



Moving from Quantities to Values: Economic value vs. Ecological value

- **Economic value = quantity x price**

Financial & national accounts: values are established by the market; prices are decided by the transactors, they relate to production costs, to the capacity for the seller to make profit, to the quality for the buyer, to its capacity to negotiate discounts…

- **Ecological value = quantity x unit values (price-equivalents)**

Ecosystem capital accounts: values need to be calculated, knowing quantity and defining an overall "quality" index equivalent to market price

➔ ***General equivalency, measurement of stores of various ecosystem capabilities and of their change (degradation, improvement), useable for offset transactions…***

➔ ***Conventional but transparent and verifiable measurement to be used to record ecological credits (ecosystem enhancement) and debts (degradation)***

Examples of equivalent-units to measure physical ecosystem flows/stocks

- **Tonne** (Ayres): Material Flows Accounts (MFA); all tonnes are equivalent…
- **Tonne of Oil Equivalent (TOE)** (International Energy Agency, OECD…): energy released by burning one tonne of crude oil
- **Livestock Unit (LU)** (FAO, …): all grazing livestock animals measured in "adult cow"…
- **Environmentally weighted tonne**: EWMF, tonnes adjusted for potential environmental impacts (toxicity, life cycle…)
- **Global Hectare** (Wackernagel): Ecological Footprint Accounts, "biocapacity" of 1 hectare
- **EMERGY** (Odum): embedded renewable energy as universal equivalent
- **Ecointegrador** (Naredo/Valero): total exergy (energy available for uses) of water systems integrating quantity and quality, with reference to environmental targets
- **Econd** (Cosier, WGCS/Australia): ecosystem condition unit (a currency) to measure ecosystem biodiversity comparing historical and present condition (extent and health)
- **ECU** (Weber, EEA): ecosystem capability (or potential) equivalent-unit (a currency) integrating quantity (productivity) and quality (ecosystem health)

ECU: a composite currency to measure ecological value

Economic value: Quantity x Price (in money)

Ecological Value: Quantity x Price-equivalent (in ECU)

In physical accounts, measurements are made in basic units (tons, joules, m^3 or ha) which cannot be aggregated. These measurements have to converted to a special composite currency named **ECU for 'Ecosystem Capability Unit'.**

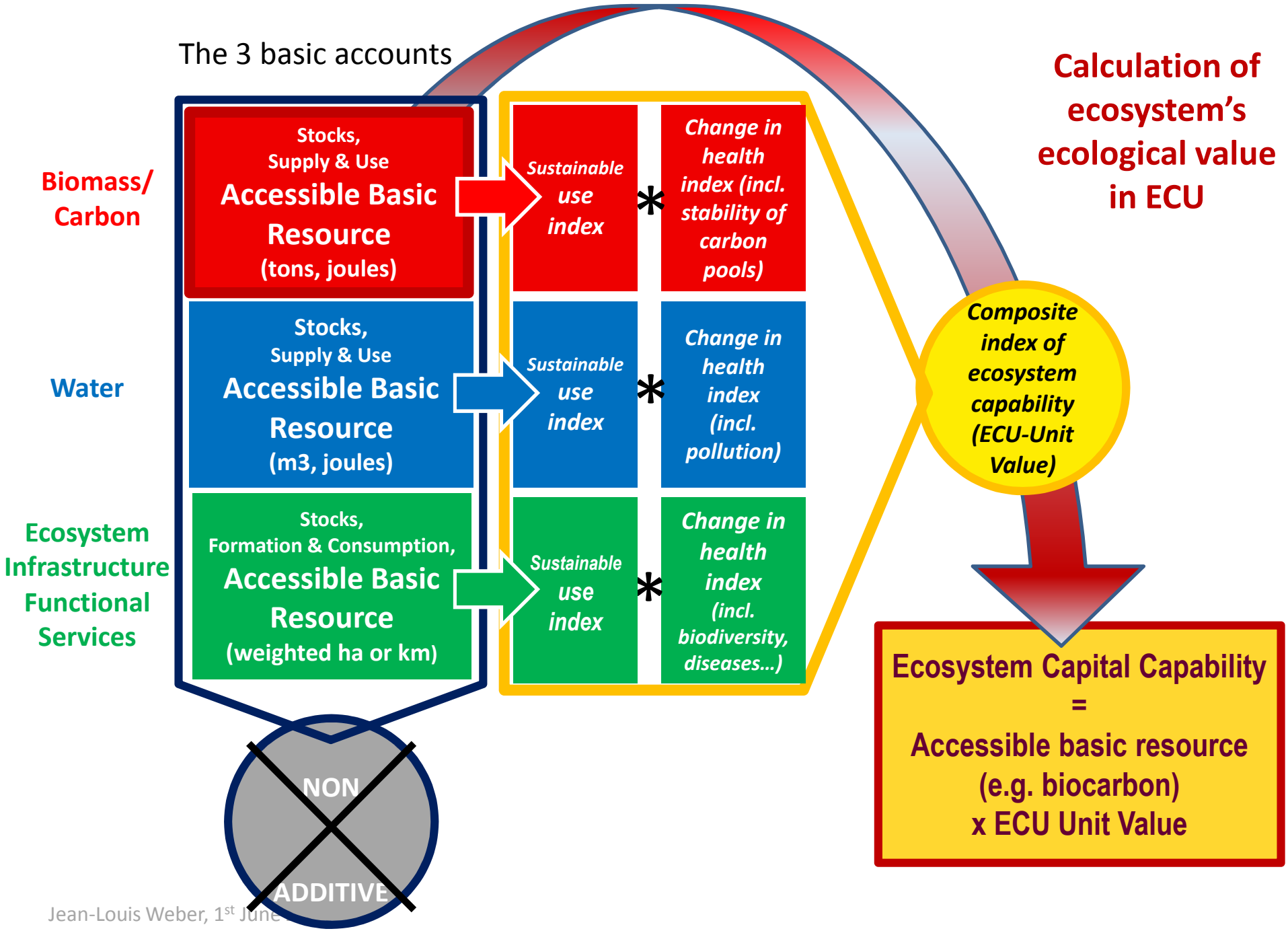
The price of one physical unit (e.g. 1 ton of biomass) in ECU expresses at the same time the intensity of use of the resource in terms of maximum sustainable yield and the direct and indirect impacts on ecosystem condition (e.g. water contamination or biodiversity loss, inversely ecosystem restoration).

François 1st (1515-1547), Ecu d'or au soleil du Dauphiné, Source : Münzen & Medaillen GmbH (DE)

1 ECU =
1 unit of accessible ecosystem resource

Jean-Louis Weber, 1st June 2015

Jean-Louis Weber, 19 July 2013


The 3 basic accounts
Calculation of ecosystem's ecological value in ECU
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…)
*
*
*
Composite index of ecosystem capability (ECU-Unit Value)
Ecosystem Capital Capability = Accessible basic resource (e.g. biocarbon) x ECU Unit Value
NON
ADDITIVE

System and Services approaches

Ecosystem capital productivity & resilience

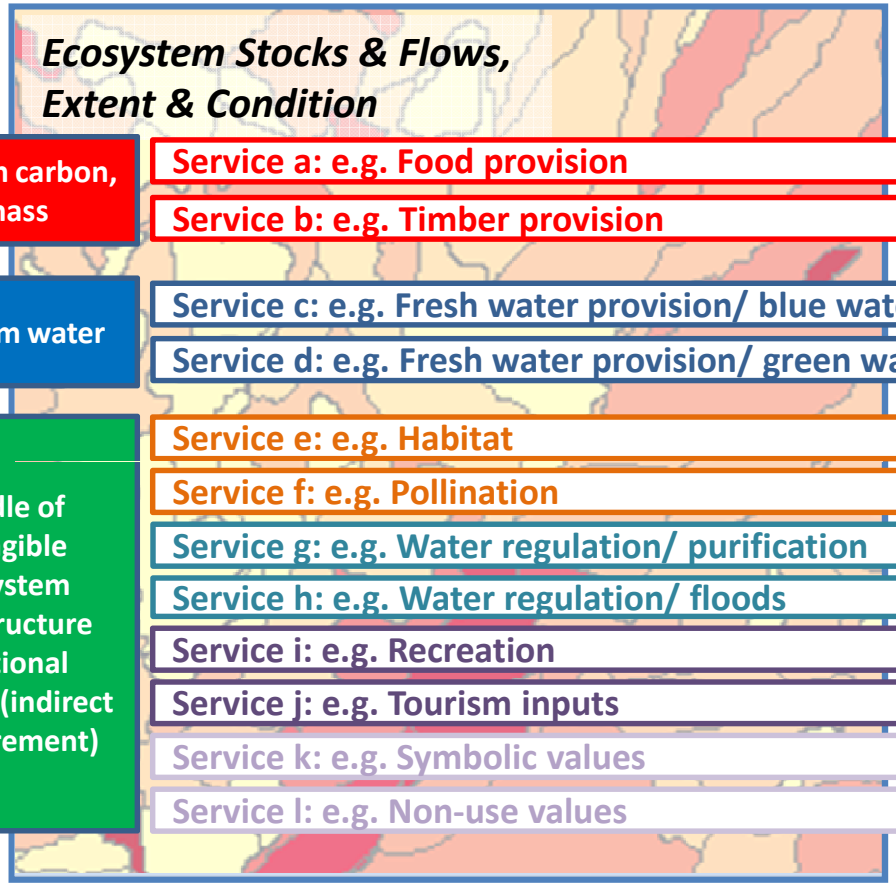
Physical ecosystems & *Ecosystem services*

Natural & modified inland socio-ecosystems + Sea, Atmosphere

Provisioning, regulating & socio-cultural services

Monetary values

Ecosystem services valuation (market & shadow prices), Payments for Ecosystem Services Wealth assessments



Balance, Sustainable Use Index Health Index

Ecosystem carbon, biomass

Service a: e.g. Food provision

Service a $ valuation

Service b: e.g. Timber provision

Service b $ valuation

Balance, Sustainable Use Index Health Index

Ecosystem water

Service c: e.g. Fresh water provision/ blue water

Service c $ valuation

Service d: e.g. Fresh water provision/ green water

Service d $ valuation

Balance, (systems potential)

Sustainable Use Index

Health Index (incl. Biodiversity change)

Bundle of intangible ecosystem infrastructure functional services (indirect measurement)

Service e: e.g. Habitat

Service e $ valuation

Service f: e.g. Pollination

Service f $ valuation

Service g: e.g. Water regulation/ purification

Service g $ valuation

Service h: e.g. Water regulation/ floods

Service h $ valuation

Service i: e.g. Recreation

Service i $ valuation

Service j: e.g. Tourism inputs

Service j $ valuation

Service k: e.g. Symbolic values

Service k $ valuation

Service l: e.g. Non-use values

Service l $ valuation

Total Ecosystem Capability (in ECU)

Degradation / Enhancement

Integrity of ecosystem structures & functions
Sustainability of ecosystem services delivery

Maintenance & remediation costs, Ecological Taxes, Mitigation banking/ Offset Certificates...

The CBD ENCA-QSP guidance manual

Jean-Louis Weber, 1st June 2015

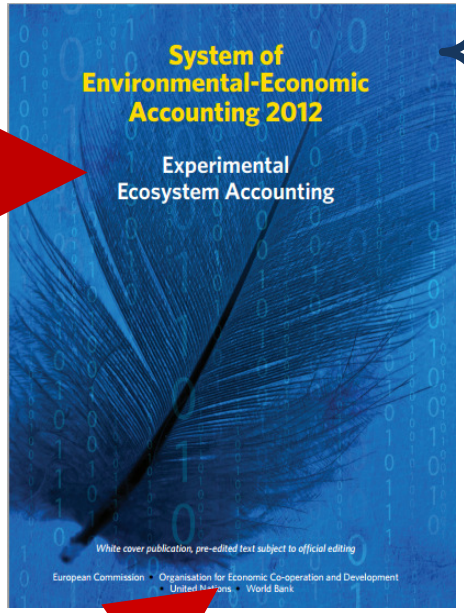
SNA and SEEA volumes 1 & 2

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

WB WAVES

SEEA-EEA Experiment

EU: ECA & MAES

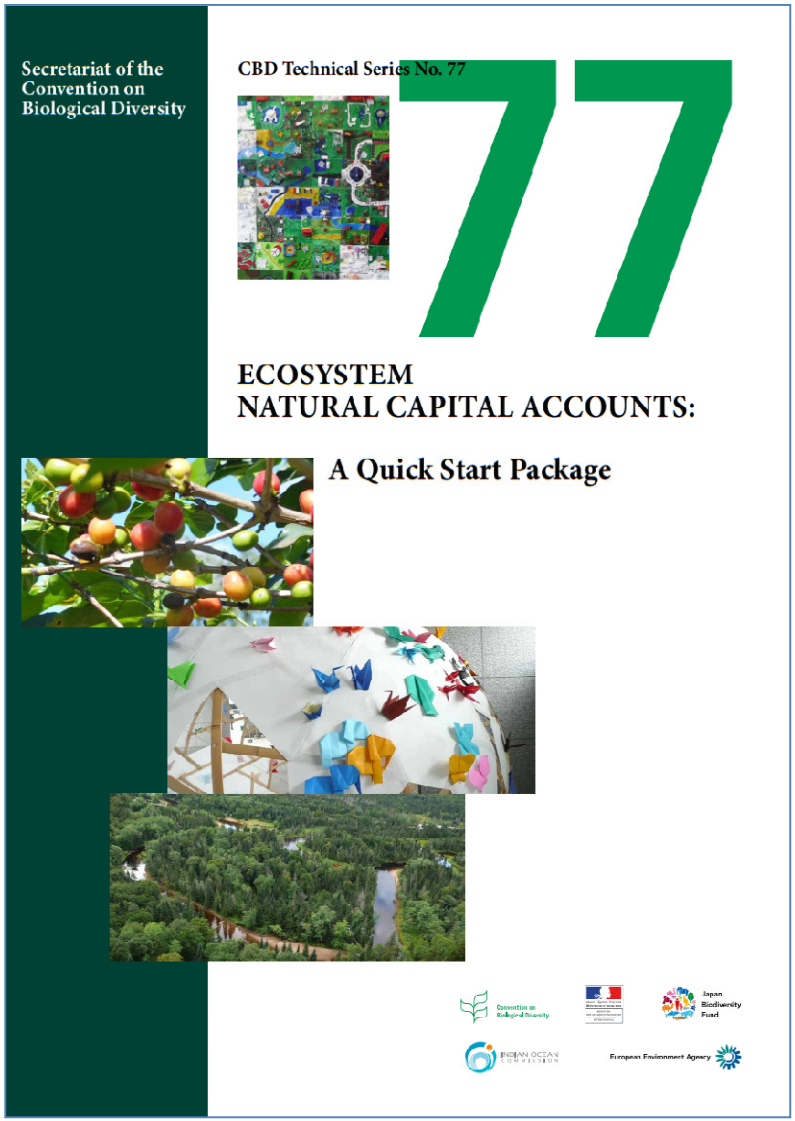
Ecosystem Capital Accounts Mapping and Assessment of Ecosystem Services

SEEA-EEA Experiment

ENCA-Mauritius

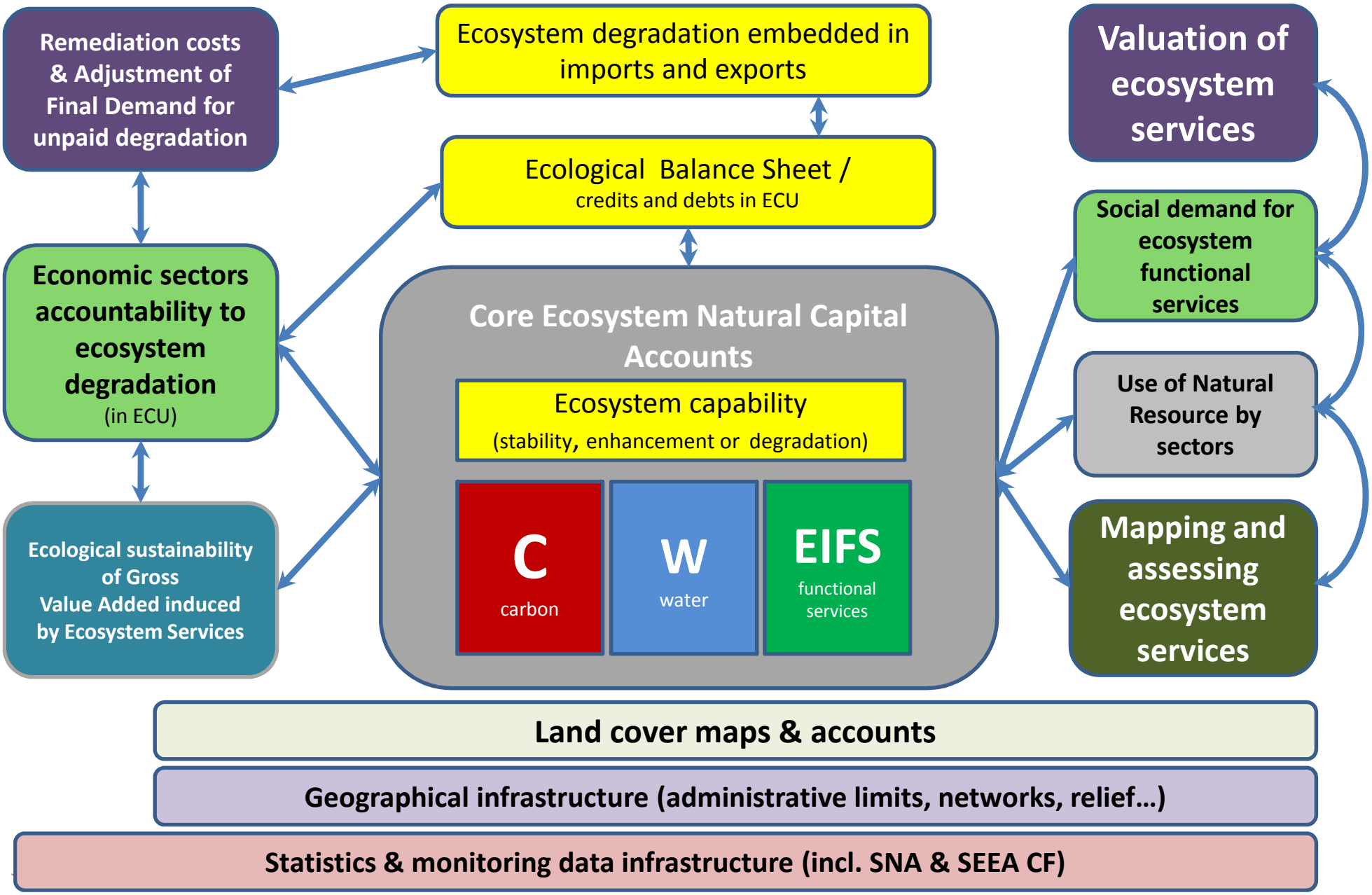
Ecosystem/ Natural Capital Accounts

An accounting framework to put the SEEA-EEA to work NOW : Ecosystem Natural Capital Accounts

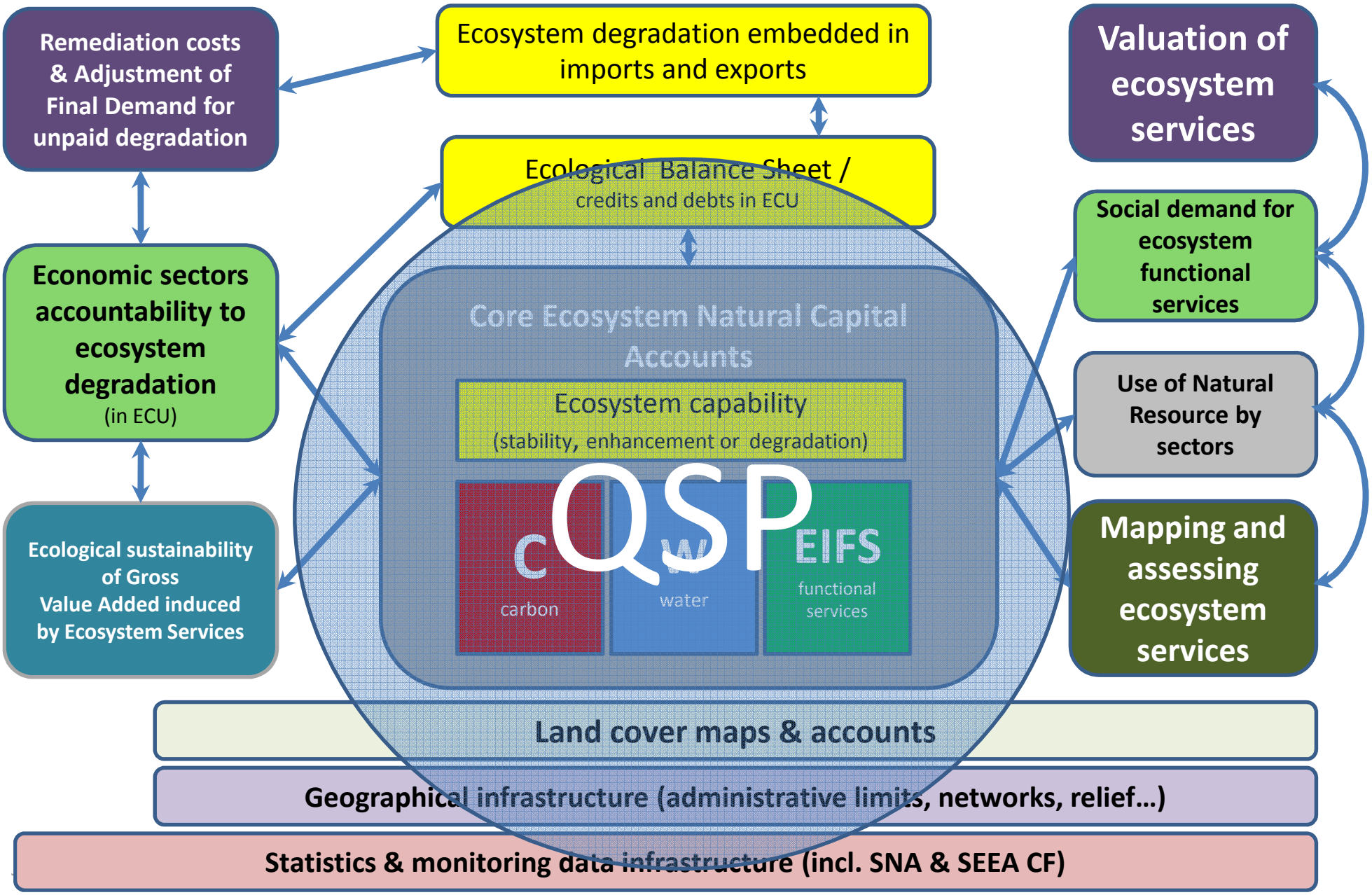


- A response to the requirement of the CBD Aichi Target 2 call for *incorporating, as appropriate and by 2020 at the latest, biodiversity values into national accounting*.
- A technical accounting framework for measuring ecosystem sustainable capacity, resilience and economic sectors' accountability to the ecosystem. It includes a set of tables and compilation guidance
- A "distribution" (in the sense used for open source software) of the SEEA-EEA, aimed at putting it to work
- A Quick Start Package for experimentations
- Supported by a tutorial for technical training of experts

Structure of Ecosystem Natural Capital Accounts



Structure of Ecosystem Natural Capital Accounts



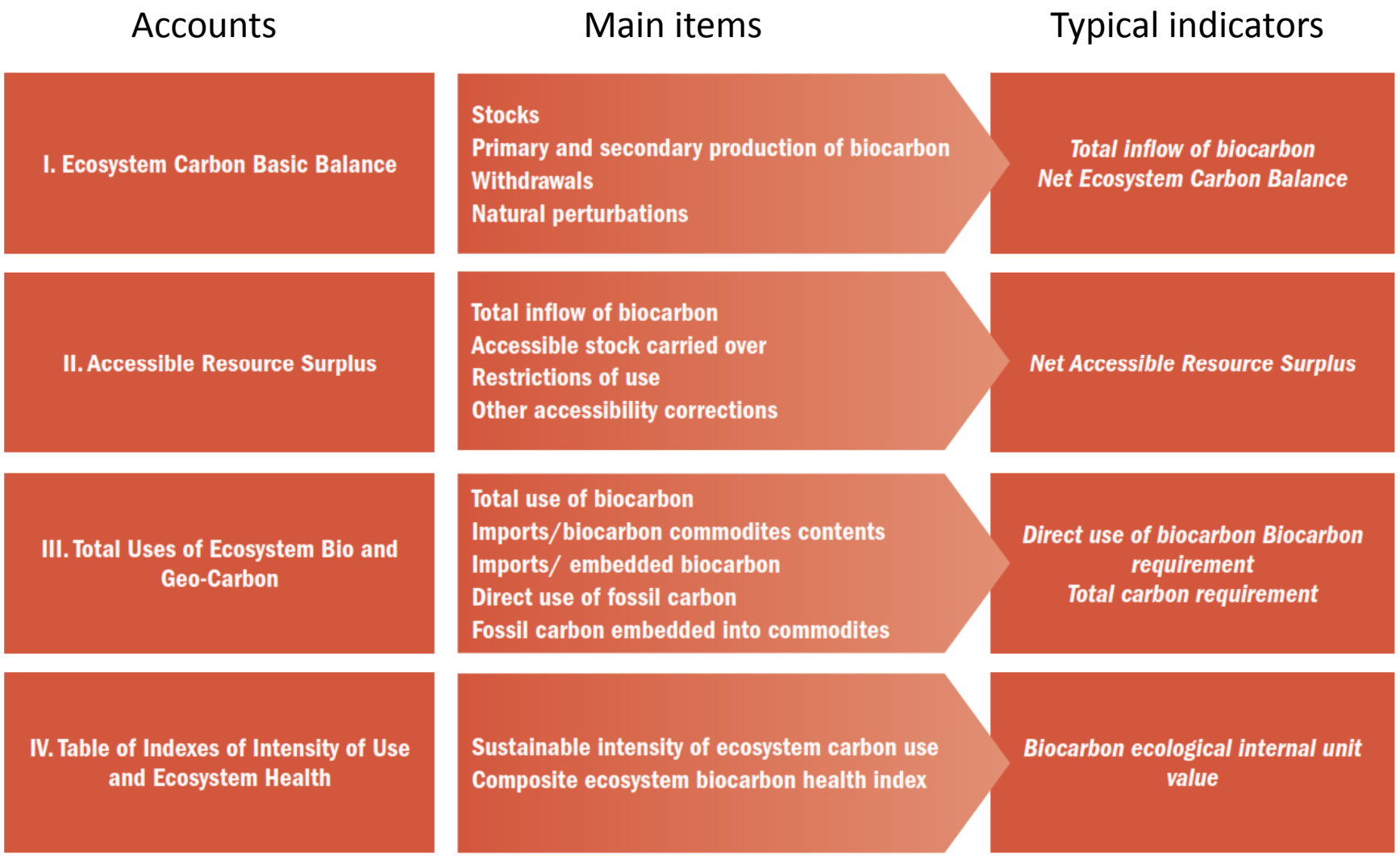
Simplified classifications of land cover types and land cover flows, to be detailed according to national/local conditions

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)

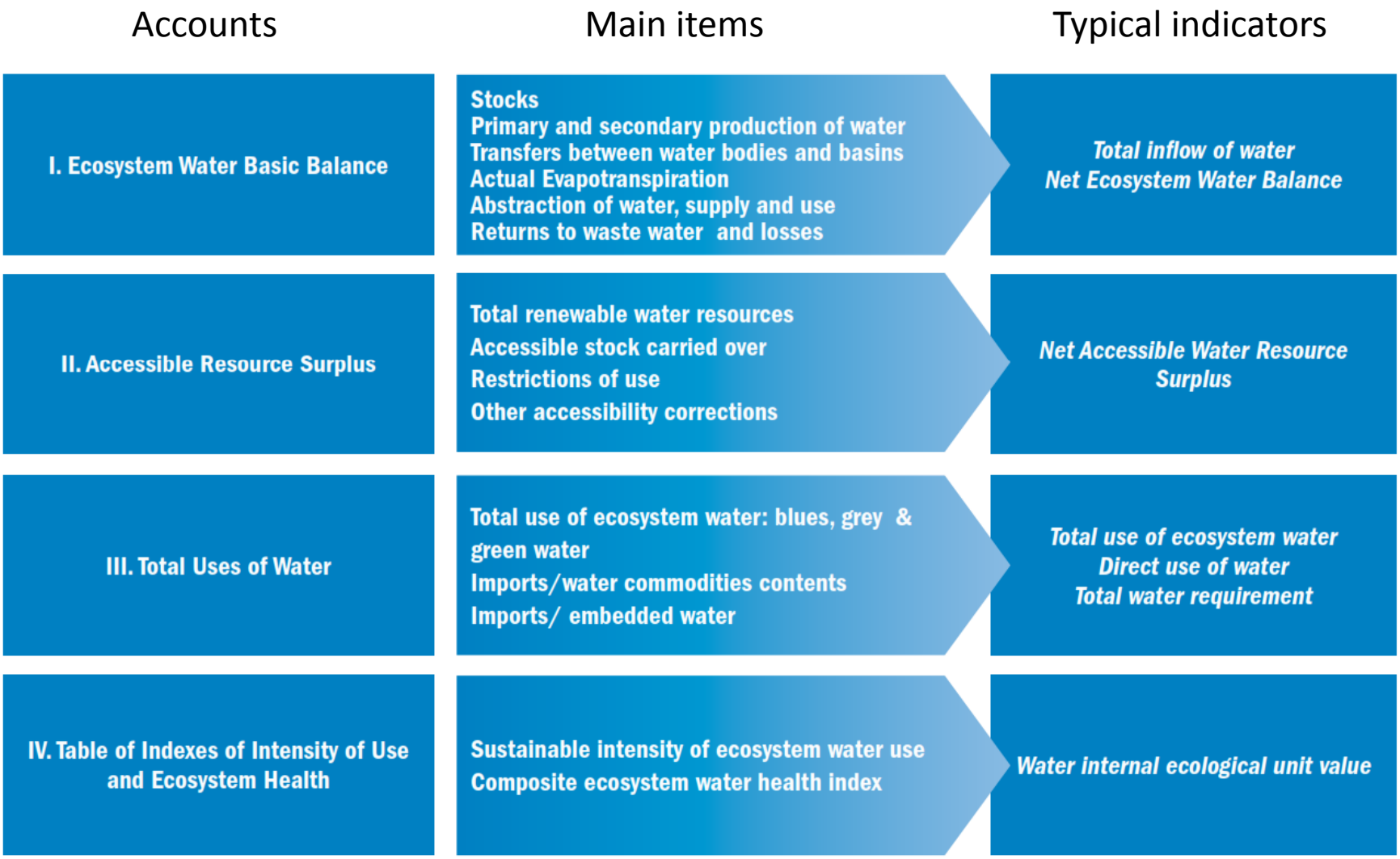
Land cover flows	
lf1	Artificial development
lf2	Agriculture extension
lf3	Internal conversions, rotations
lf4	Management and alteration of forested land
lf5	Restoration and development of habitats
lf6	Changes of land-cover due to natural and multiple causes
lf7	Other land cover changes n.e.c. and reclassification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

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

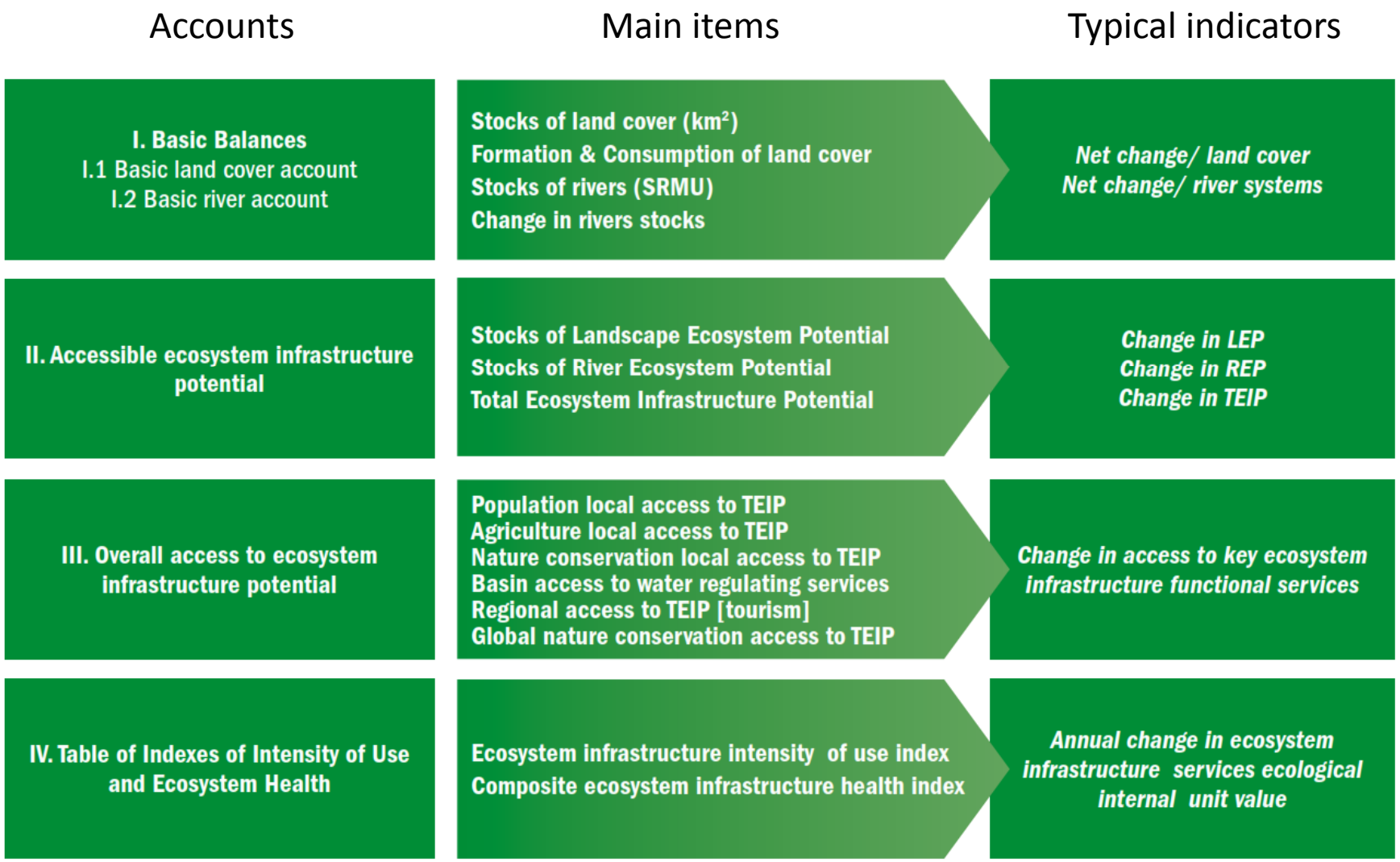
Ecosystem carbon account



Ecosystem water resource account



Ecosystem infrastructure functional services account



Ecosystem capability account, creation of ecological debts & credits

YEAR (2)			[C]	[W]	[EIP]	[ECC]
			Biomass/ Carbon	Water	Ecosystem infrastructure potential	Ecosystem Capital Capability
Accessible Ecosystem Resource and Use			t or j	m^3 or j	Weighted ha_or_km	*NA*
Accessible Basic Resources	**EC1**	**Net Accessible Ecosystem Resources, year (t-1) (NEACS, NEAWS & Net Ecosystem Infrastructure Potential)**	**1270**	1980	2331	
	EC211	Change due to Use of Accessible Basic Resources	90	-30	-11	NA
	EC212	Other Change due to Natural & Multiple Causes	-60	50	0	NA
	EC21	***Total Change in Basic Resource Accessibility***	30	20	-11	*NA*
	EC2	**Net Accessible Ecosystem Resources, year (t) (NEACS, NEAWS & Net Ecosystem Infrastructure Potential)**	**1300**	**2000**	**2320**	NA
Use of ecosystem resource	**EC3**	**Use of ecosystem resource**	**1210**	**2030**	**2331**	*NA*
Ecosystem Capability Account			**ECU**	ECU	ECU	**ECU**
Calculation of unit values in ECU	**EC4**	**Mean ECU unit value of Accessible Resources & Ecosystem Capital Capability in year (t-1)**	**0.963**			
	EC511	Indexes of sustainable intensity of resource use [IF<1, = overuse, dilapidation; IF>1, accumulation]	*1.074*	*0.985*	*0.995*	*NA*
	EC512	Indexes of change in ecosystem health [IF<1, = deterioration; IF>1, improvement]	*0.910*	*0.960*	*0.950*	*NA*
	EC51	***Annual change in accessible resources internal unit values & change of ECU unit value***	***0.992***	***0.973***	***0.973***	***0.979***
	EC5	**Mean ECU unit value of Accessible Resources & Ecosystem Capital Capability in year (t) [EC5 = EC4 x EC51_ECC]**	***0.943***			
Accessible Resources & Ecosystem Capital Capability	**EC6**	**Net Accessible Resources & Ecosystem Capital Capability, ecological value in ECU, year (t-1)**	**1222.7**	**1906.3**	**2244.2**	***1222.7***
	EC7	**Net Accessible Resources & Ecosystem Capital Capability, ecological value in ECU, year (t)**	**1225.5**	**1885.4**	**2187.0**	***1225.5***
	EC71	***Activities' Net Accumulation of Ecosystem Capital Capability, in ECU [IF<0, = degradation; IF>0, = renewal]***	0.8	-22.9	-59.2	***0.8***
	EC722	Global/continental/regional processes	***1.0***	*1.0*	*1.0*	***1.0***
	EC722	Change caused by neighbouring/interacting ecosystems	***1.0***	*1.0*	*1.0*	***1.0***
	EC72	***Change in Ecosystem Capital Capability Due to Natural and Multiple Causes, in ECU***	***2.0***	*2.0*	*2.0*	***2.0***
	EC73	***Total Change in Accessible Resources & Ecosystem Capital Capability, in ECU = EC7-EC6***	***2.8***	*-20.9*	*-57.2*	***2.8***
Creation of Ecological Debts & Credits	***EC81 = EC71***	***Activities' Net Accumulation of Ecosystem Capital Capability, in ECU [IF<0, = degradation; IF>0, = renewal]***	***0.8***	*-22.9*	*-57.2*	***0.8***
	EC821	Indirect change caused, Global/continental/regional processes	***-3.0***	*-2.0*	*-4.0*	***-3.0***
	EC822	Change caused to neighbouring/interacting ecosystems	***-1.0***	*-10.0*	*-15.0*	***-1.0***
	EC82	***Net Change Caused to Other Ecosystems' Capability, in ECU [degradation (-) or enhancement (+)]***	***-4.0***	*-12.0*	*-19.0*	***-4.0***
	EC8	**Creation of New Ecological Debts & Credits (in ECU) [direct & indirect ecosystem degradation or renewal]**	***-3.2***	*-34.9*	*-78.2*	***-3.2***
	EC9	**Cumulated Net Balance of Ecological Debts (-) & Credits (+) in ECU (from baseline year 0)**				***-16.5***
Indexes						
Indexes	***EC51***	***Annual change in accessible resources internal unit values & change of ECU unit value***	***0.992***	***0.505***	***0.498***	***0.665***
	EC5	***Mean ECU unit value of Accessible Resources & Ecosystem Capital Capability in year (t)***	***0.943***			
	EC22	***Index of Change in Volume of Basic Resource Accessibility = EC2/EC1***	***1.024***	**1.010**	**0.995**	NA
	EC23	***Index of Change in Ecological Value of Ecosystem Capital Capability =EC22xEC5***	**0.965**	**0.952**	**0.938**	**0.965**

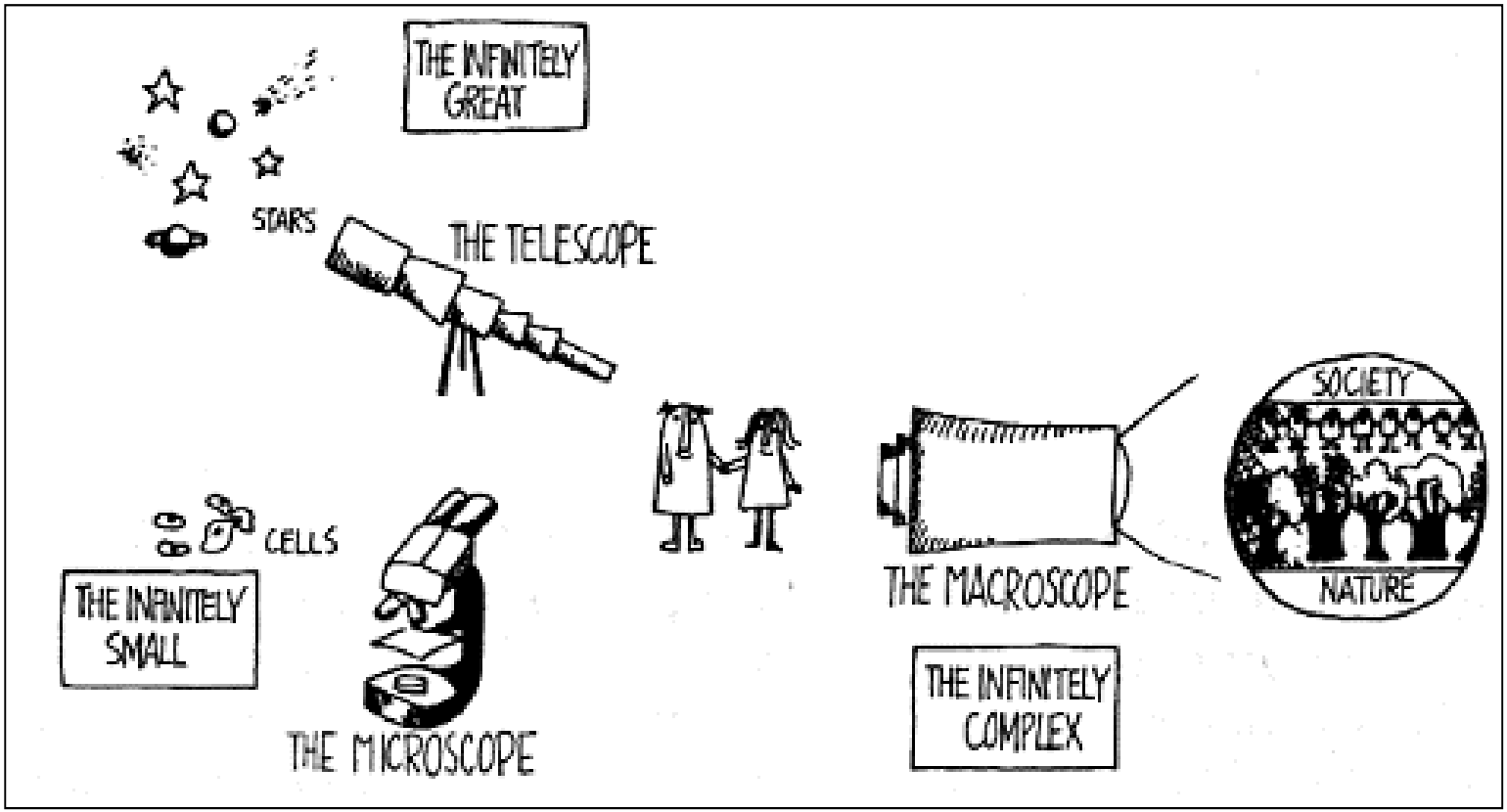
Ecological balance- sheet in ECU

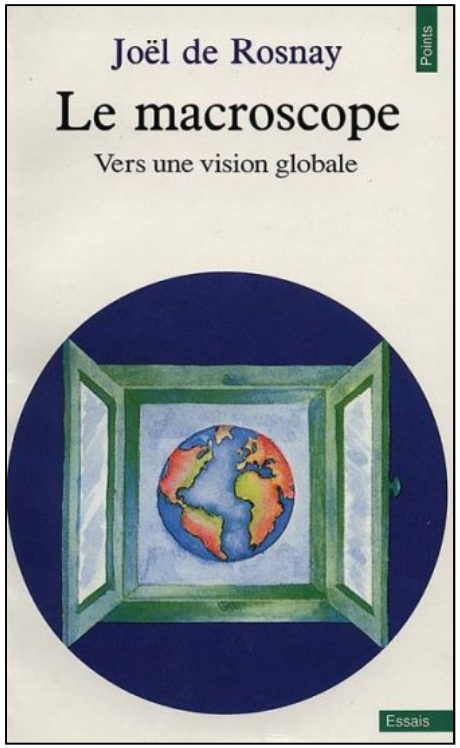
	Domestic physical assets [a]	Ecological credits [b]	Ecological debts [c]	Net Ecological Worth = [b]-[c]
I - Short term assets and liabilities				
Opening balance sheet/ short term	**100**	**100**		**100**
Degradation by activities	-12		12	-12
Natural losses	-9	-9		-9
Restoration from previous degradation	2		-2	2
Ecosystem creation/ enhancement	7	7		7
Natural gains	4	4		4
Net change in short term assets and liabilities	**-8**	**2**	**10**	**-8**
Closing balance sheet/ short term	**92**	**102**	**10**	**92**
II - Long term assets and liabilities				
Ecosystem restoration commitments		50	50	0
Accumulated ecological credits/ allocations		13		13
Accumulated ecological debts			35	-35
Opening balance sheet/ long term		**63**	**85**	**-22**
Change in ecosystem restoration commitments		0	**0**	0
Change in accumulated ecological credits/ allocations		8		8
Change in accumulated ecological debts			11	-11
Net change in longterm assets and liabilities		**8**	**11**	**-3**
Ecosystem restoration commitments		50	50	0
Accumulated ecological credits/ allocations		21		21
Accumulated ecological debts			46	-46
Closing balance sheet/ long term		**71**	**96**	**-25**
III - International liabilities				
Opening balance sheet/ Embedded ecosystem degradation			**30**	**-30**
Accquisition of embedded ecosystem degradation			15	-15
Compensation of embedded ecosystem degradation			-5	5
Net change in ecosystem degradation embedded in trade			**10**	**-10**
Closing balance sheet/ Embedded ecosystem degradation			**40**	**-40**
Consolidated balance sheet (I + II + III)				
Opening balance sheet	100	163	115	48
Net change	-8	10	31	-21
Closing balance sheet	92	173	146	27

Jean-Louis Weber, 1st June 2015

The Ecological Balance Sheet: an integrated framework

QUESTION: Is the Ecological Balance Sheet similar to the Macroscope?

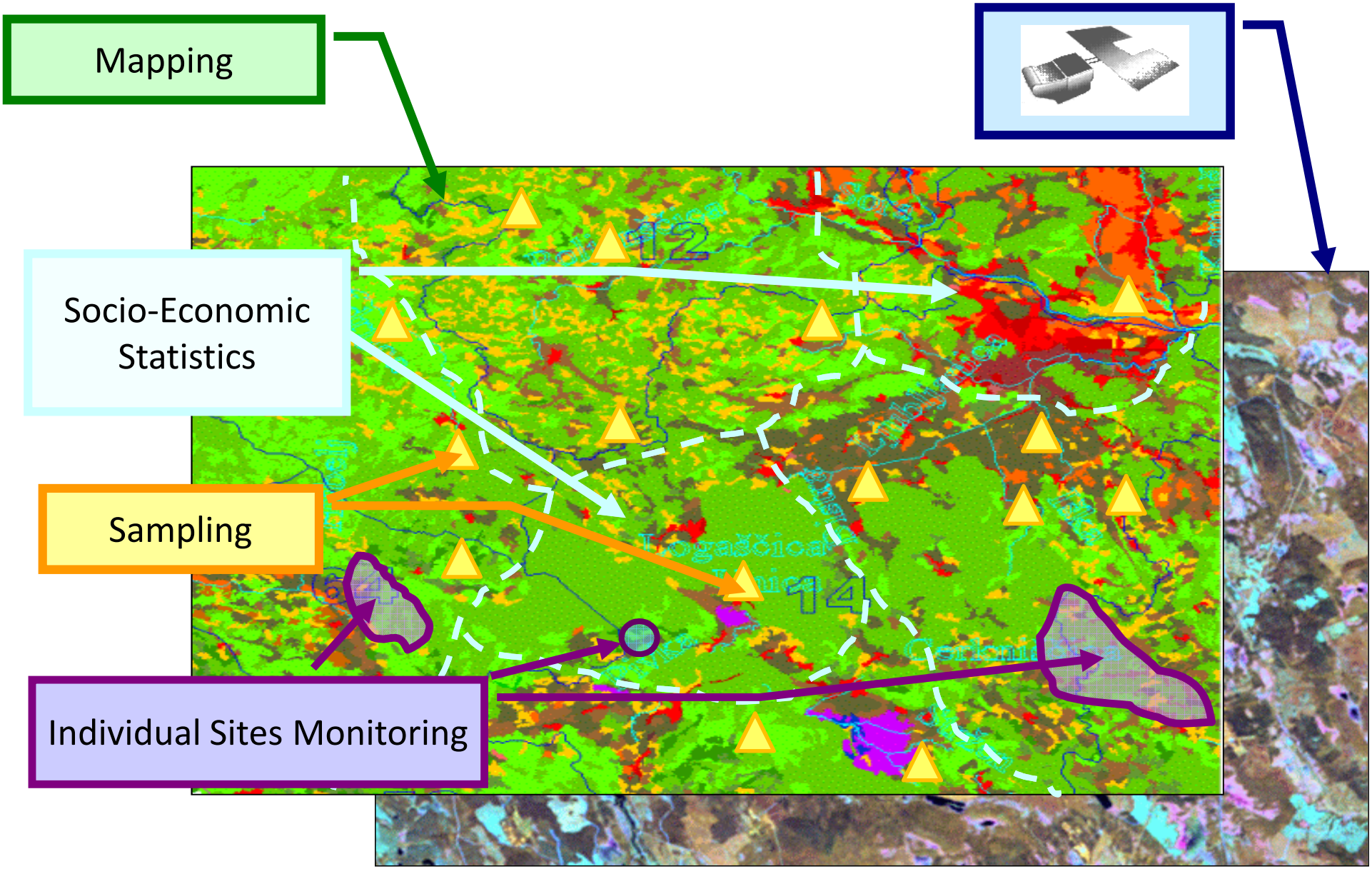




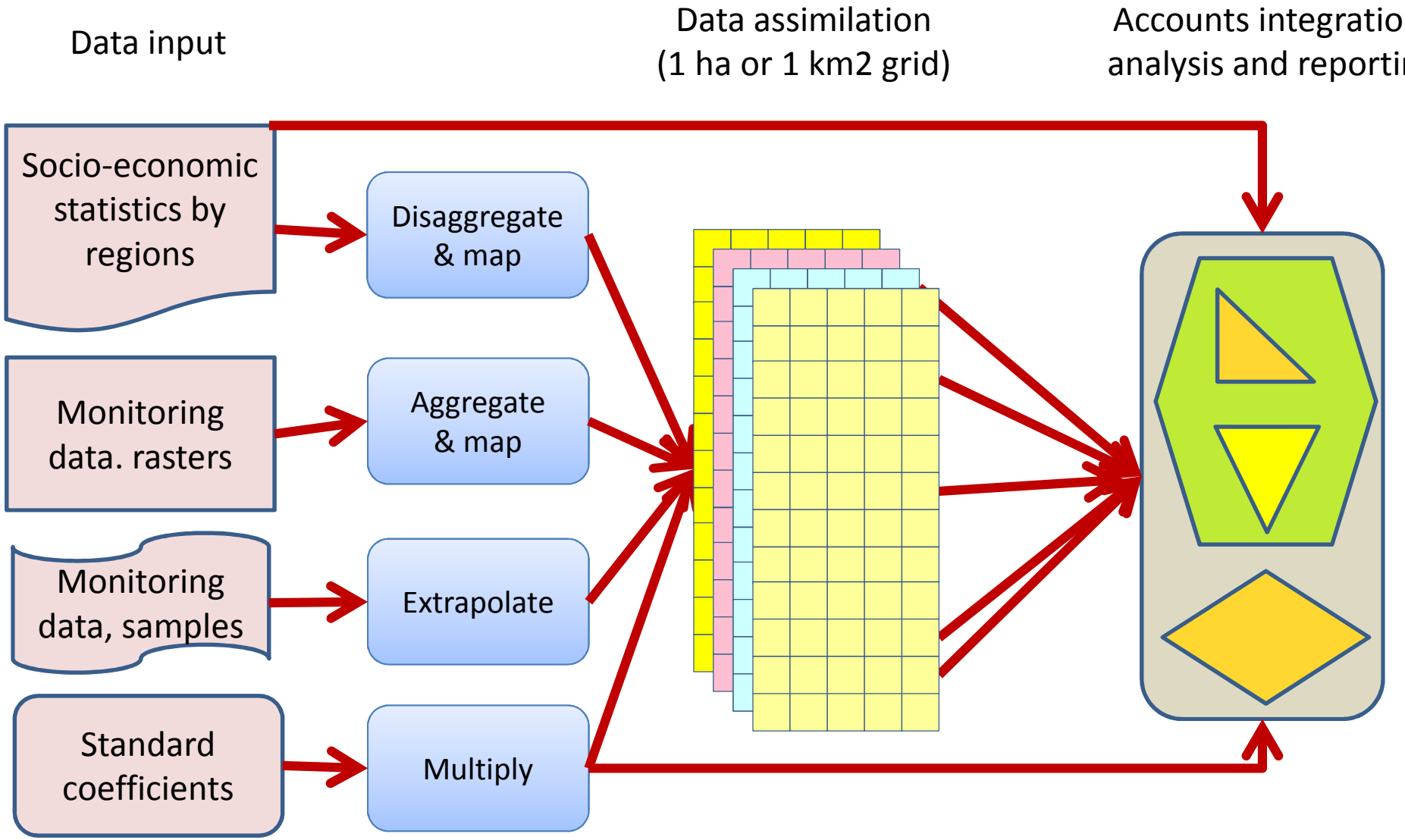
Implementation of (Integrated) Ecosystem Natural Capital Accounts and Example of experimental results for Mauritius

Jean-Louis Weber, 1st June 2015

Spatial Integration of Environmental & Socio-Economic Data



Main data flows to compile ecosystem capital accounts



From ecosystem physical degradation to capital consumption, ecological debts and sustainable benefits

Consumption of ecosystem capital (unpaid costs) & ecological debts (in $)

Economic statistics & national accounts

Ecological sustainability of **Value Added supported by ecosystem services**

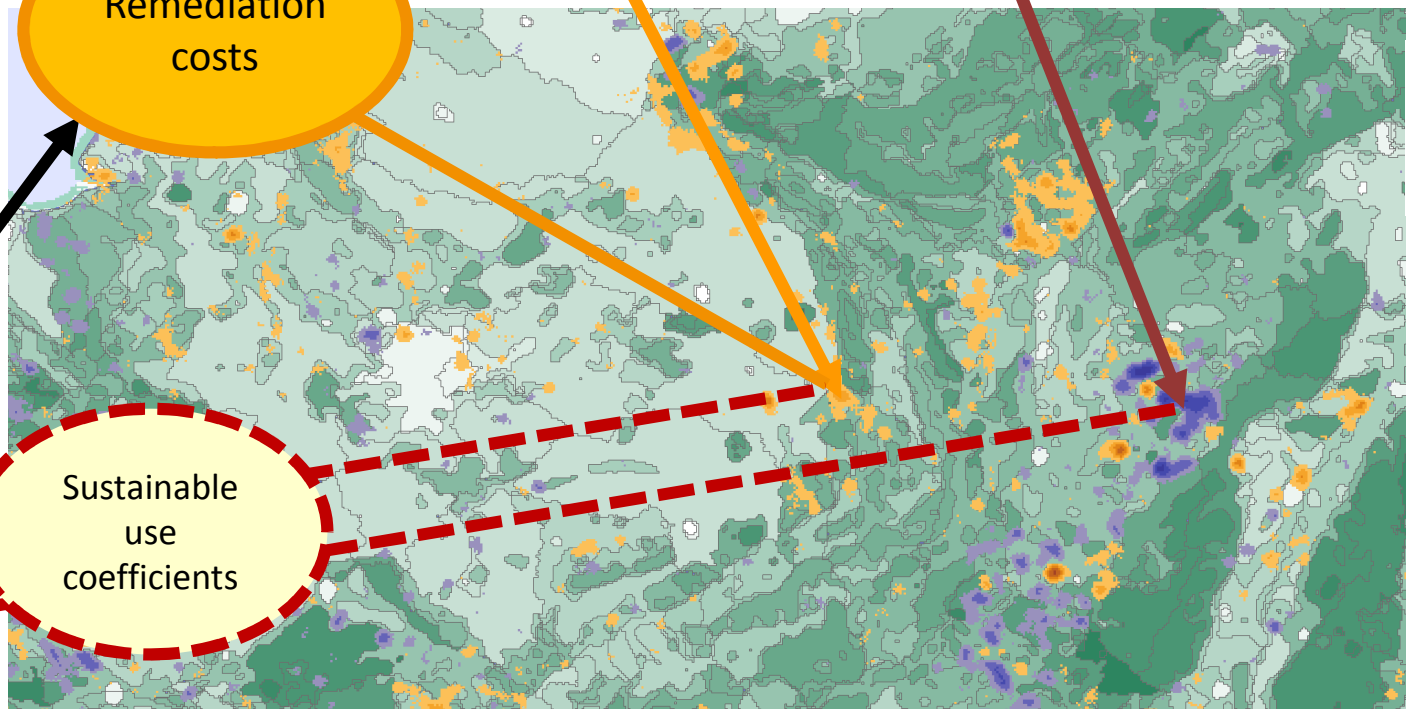
Remediation costs

Sustainable use coefficients

Degradation

Enhancement

Balance sheet of ecological debts & credits (ECU)

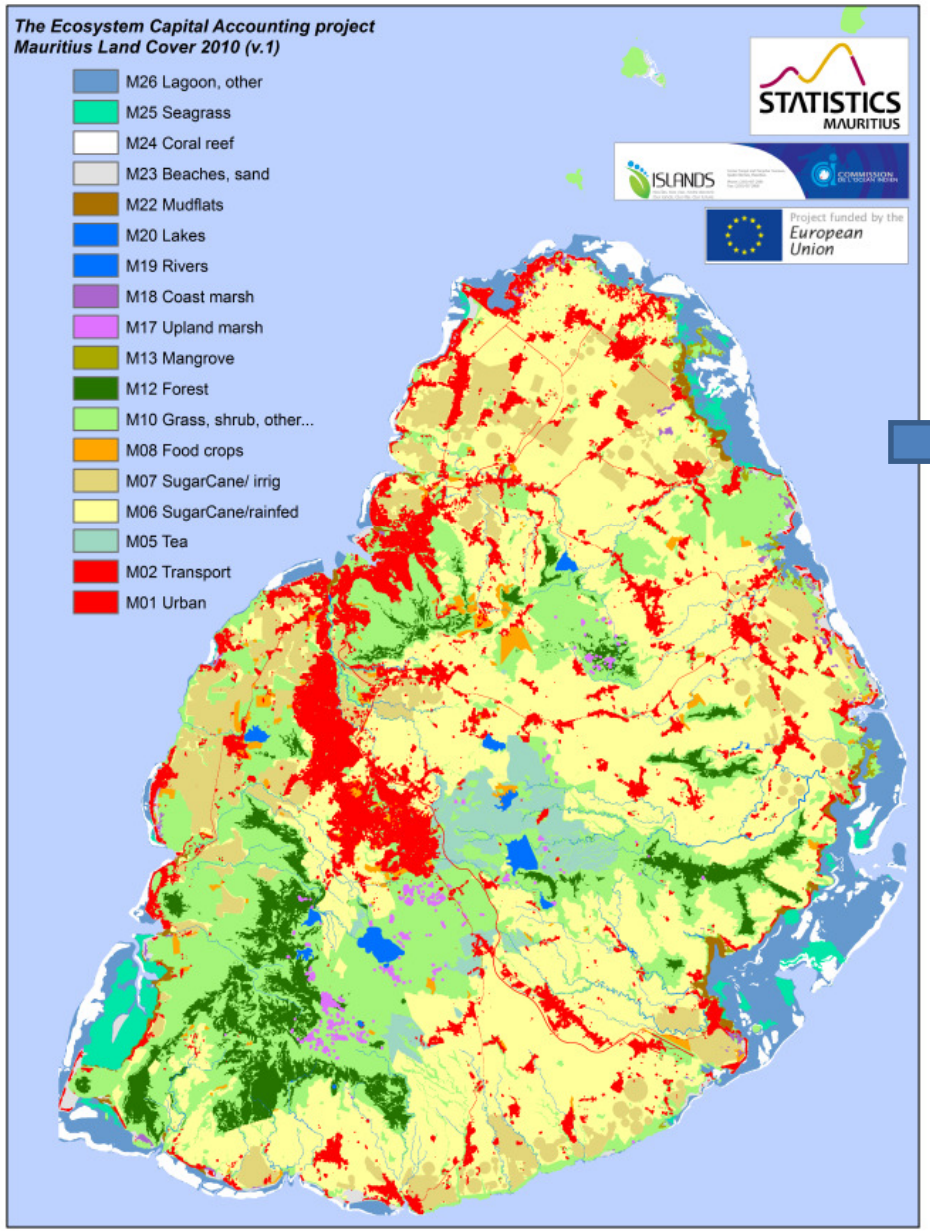


Landscape Ecological Potential change 1990-2006, by ecosystem landscape units

(J-L Weber and E. Ivanov, 2011)

SEEA-ENCA Mauritius preliminary results :

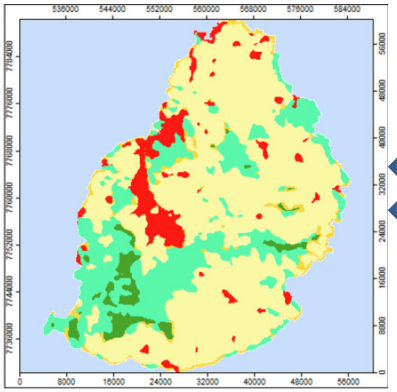
Creation of Ecosystem Accounting Units



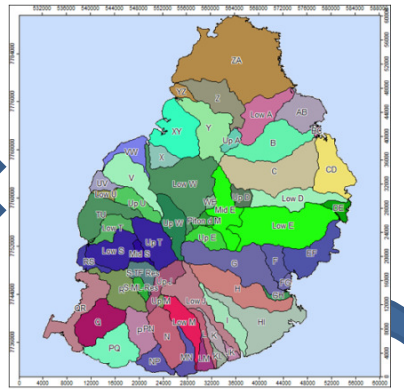
A land cover map has been produced from the start for:

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

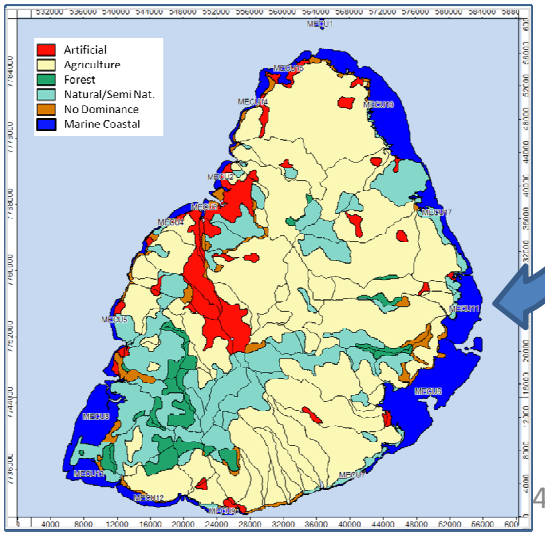
Dominant land cover types (>50%)

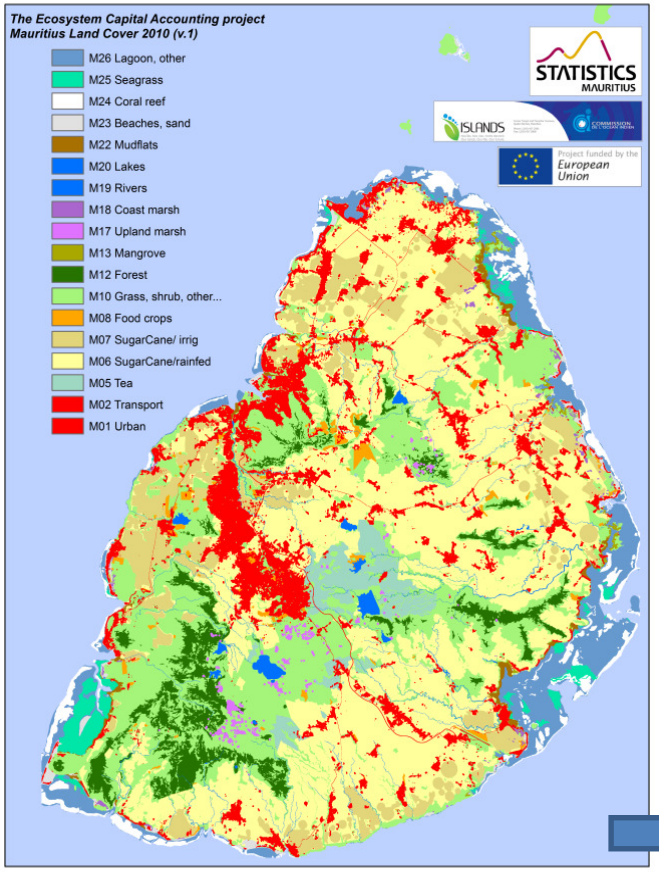


River sub-basins



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



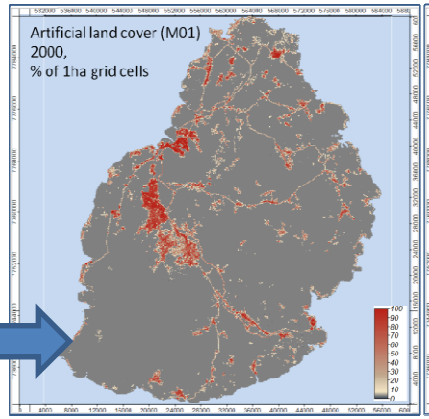


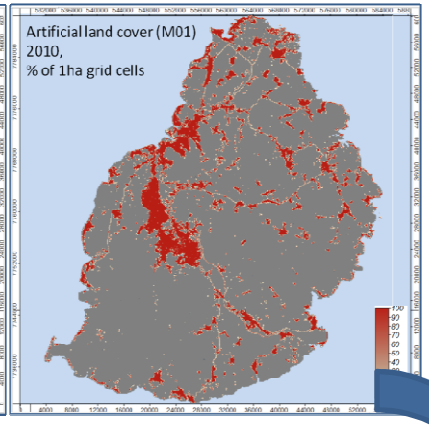
SEEA-ENCA Mauritius preliminary results :

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





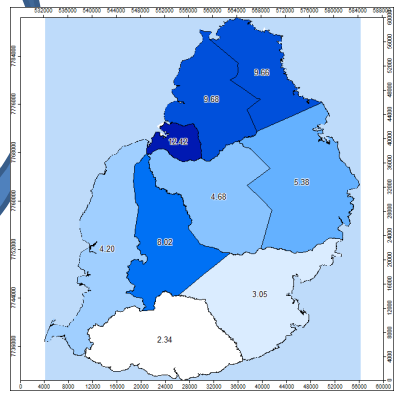
These grids allow computing statistics and producing ecosystems/natural capital accounts for various statistical units such as municipal and village council areas, districts, coastal zones, river basins, socio-ecological landscape units and any relevant zoning.

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).

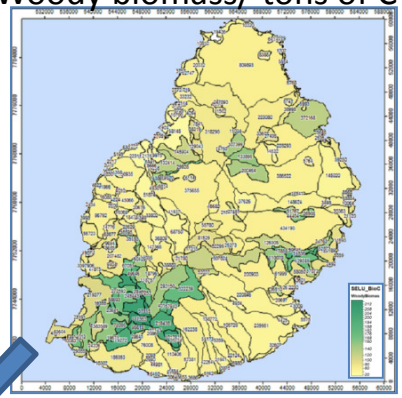
Accounts are compiled using various sources such as products based on earth observation by satellite (e.g. MODIS NPP), on in situ monitoring (for IPCC-LULUCF, FAO/soil, FRA2010) and official statistics .

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

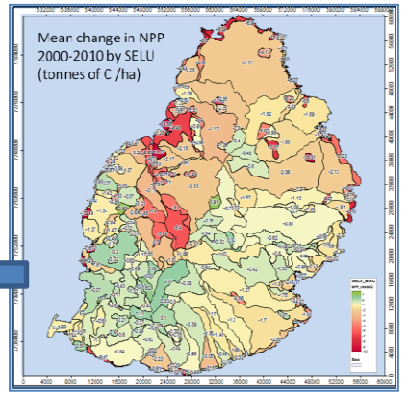
Provisional

2010	Rivière 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**

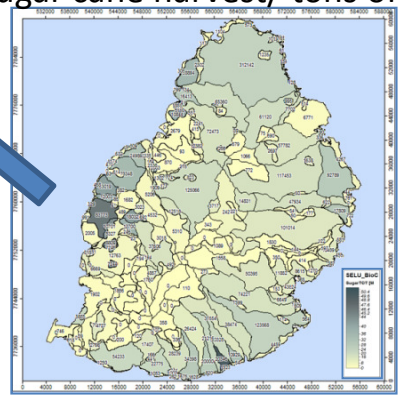
Woody biomass/ tons of C



Change in NPP/ tons of C



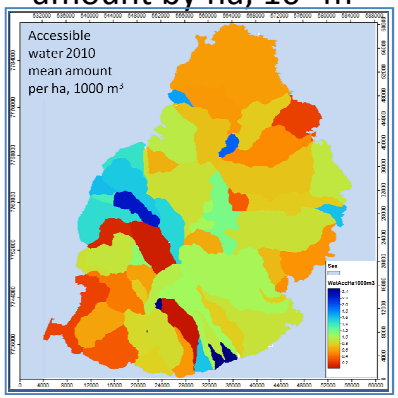
Sugar cane harvest/ tons of C



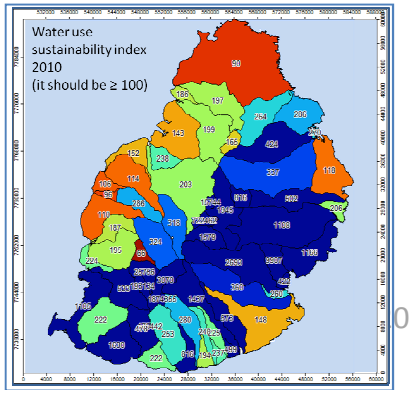
SEEA-ENCA Mauritius preliminary results :
The ecosystem water account

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)

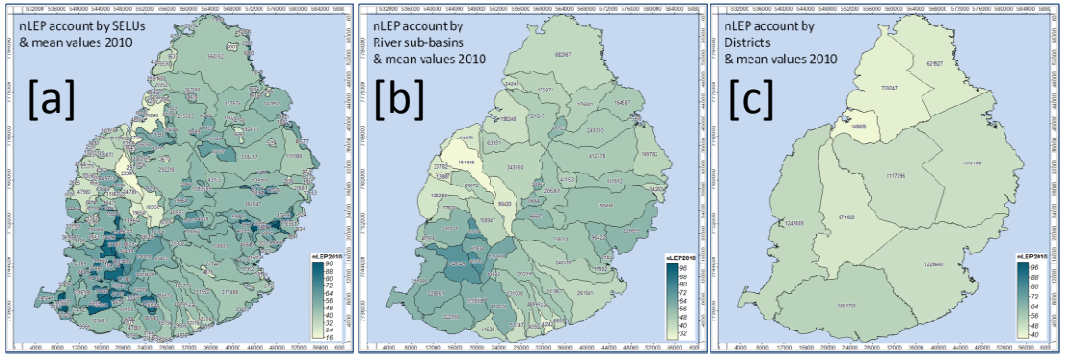
The biodiversity of systems and species account is made of two accounts which describe the state of ecosystems green infrastructure (landscapes, rivers and sea coastal zones) on the one hand and changes in species biodiversity on the other hand.

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

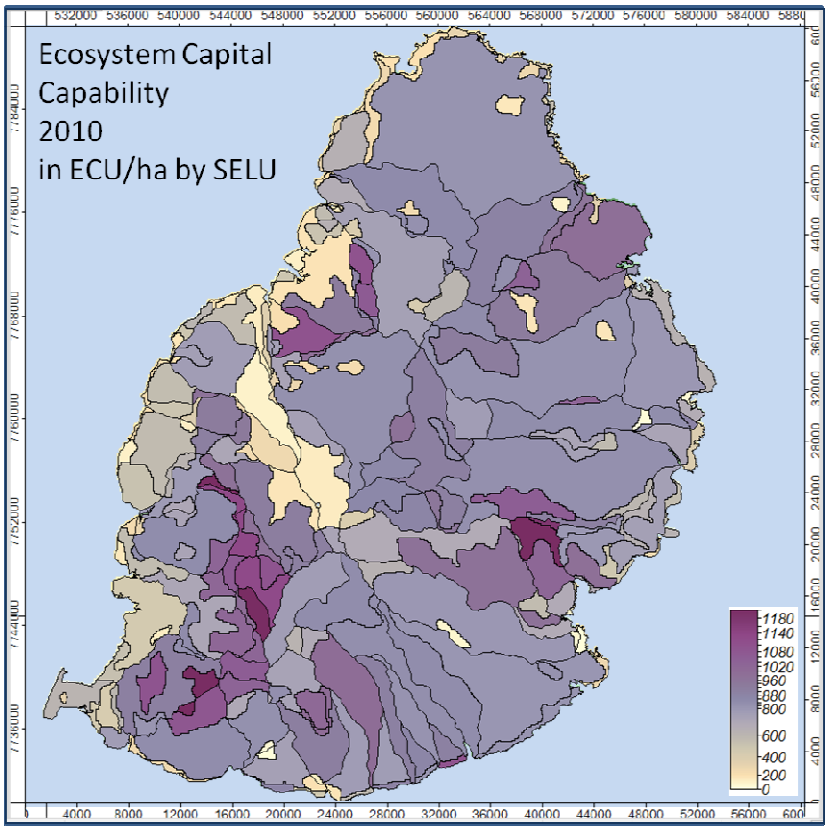
Provisional	*Riviere du Rempart*	*Pamplemousses*	*Flacq*	*Moka*	*Grand Port*	*Plaines Wilhems*	*Black River*	*Savanne*	*Port Louis*	**Total** */ Mean values*
AREA_ha	14703	18019	29826	23512	26134	19839	25558	24758	3976	186325
Indexes (0-100 value per ha)										
GBL 2000 index	*43.4*	*41.7*	*49.7*	*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]

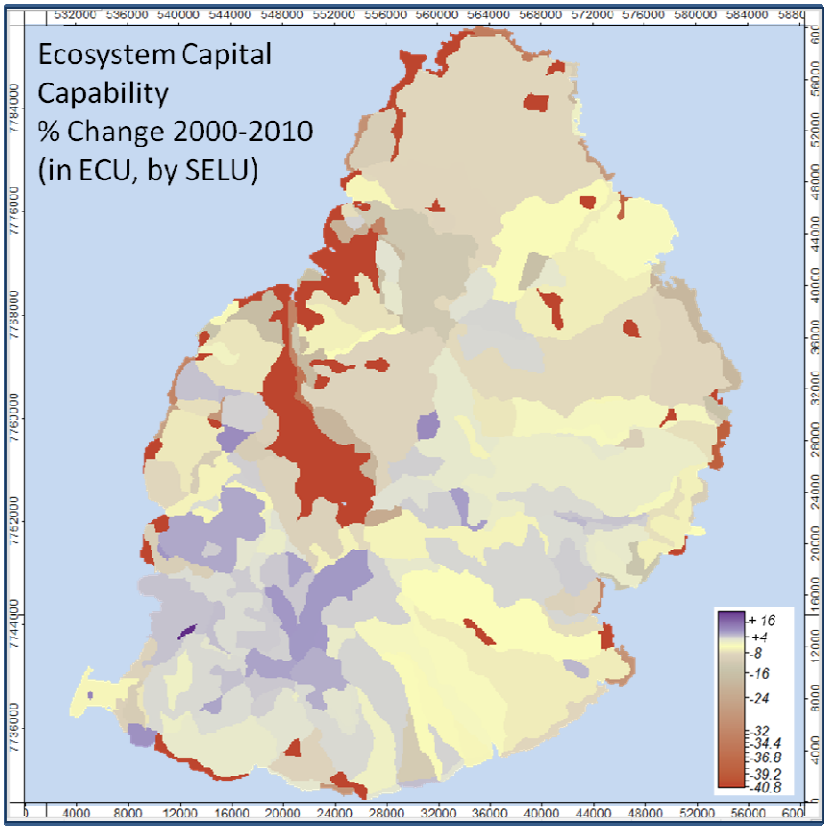


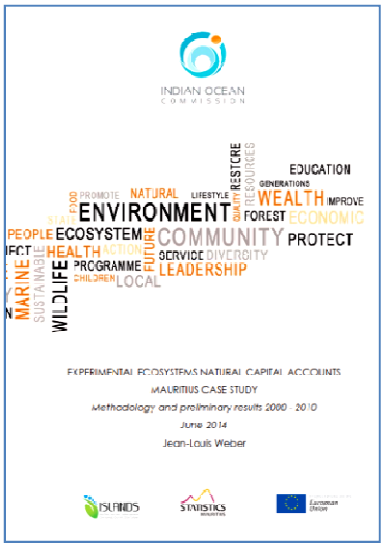
A first attempt to calculate Ecosystem Capital Capability (in ECU) for Mauritius

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



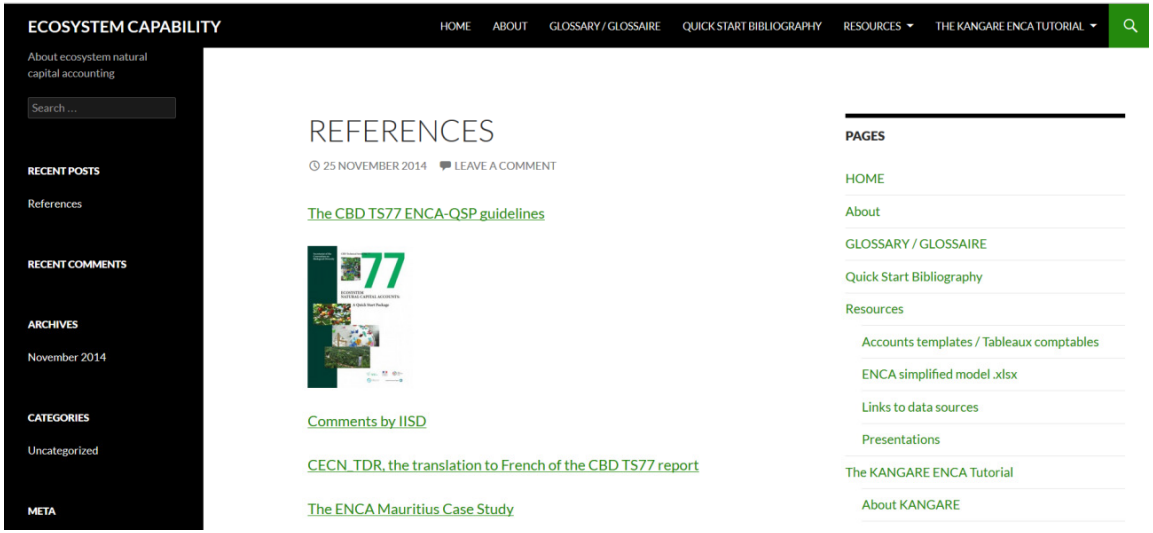
Ecosystem Capital Capability (inland):
Change in ECU value, % by Socio-Ecological Landscape Units, 2000-2010





Provisional results

Experimental ENCA, Mauritius Case Study (IOC, 2014)



http://www.ecosystemaccounting.net/