Ecosystem Accounting in the Philippines – Workshop 2: Introduction

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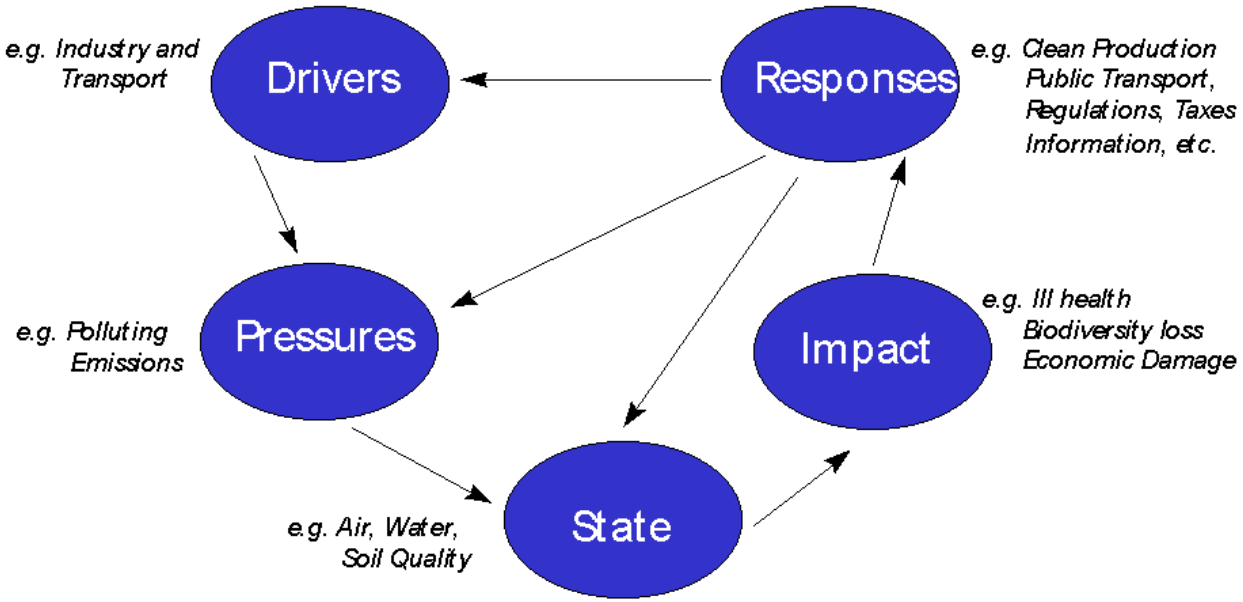
Hence we need to better understand, a.o.:

- The impacts of ecosystem change on people
- Potential response options (mitigate, adapt)
- The effects, and cost/benefit ratio of response options



Source (DPSIR): EEA

Policy applications of ecosystem accounts

- Measuring and monitoring sustainability: what are the changes in ecosystem capital / ecosystem assets from one year to the next
- Identifying ecosystem types/ areas / services under particular threat
- Understanding the contribution of ecosystems to economic activities (and the monetary value of these ecosystems)
- Spatial approach: land and resource use planning

How people benefit from ecosystems

Ecosystem services are the contributions of ecosystems to human welfare, for instance:

- Timber and fish that can be harvested
- Crops that can be grown in areas with water and fertile soil
- The regulation of climate processes
- The regulation of hydrological processes
- Providing opportunities for recreation and tourism
- Providing cultural experiences

Types of ecosystem services

- **Provisioning services**: the products that can be extracted from or harvested in ecosystems
- **Regulating Services**: the regulation of ecological, hydrological and climate processes
- **Cultural services**: the non-material benefits from ecosystems (e.g. recreation)

- **Different classifications**
  - Millennium Ecosystem Assessment
  - TEEB
  - CICES

CICES: Provisioning Services

Theme	Service Class	Service Group	Service Type	Sub-types	Examples and indicative benefits
Provisioning	Nutrition	Terrestrial plant and animal	Commercial cropping	eg. by crops	Cereals, vegetables, vines etc.
			Subsistence cropping	eg. by crops	Cereals, vegetables, vines etc.
			Commercial animal production	eg. by animal	Sheep, cattle for meat and dairy products
			Subsistence animal production	eg. by animal	Sheep, cattle for meat and dairy products
			Harvesting wild plants and animals for food	eg. by resource	Berries, fungi etc
		Freshwater plant and animal	Commercial fishing (wild populations)	eg. by fishery	By species
			Subsistence fishing	eg. by fishery	By species
			Aquaculture	eg. by fishery	By species
			Harvesting fresh water plants for food	eg. by resource	Water cress
		Marine plant and animal	Commercial fishing (wild populations)	eg. by fishery	Includes crustaceans
			Subsistence fishing	eg. by fishery	Includes crustaceans
			Aquaculture	eg. by fishery	Includes crustaceans
			Harvesting marine plants for food	eg. by resource	Seaweed
		Potable water	Water storage	eg. by feature	Spring, well water, river, reservoir, lake
			Water purification	eg. by habitat	Wetlands
	Materials	Biotic materials	Non-food plant fibres	eg. by resource	Timber, straw, flax
			Non-food animal fibres	eg. by resource	Skin, bone etc., guano
			Ornamental resources	eg. by resource	Bulbs, cut flowers, shells, bones and feathers etc. (Stones? Gems?)
			Genetic resources	eg. by resource	Wild species used in breeding programmes
			Medicinal resources	eg. by resource	Bio prospecting activities
		Abiotic materials	Mineral resources		Salt, aggregates, etc. (EXCLUDE subsurface assets)
	Energy	Renewable biofuels	Plant based resources	eg. by resource	Wood fuel, energy crops etc.
			Animal based resources	eg. by resource	Dung, fat, oils
		Renewable abiotic energy	Wind	eg. by resource	
			Hydro	eg. by resource	
			Solar	eg. by resource	
			Tidal	eg. by resource	
			Thermal	eg. by resource	

Source: EEA, 2011: CICES Update

CICES Regulating and Maintenance, Cultural

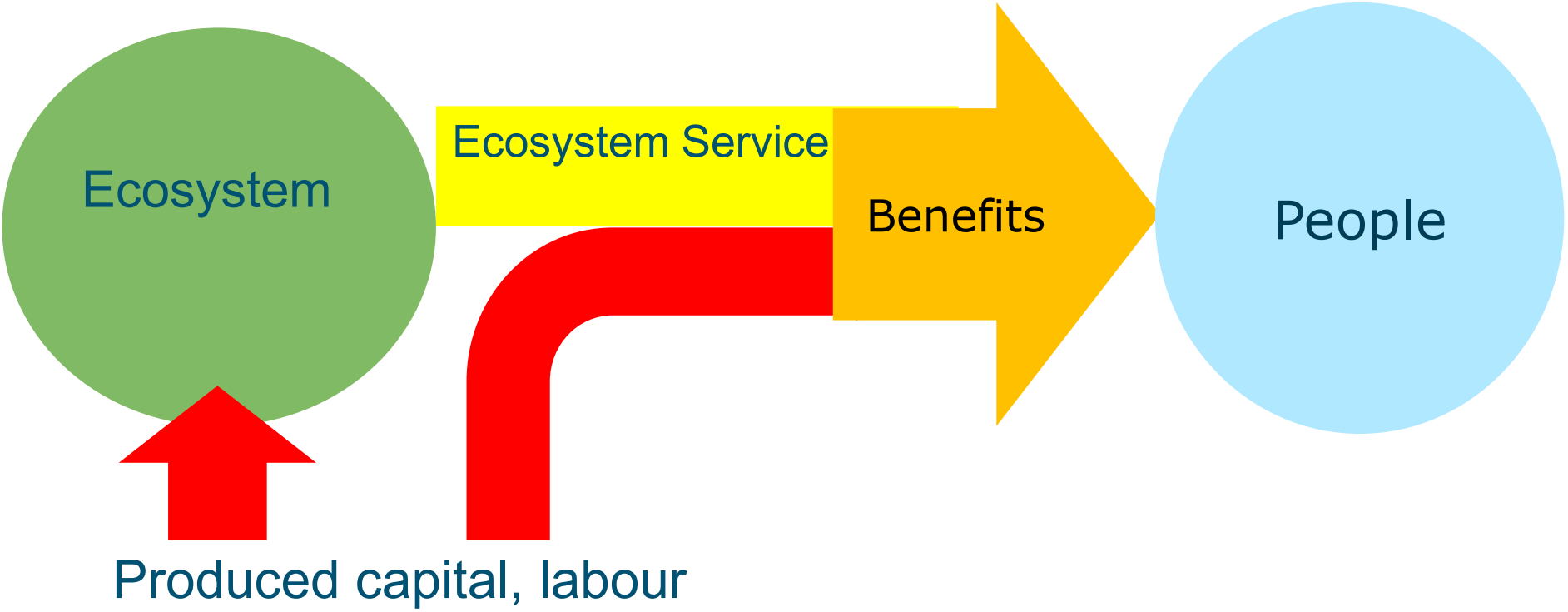
Theme	Service Class	Service Group	Service Type	Sub-types	Examples and indicative benefits
Regulation and Maintenance	Regulation of wastes	Bioremediation	Remediation using plants	eg. by method	Phytoaccumulation, phytodegredation, phytostabilisation, rhizodegradation,
			Remediation using micro-organisms	eg. by method	In situ (Bioremediation), ex situ (composting), bioreactors
		Dilution and sequestration	Dilution	eg. by method	Wastewater treatment
			Filtration	eg. by method	Filtration of particulates and aerosols
			Sequestration and absorption	eg. by method	Sequestration of nutrients in organic sediments, removal of odours
	Flow regulation	Air flow regulation	Windbreaks, shelter belts	eg. by process	
			Ventilation	eg. by process	
		Water flow regulation	Attenuation of runoff and discharge rates	eg. by process	Woodlands, wetlands and their impact on discharge rates
			Water storage	eg. by process	Irrigation water
			Sedimentation	eg. by process	Navigation
			Attenuation of wave energy	eg. by process	Mangroves
		Mass flow regulation	Erosion protection	eg. by process	Wetlands reducing discharge peak
			Avalanche protection	eg. by process	Stabilisation of mudflows, erosion protection [reduction]
	Regulation of physical environment	Atmospheric regulation	Global climate regulation (incl. C-sequestration)	eg. by process	Atmospheric composition, hydrological cycle
			Local & Regional climate regulation	eg. by process	Modifying temperature, humidity etc.; maintenance of regional precipitation
		Water quality regulation	Water purification and oxygenation	eg. by process	Nutrient retention in buffer strips etc. and translocation of nutrients
			Cooling water	eg. by process	For power production
		Pedogenesis and soil quality regulation	Maintenance of soil fertility	eg. by process	Green mulches; n-fixing plants
			Maintenance of soil structure	eg. by process	Soil organism activity
	Regulation of biotic environment	Lifecycle maintenance & habitat protection	Pollination	eg. by process	By plants and animals
			Seed dispersal	eg. by process	By plants and animals
		Pest and disease control	Biological control mechanisms	eg. by process	By plants and animals, control of pathogens
		Gene pool protection	Maintaining nursery populations	eg. by process	Habitat refuges
Cultural	Symbolic	Aesthetic, Heritage	Landscape character	eg. by resource	Areas of outstanding natural beauty
			Cultural landscapes	eg. by resource	Sense of place
		Spiritual	Wilderness, naturalness	eg. by resource	Tranquillity, isolation
			Sacred places or species	eg. by resource	Woodland cemeteries, sky burials
	Intellectual and Experiential	Recreation and community activities	Charismatic or iconic wildlife or habitats	eg. by resource	Bird or whale watching, conservation activities, volunteering
			Prey for hunting or collecting	eg. by resource	Angling, shooting, membership of environmental groups and organisations
		Information & knowledge	Scientific	eg. by resource	Pollen record, tree ring record, genetic patterns
			Educational	eg. by resource	Subject matter for wildlife programmes and books etc.

Source: EEA, 2011: CICES Update

Hence

- No definite common classification of ecosystem services yet.
- CICES presents a comprehensive checklist of potential service types (although not always formulated in a consistent manner)
- Need to adjust service selection and definition to the country and it's ecosystem and ecosystem uses
- Need to define the services in a precise manner
- Need to distinguish services from benefits (for provisioning and cultural services, in particular)

Services versus benefits



Ecosystem assets / capital

- We can see ecosystems as presenting a form of 'capital', i.e. an asset, or aggregation of ecosystem assets that is fundamental to sustaining human well-being by:
  - setting the conditions for human life (regulating environmental processes),
  - providing (renewable) inputs to a broad range of economic activities, and through
  - absorbing and assimilating waste and emissions.
- The Experimental Ecosystem Accounting Guidelines (EEA) do not use the term ecosystem capital but rather 'ecosystem assets', defined as "spatial areas containing a combination of biotic and abiotic components and other characteristics that function together"
- Ecosystem capital is a subset of natural capital

Environmental and Environmental Economic Accounting

- Basis: System of National Accounts (2008) (UN-DESA)
- **Environmental** Accounting: measuring and recording water and energy use, emissions, discharges, environmental expenditure, environmental taxes
- **Environmental Economic** Accounting
  - Central Framework
  - Land and Water Accounts
  - Carbon Accounts, Biodiversity Accounts
  - **Ecosystem Accounting**

The System of National Accounts

Describes transactions (e.g. buying a product, or paying a tax) between institutional units such as households, the central government, or enterprises (classified in sectors such as agriculture or mining).

Transactions are described in a sequence of accounts:

- The current accounts (production, distribution and use of income) provide information on production, value added and income : gross and net domestic product (GDP and NDP) and national income (NNI).
- The accumulation accounts (capital, financial, other changes in volume) describe changes in **assets** by ownership. The resulting net worth and changes therein is recorded in the balance sheets.

Source: Edens and Hein, 2013

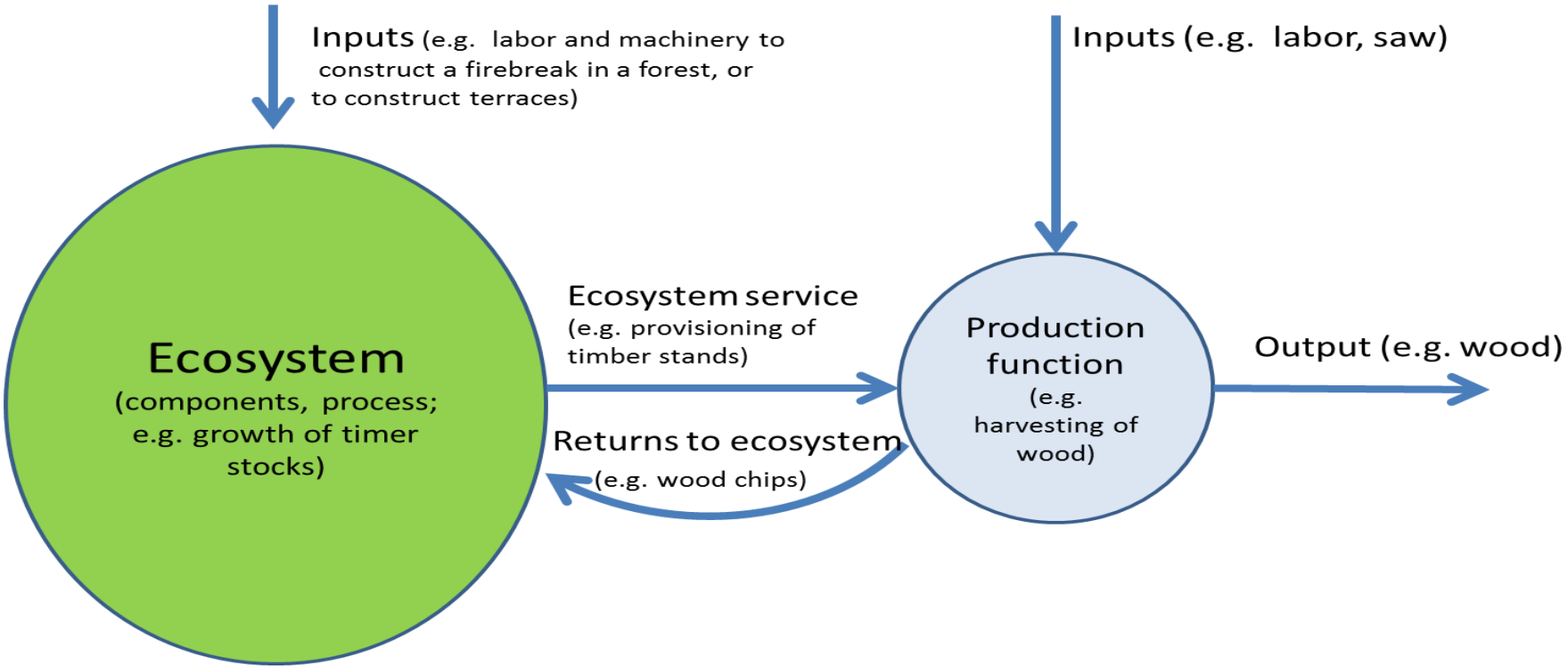
Production and assets

- SNA: economic production = “an activity carried out under the control and responsibility of an institutional unit that uses inputs of labour, capital and goods and services to produce outputs of goods or services” (6.24)
- Criteria: (i) presence of institutional unit; and (ii) ownership of output/ potential to be compensated/paid
- Excluding natural processes from the production boundary
- The SNA defines assets in terms of two necessary conditions of benefits and ownership
- The SEEA defines environmental assets more broadly as “the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity” (SEEA Central Framework, 2.17).

Why Ecosystem Accounts ?

- Ecosystem assets not covered in the SNA
- In recognition of the holistic nature of ecosystems: the combination of biotic and abiotic components and processes, and human management leads to the generation of services and benefits to people
- An ecosystem services approach allows for a comprehensive recording of the various services of ecosystems, hence better insight in trade-offs and complexities
- Spatial approach allows more comprehensive assessment PLUS additional applications

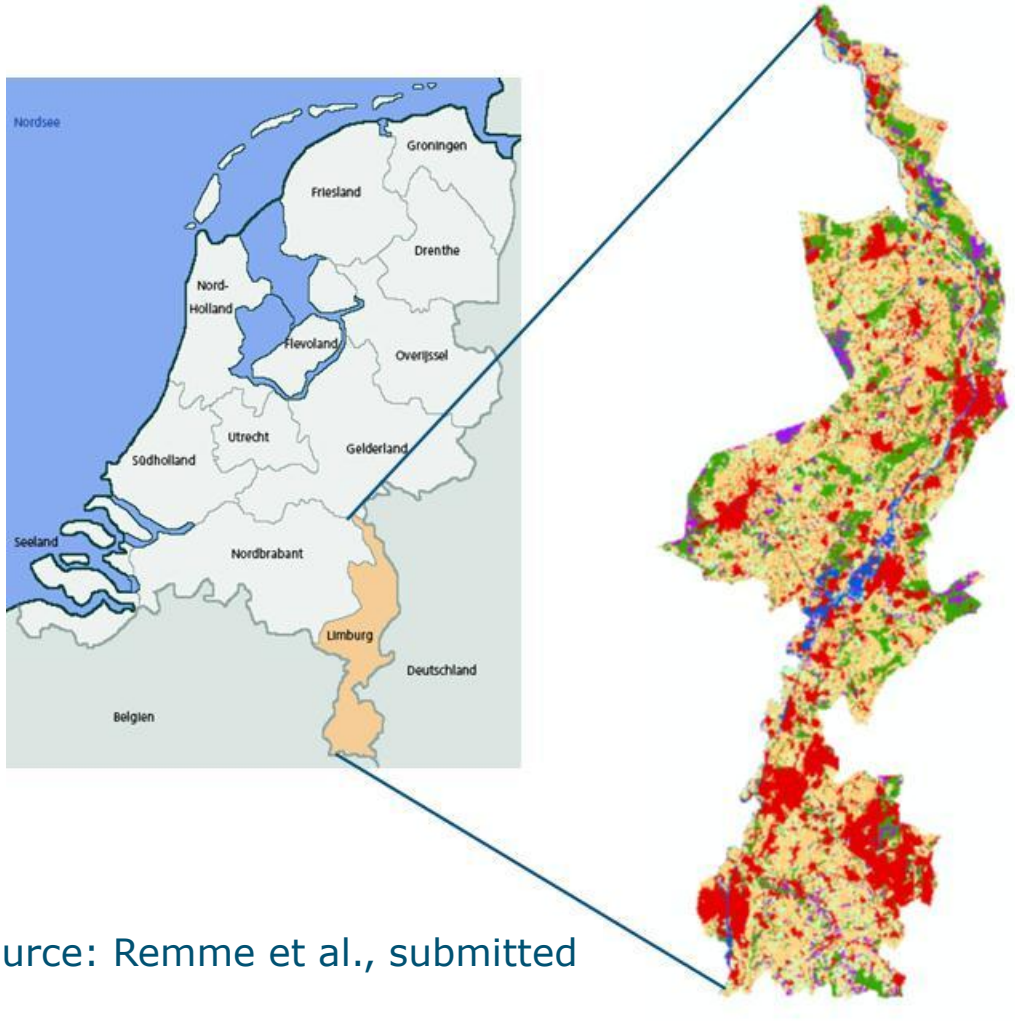
Ecosystem services in accounting



Sometimes the value of an ecosystem services can be observed in the market (e.g. stumpage value)

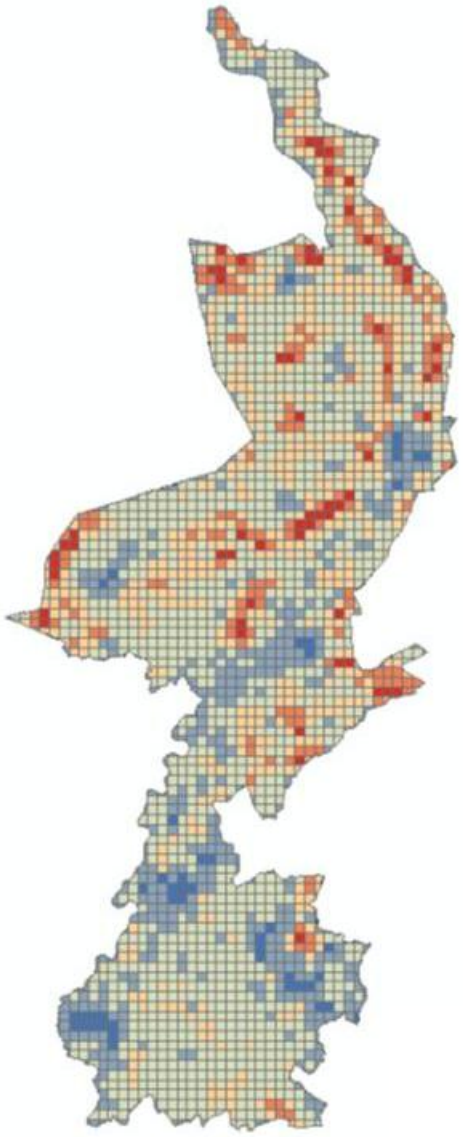
Ecosystem accounts example: Limburg

- Biophysical ecosystem account developed for Limburg Province, the Netherlands
- 2200 km^2, 1.1 million inhabitants
- Analysis of 8 ecosystem services



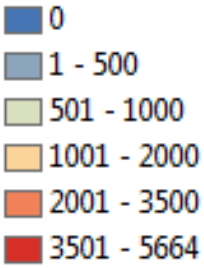
Source: Remme et al., submitted

Ecosystem accounts example: Limburg



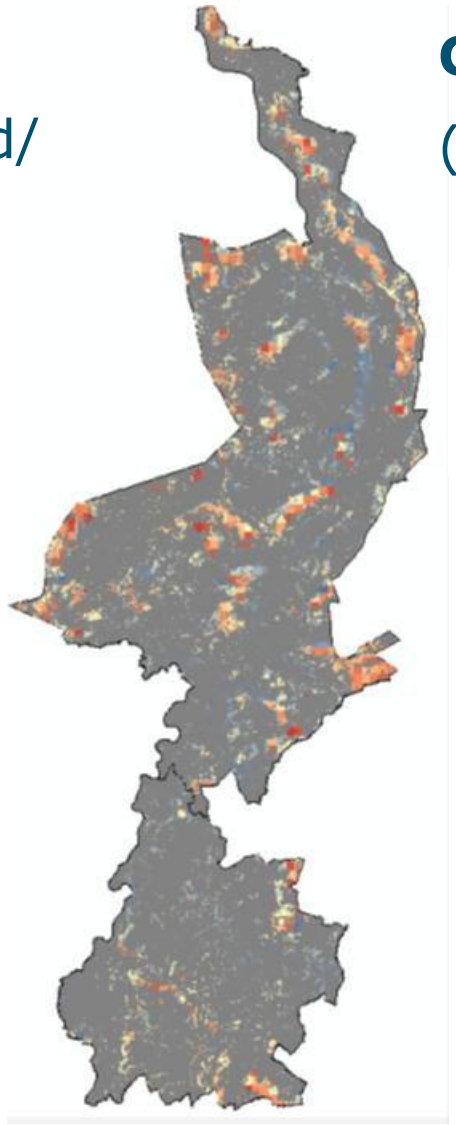
PM10 capture

(kg PM_{10} captured/ km^2/year)



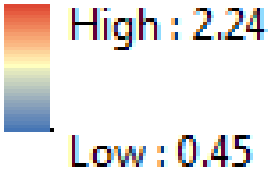
Total PM_{10} capture 2011:

2.3 million tons of PM_{10}



C sequestration

(ton C/ha/year)



Carbon sequestration equivalent to CO_2 emissions from 5000 households

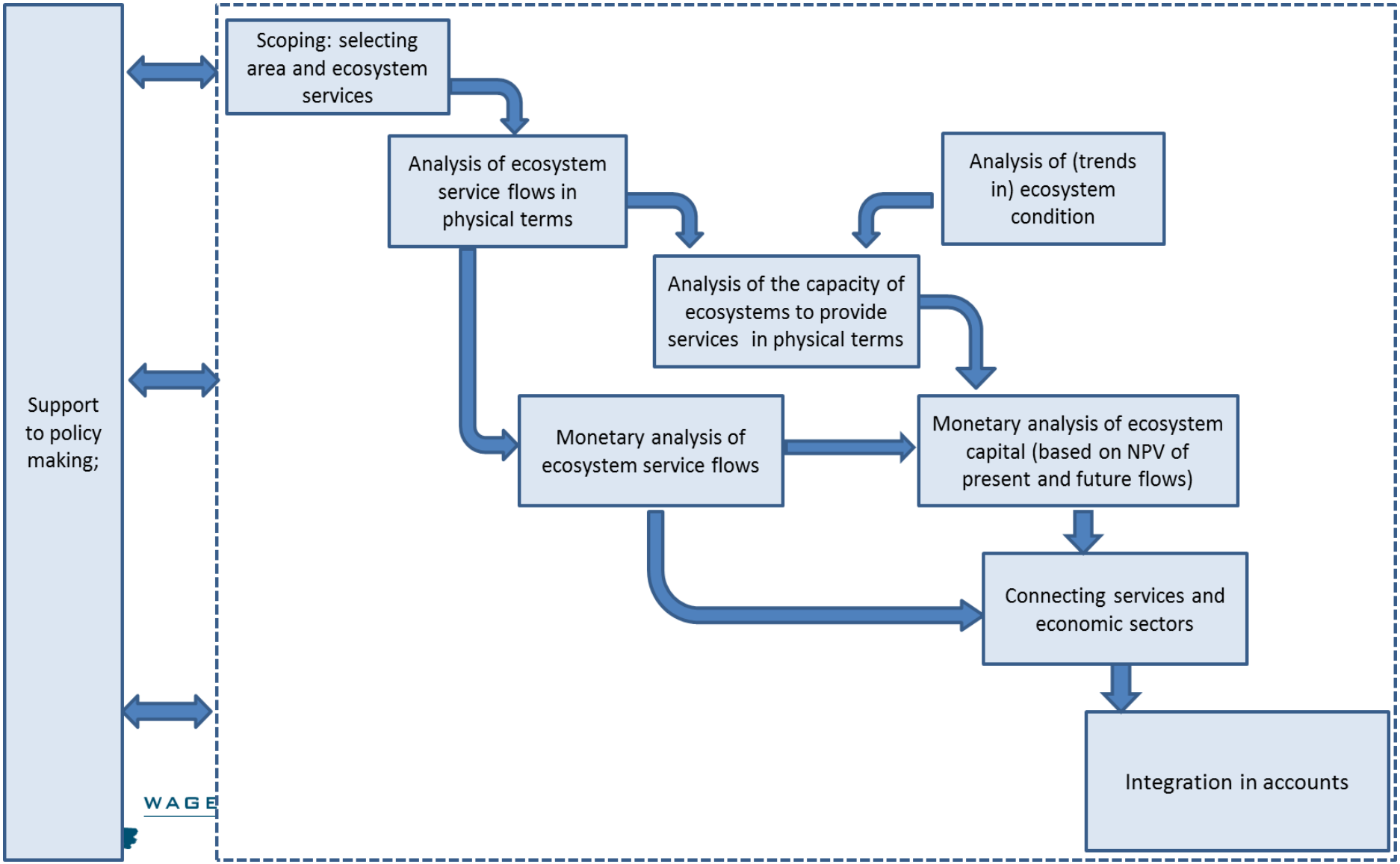
Source: Remme et al., submitted

Ecosystem accounting table

EAU	Ecosystem service													
	Crop production		Fodder production		Drinking water extraction		Hunting		Air quality regulation		Forest carbon sequestration		Recreational cycling	
	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)	Total	Mean (SD)
	Mtons MEQ	kg MEQ ha^{-1} yr^{-1}	ktons dm	kg dm ha^{-1} yr^{-1}	10^3 m^3 water	m^3 water ha^{-1} yr^{-1}	kg meat	kg meat km^{-2} yr^{-1}	tons PM_{10}	kg PM_{10} km^{-2} yr^{-1}	ktons C	kg C ha^{-1} yr^{-1}	10^3 trips	trips ha^{-1} yr^{-1}
Pasture	-	-	521	12,041 (1,573)	9,110	3,099 (2,231)	9,100	21 (17)	405	911 (532)	-	-	1,872	103 (78)
Cropland	2.46	36,314 (1,785)	-	-	14,855	3,082 (2,422)	14,732	20 (17)	715	956 (534)	-	-	2,631	99 (73)
Forest	-	-	-	-	4,577	3,214 (2,624)	8,100	24 (20)	686	2,040 (1,221)	55	1,563 (263)	1,472	126 (94)
Water	-	-	-	-	3,289	9,460 (3,698)	-	-	40	624 (569)	-	-	147	110 (92)
Urban	-	-	-	-	7,862	4,321 (3,527)	-	-	285	547 (562)	-	-	2,735	70 (57)
Heath	-	-	-	-	219	1,293 (821)	678	32 (25)	45	2,062 (1,111)	-	-	30	82 (59)
Peat	-	-	-	-	0	0 (0)	70	13 (3)	7	970 (345)	-	-	3	92 (44)
Other nature	-	-	-	-	1,187	3,093 (2,567)	1,513	25 (20)	69	1,155 (710)	-	-	226	128 (93)
Provincial total	2.46		521		41,099		34,193		2,252		55		9,116	

Source: Remme et al., submitted

Key elements of Ecosystem Accounts (2)



Biophysical and Monetary indicators

	Biophysical	Monetary
Ecosystem condition	X	
Ecosystem service flows	X	X
Ecosystem service capacity	X	X

Key elements of Ecosystem Accounts (3)

- Condition = reflects the state / health of the ecosystem
- Capacity = reflects the capacity of the ecosystem to generate ecosystem services, now and in the future (for provisioning services: as a function of the stock and of the regenerative capacity)
- Ecosystem service = the contribution of the ecosystem to a benefit, e.g. the production of a good or to consumption (a flow, to be recorded for a specific time unit – usually a year)

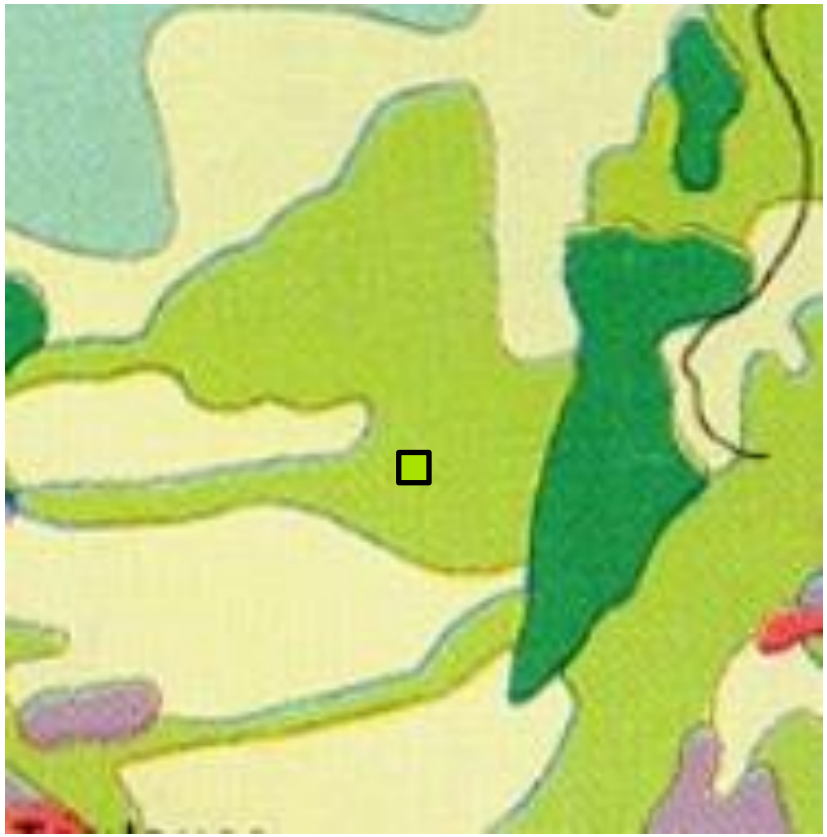
Key elements of Ecosystem Accounts (4)

- Ecosystem Asset (EA) = spatial, heterogeneous area that (i) has a certain size (ha); (ii) has a certain condition and capacity; and (iii) provides services. An EA may contain one or more EAUs or LCEUs.

- Ecosystem Accounting Unit (EAU), large, mutually exclusive units delineated for the purpose of accounting, e.g. a country, province or watershed.
- Land cover / ecosystem functional unit (LCEU), a specific type of land cover (e.g. deciduous forests) for which the ecosystem services can be quantified.
- Pixel / basic spatial unit (BSU): the spatial element underlying the Ecosystem Account

Key elements of Ecosystem Accounts

Land cover map of Province X



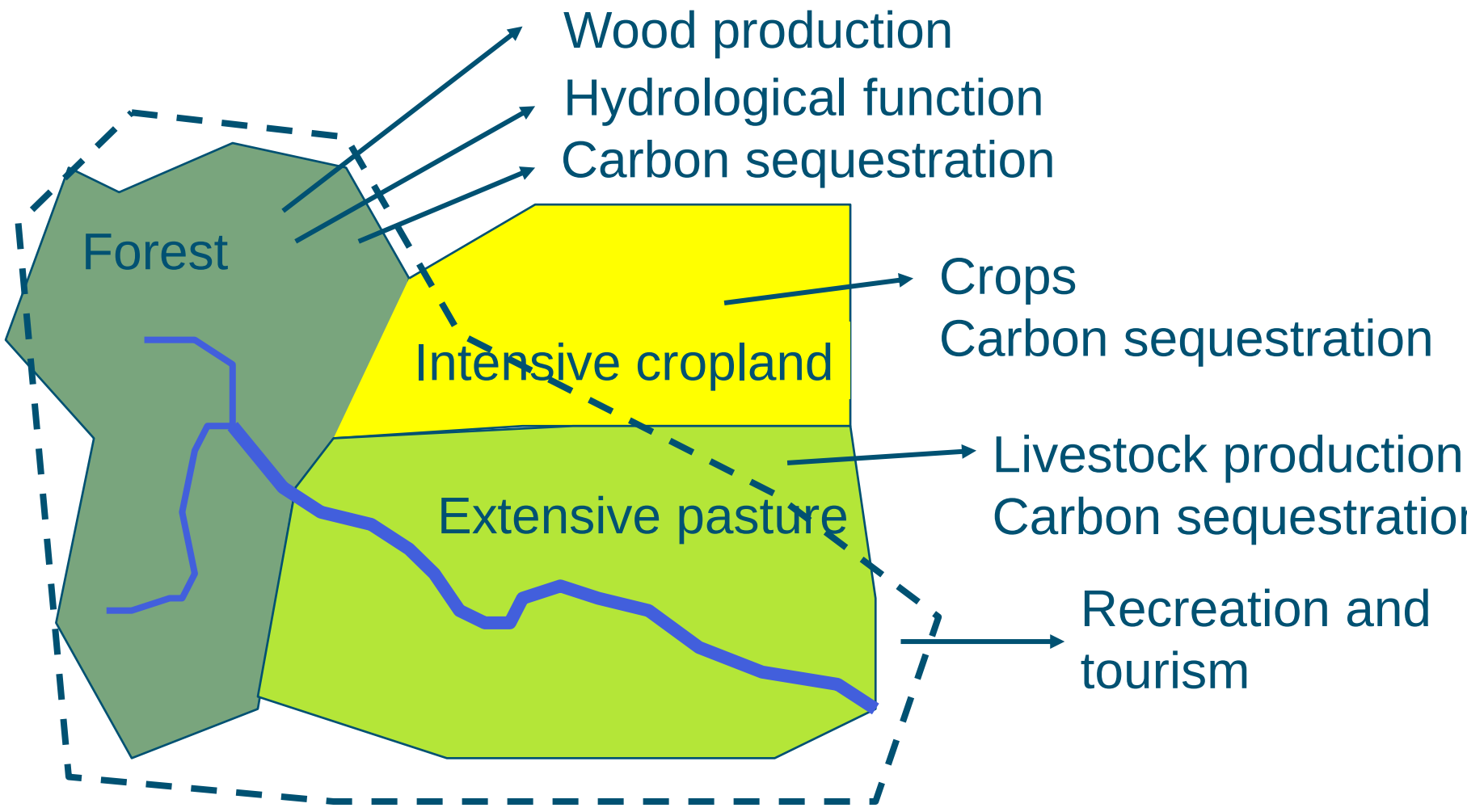
Scale

Pine forest

Deciduous forest

- Ecosystem Accounting Unit (EAU) = a country, province or watershed
- Land cover/ecosystem functional unit (LCEU) = e.g. Deciduous forest
- Pixel / BSU = a pixel

Accounting Units and ecosystem services



Challenges in ecosystem accounting

- Modelling some of the services (e.g. hydrology) – can be done but requires considerable effort and data
- Linking condition – capacity – service flow
- Forecasting service flow in order to calculate asset value (NPV of expected flow of services) – dealing with resilience, probabilities, trade-offs between services)
- Valuation: can avoided damage cost and simulated market exchange methods be used ?
- Constructing the actual ecosystem accounts

Limitations of Ecosystem Accounts

- Data and input intensive
- Ecosystem accounts may, for the foreseeable future, not include all types of ecosystem services
- Ecosystem accounts do not provide information on critical thresholds
- Ecosystem accounts capture part of economic value
  - By using market rather than shadow labour costs
  - By excluding consumer surplus
- Much more comprehensive (and integrated) than current information sets

Methodologies for ecosystem accounting

- Spatial / ecological modelling
  - Interpolation
  - Modelling services that can not be observed directly (erosion control, carbon sequestration, flood regulation)
  - Modelling future flows of services to analyse the value of ecosystem assets
- Valuation
  - Resource rent approach for provisioning services
  - Replacement costs (under certain assumptions)

Modelling provisioning services

- Flows of provisioning services:
  - Data: Recording outputs of the ecosystem: production statistics, surveys, production models.
  - Mapping: Interpolation (spatial tools), allocation (allocation models)
  - Cross validation

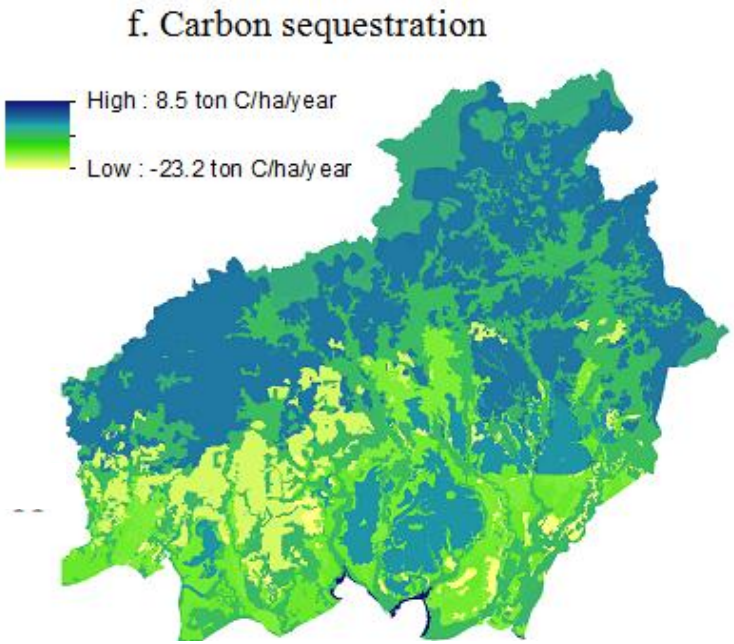
- Analysis of capacity to generate provisioning services
  - Analyse current stock of the service involved (e.g. standing stock of timber)
  - Analyse regrowth (varies as a function of stock, carrying capacity and management; assumption: under current management)

Modelling - regulating services

Requires maps

- Carbon sequestration
  - Look-up tables / NPP models based on remote sensing / forest statistics

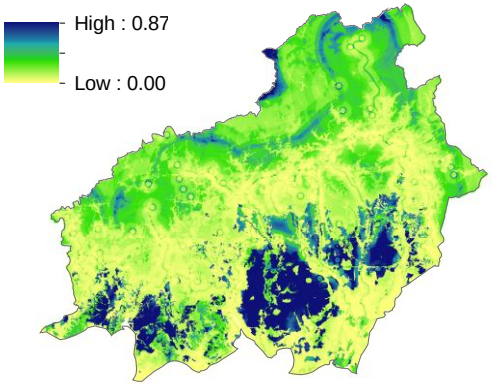
Land cover	Carbon flux; + indicates sequestration, - is emission (ton C/ha/year)	Sources
Mangrove	8.5	Komiyama (2006)
Primary dipterocarps forest (protected forest)	0.8	Hirata et al. (2008)
Primary dipterocarp forest	0.6	Hirata et al. (2008)
Secondary dipterocarp forest	4.0	Luyssaert et al. (2007); Hirata et al. (2008); Saigusa et al. (2008)



Source: Sumarga et al. 2014

Basic methodologies - cultural services

- Recreation and tourism:
  - Flow: number of tourists per area per year
  - Capacity: maximum number of tourists that can be sustained and can be expected (given access to an area, facilities, etc.)
- Biodiversity (Biodiversity account)
  - Flow: presence of species (# red list, functional species, species in groups, species abundance)
  - Capacity: potential presence (may be higher or lower)



Suitability for orang utan, Central Kalimantan, from Sumarga and Hein, 2014

Valuation of non-market goods in Ecosystem Accounting (in order of preference..)

- Production factor approaches: Production function approaches estimate the contribution of ecosystem services to production processes in terms of their contribution to the value of the final product being traded on the market (e.g. pollination).
- Replacement costs (not restoration costs !): In case an ES provides input into a whole range of different benefits (e.g. a coastal protection service). It is required that it can be reasonably be expected that society would indeed replace the service if it was lost.
    - Example: the value of coastal protection equals the costs of dykes ***if*** it can be expected that these dykes would indeed be constructed
- Avoided damage cost: This valuation approach may be applicable where replacement investments are not likely to be made.

Valuing provisioning services in ecosystem accounting: basic approach

RR = TR – (IC + LC + CC)

where

RR = resource rent

TR = total revenue

IC = intermediate consumption

CE = labour costs

CC = consumption of fix capital

Valuing regulating services

- Carbon sequestration:
  - Carbon market (but: prices strongly dependent on set-up of the market)
  - Marginal damage costs (but: strongly dependent on discount rate, and the way complex dynamics (large-impact, low probability events) are taken into account).
  - Marginal damage costs range from US$ 20 to over US$ 1000/ton C (Ceronsky et al., 2009)
- Hydrological services:
  - Production factor approach (if flood risk can be linked to one or few economic activities)
  - Replacement costs (costs of levees, dykes)
  - Avoided damage costs (avoided costs of flooding)

Valuing recreation

- Benefits for recreation industry: resource rent approach
- Benefits for visitors: consumers surplus to be excluded (alternative valuation options are being explored, e.g. by Campos, Camparrós, Edens)

Valuing capacity

Capacity is valued on the basis of the discounted flows of services provided by the ecosystem

This is a forward looking valuation approach and requires assumptions on future output of ecosystems (present management or sustainable management)

It also requires the selection of a discount rate. SNA: market discount rate. But: many ecosystem services are public benefits, two options:

- Market discount rate for all services
- Market discount rate for private services, public discount rate for public services

The discount rate and the Net Present Value (NPV)

$$NPV = \sum_{t=0}^{T} \frac{Ct}{(1+r)^t} = C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots$$

- NPV = Net Present Value
- C = Net benefits in year t
- T = Discount period (e.g. 20 year)
- r = Discount rate

The NPV reflects the monetary value of an investment on the basis of it's cash flow during a discounting period and a discount rate

Net Present Value; an example

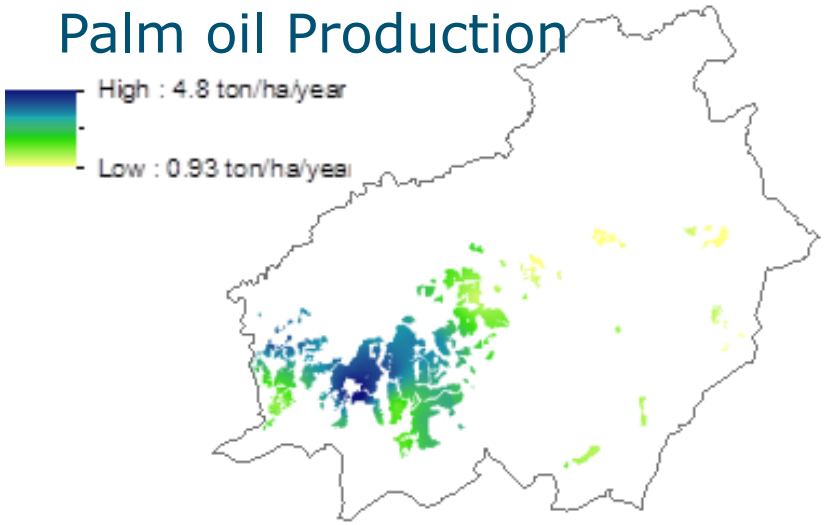
year	1	2	3	4	5	6	7	8	9	10
Cash flow (mln euro)	-10	2	2	2	2	2	2	2	2	2

$$NPV = \sum_{t=0}^{T} \frac{Ct}{(1+r)^t} = -10 + \frac{2}{(1+0.05)^1} + \frac{2}{(1+0.05)^2} + \frac{2}{(1+0.05)^3} + \ldots$$

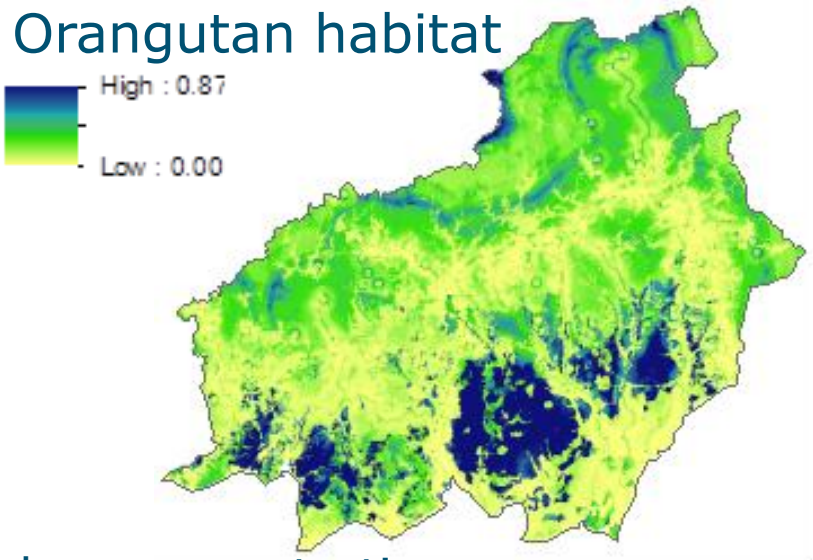
- C reflects the net benefits, for instance investment costs in year 1, and benefits – operation and maintenance costs in year 2 to 10
- NPV (at 5% discount rate) = 4.01 million euro

Ecosystem services Central Kalimantan (1)

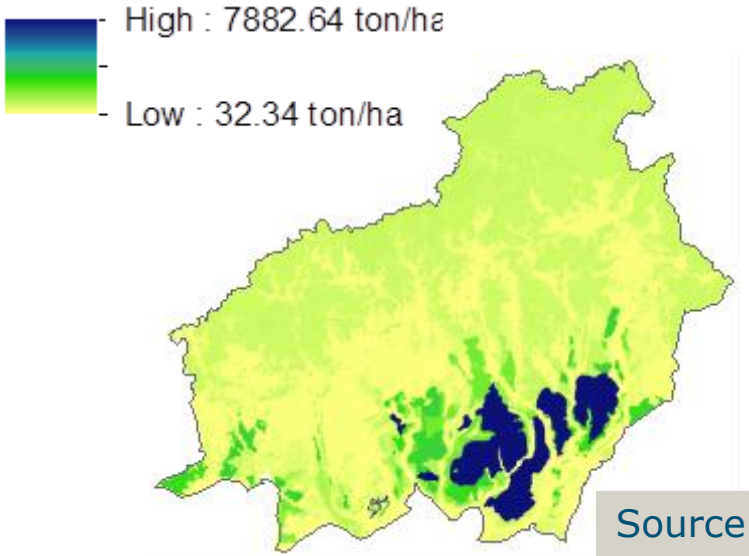
Palm oil Production



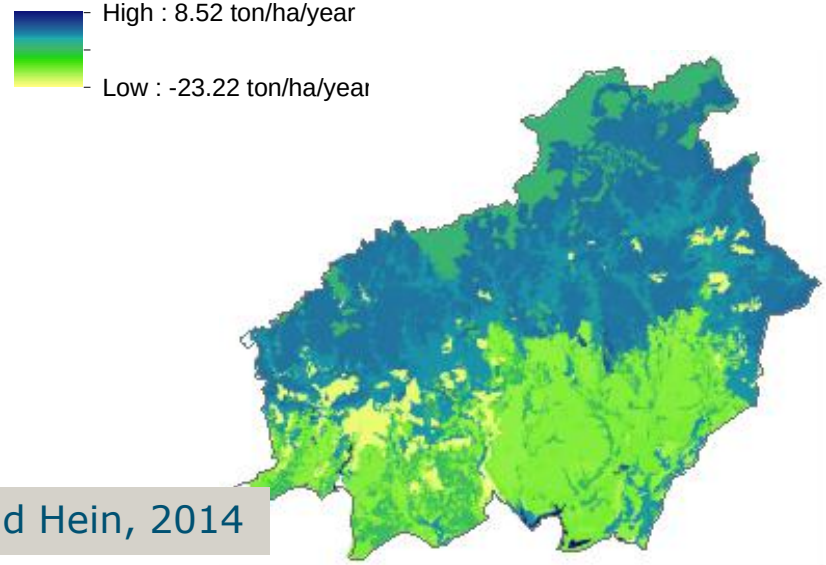
Orangutan habitat



Carbon storage



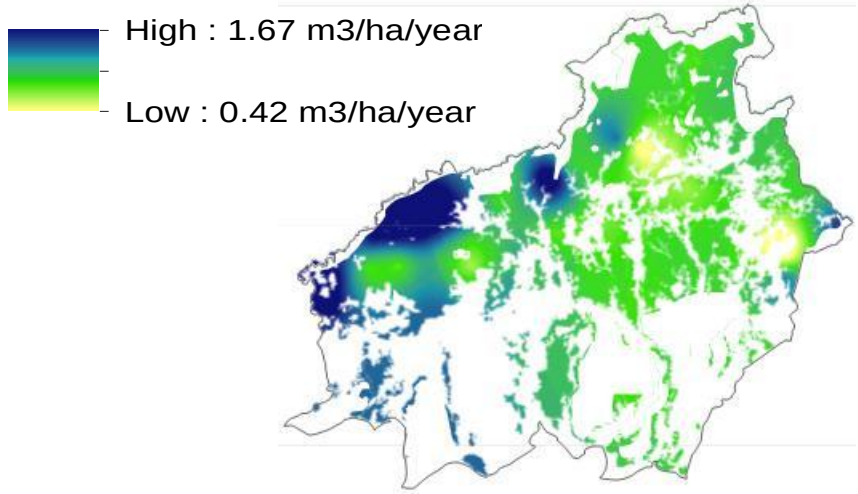
Carbon sequestration



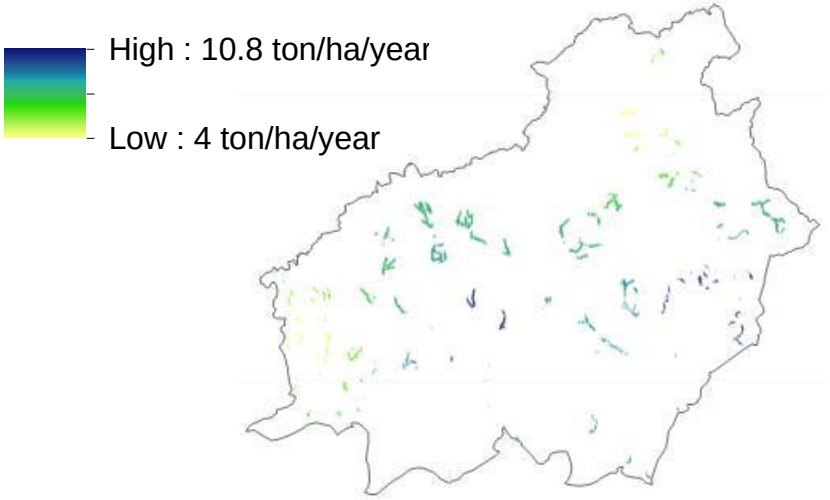
Source: Sumarga and Hein, 2014

Ecosystem services in Central Kalimantan (2)

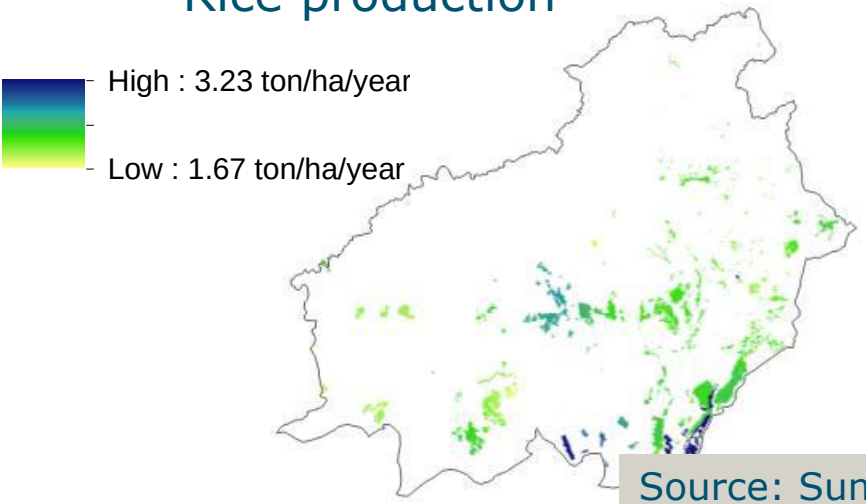
Timber production



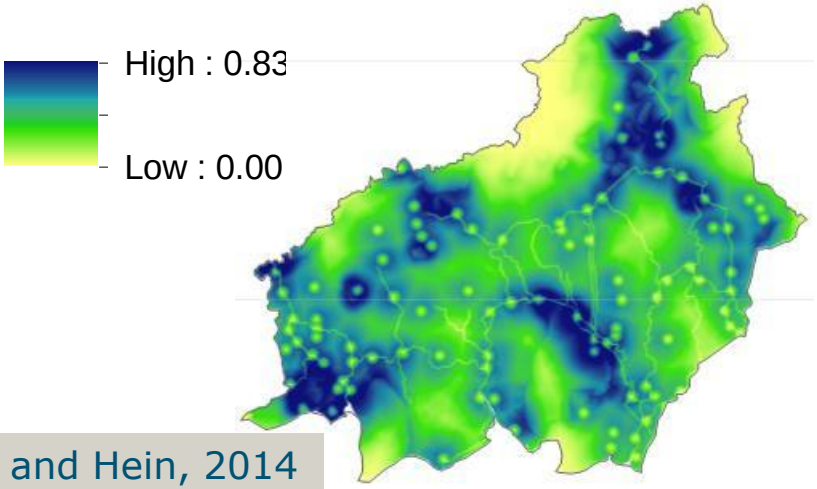
Rattan



Rice production



Nature recreation



Source: Sumarga and Hein, 2014

Stakeholders' development scenarios

Environmentally sustainable scenario

- Exclusion of orangutan habitat (suitability > 50%).
- Excluding areas where the current carbon storage in the vegetation exceeds the carbon storage in a mature oil palm plantation.
- Excluding peatlands. Exclusion of areas with high potential for nature recreation.
- Maintaining the supply of areas important for timber, rattan and paddy rice production.

Thank you