TPSD – Theories & Practices of Sustainable Development

Ecosystem management and human well-being
ES as an analytical framework

2nd lecture

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Part 1

Linking ecosystem management and human well-being

- Biodiversity, ecosystems and ecosystem services

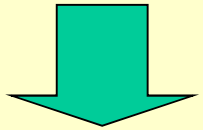
- Typology of ecosystem services

- Structure and process, intermediate services, final services and benefits

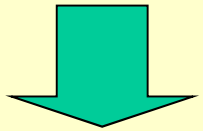
- Integrating the value of ecosystem services in the GDP: Green DGP and Ecosystem services index

- Ecosystem services: what is it?

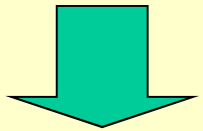
Ecosystem management (e.g. protecting river buffers)



State of the ecosystem (e.g. Biodiverse, complex, high and wide riparian woodland)



Ecosystem service (e.g. Water quality improvement through pollutant filtering by the vegetation)



Human well-being (e.g. Reduced water treatment costs, or reduced allergy symptoms)

Concluding, water quality improvement through pollutant filtering is an ecosystem service and not an economic service because:

– it flows from the ecosystem to human beneficiaries

– the level of the service depends on the state of the ecosystem.

In typical economic services, an economic agent (the producer of the service) uses man-made inputs (e.g. labour, a taxy and gasoil), which have a cost, to provide a (transportation) service to other economic agents (clients, the consumers of the service).

Obviously, the state of the ecosystem and the level of the ecosystem service often depend on past management of that ecosystem, and thus on the use of inputs (machines, labour, energy, fertilizers, capital ...), which also have a cost.

Examples of other ecosystem services (ES):

- **Carbon sequestration / climate-change mitigation;**
- **Habitat and biodiversity conservation;**
- **Soil erosion control, groundwater quality, flow regulation and flood prevention;**
- **Fire-risk prevention;**
- **Pest & disease regulation by biotic controls;**
- **Landscape, recreation and the quality of living space**

Resilient ecosystems are crucial for the sustainable delivery of all these ES.

- Ecosystem services: why are we loosing them?

- Any ecosystem service (e.g.: carbon sequestration /climate-change mitigation) depends on the state of the ecosystem (above and below ground biomass, soil carbon content, plant growth, vulnerability to fires...);
- On the other hand, the state of the ecosystem depends on past ecosystem management;
- There are no markets for many ecosystem services ...
- ... but there are markets for some other outputs (food, fiber, wood...) that we extract from ecosystems.

- And this is the origin of the problem!!!

- **Ecosystem managers made their management decisions looking for their effects on outputs that have a market price – because these are the ones generating their income;**
- **As a side-effect, these decisions also "produce" a particular state of the ecosystem and thus particular levels of ecosystem services (carbon sequestration, biodiversity, landscape, ...).**
- **Ecosystem service levels are, therefore, a side-effect of management decisions made with other goals (namely profit maximization) in mind...**
- **... this is why existing levels of ecosystem services are often far from those that would be more apropriate to fulfil relevant human needs such as security, health or recreation.**
- **The market fails in creating effective incentives that reward ecosystem managers for adequate management, that is: adequate ecosystem-service (and thus human well-being) levels.**

- **Economists call this a *market failure*.**

- **If this is the cause of ecosystem-services decline, then we need to look for solutions that:**

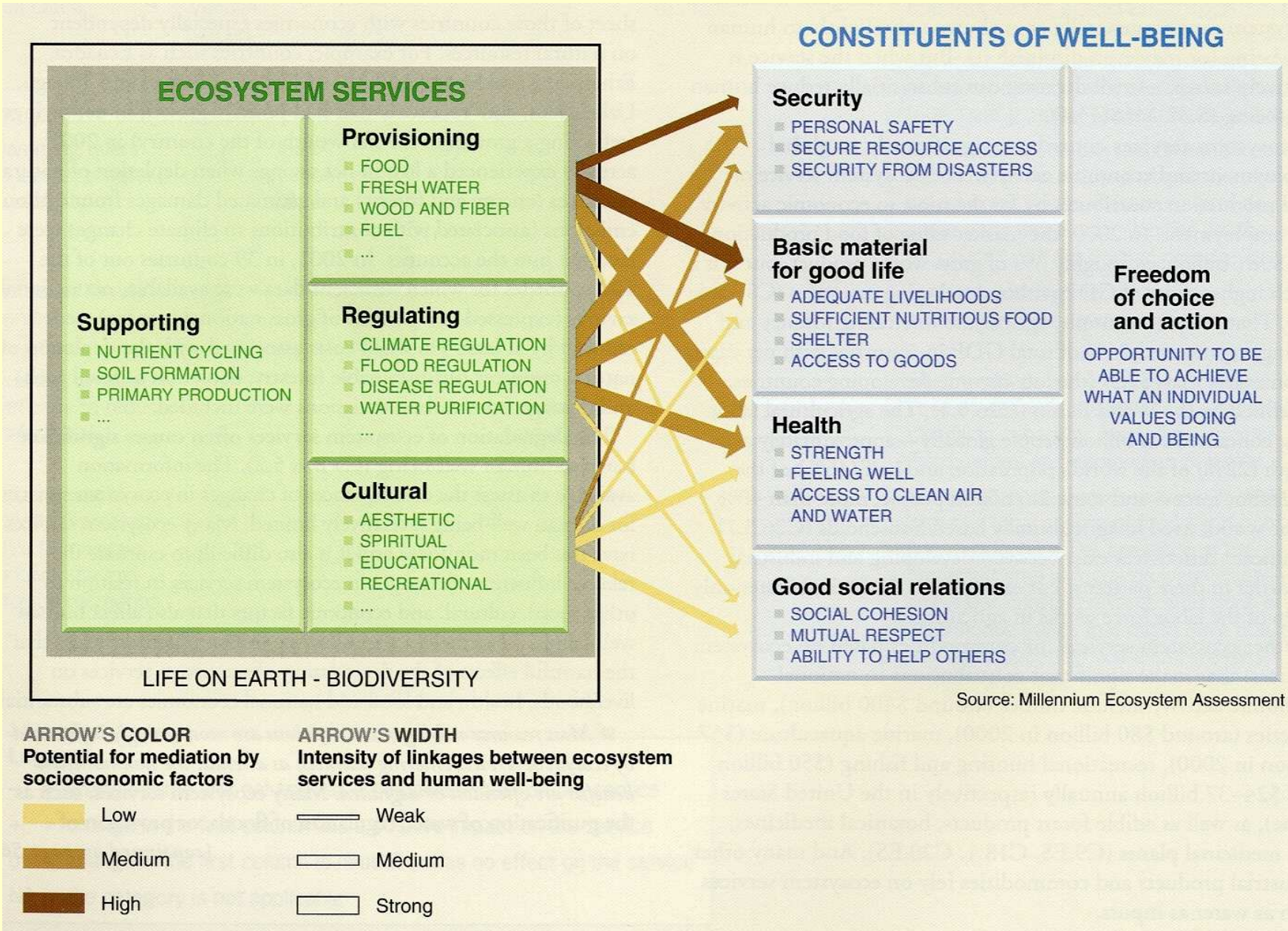
  create incentives that reward ecosystem-managers effort to manage ecosystems in ways that lead to better levels of ecosystem services

e.g. Payments for ES

Market failure usually requires *policy intervention* to correct that (incentive) failure

Typology of ecosystem services (MEA - Millenium ecosystem assessment)

- Provisioning services
- Regulating services
- Cultural services
- Supporting services



Source: Millennium Ecosystem Assessment

Table 1. Global Status of Provisioning, Regulating, and Cultural Ecosystem Services Evaluated in the MA

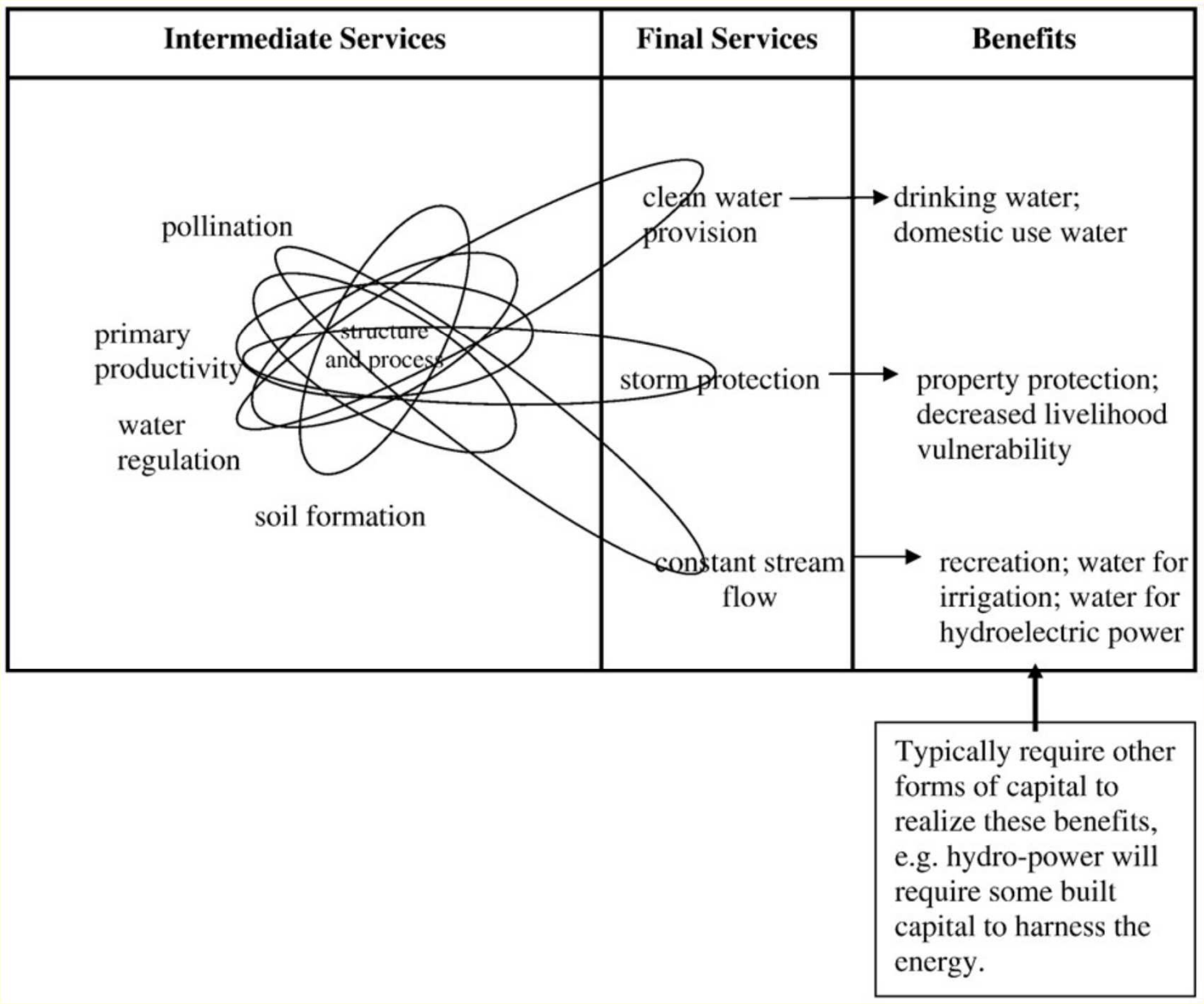
Status indicates whether the condition of the service globally has been enhanced (if the productive capacity of the service has been increased, for example) or degraded in the recent past. Definitions of "enhanced" and "degraded" are provided in the note below. A fourth category, supporting services, is not included here as they are not used directly by people.

Service	Sub-category	Status	Notes
Provisioning Services			
Food	crops	▲	substantial production increase
	livestock	▲	substantial production increase
	capture fisheries	▼	declining production due to overharvest
	aquaculture	▲	substantial production increase
	wild foods	▼	declining production
Fiber	timber	+/–	forest loss in some regions, growth in others
	cotton, hemp, silk	+/–	declining production of some fibers, growth in others
	wood fuel	▼	declining production
Genetic resources		▼	lost through extinction and crop genetic resource loss
Biochemicals, natural medicines, pharmaceuticals		▼	lost through extinction, overharvest
Fresh water		▼	unsustainable use for drinking, industry, and irrigation; amount of hydro energy unchanged, but dams increase ability to use that energy

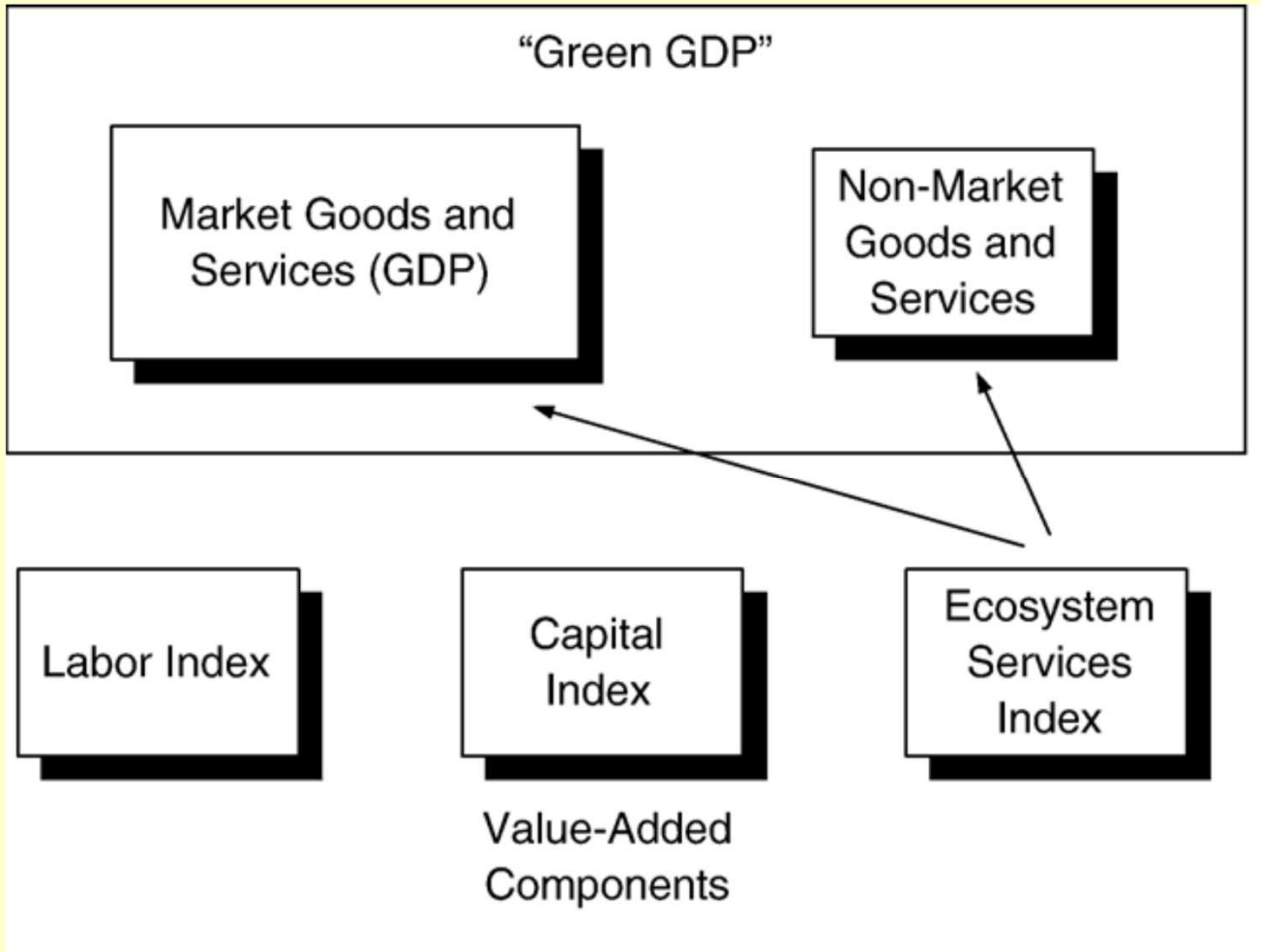
Regulating Services			
Air quality regulation		▼	decline in ability of atmosphere to cleanse itself
Climate regulation	global	▲	net source of carbon sequestration since mid-century
	regional and local	▼	preponderance of negative impacts
Water regulation		+/–	varies depending on ecosystem change and location
Erosion regulation		▼	increased soil degradation
Water purification and waste treatment		▼	declining water quality
Disease regulation		+/–	varies depending on ecosystem change
Pest regulation		▼	natural control degraded through pesticide use
Pollination		▼[a]	apparent global decline in abundance of pollinators
Natural hazard regulation		▼	loss of natural buffers (wetlands, mangroves)
Cultural Services			
Spiritual and religious values		▼	rapid decline in sacred groves and species
Aesthetic values		▼	decline in quantity and quality of natural lands
Recreation and ecotourism		+/–	more areas accessible but many degraded

Note: For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., mangrove loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem.

Structure & process, intermediate services, final services and benefits (Fisher, 2009)



ES, Green GDP and ES Index (Boyd e Banzhaf, 2007)



What is a final service depends on what is the benefit we are interested in

BENEFIT	Final Services	Intermediate Components
Recreational angling	The water body The bass population The riparian forest	The water body's quality
Drinking water	The water body's quality	Wetlands, natural riparian land cover

Part 2

Biodiversity and human well-being

(Cont.)

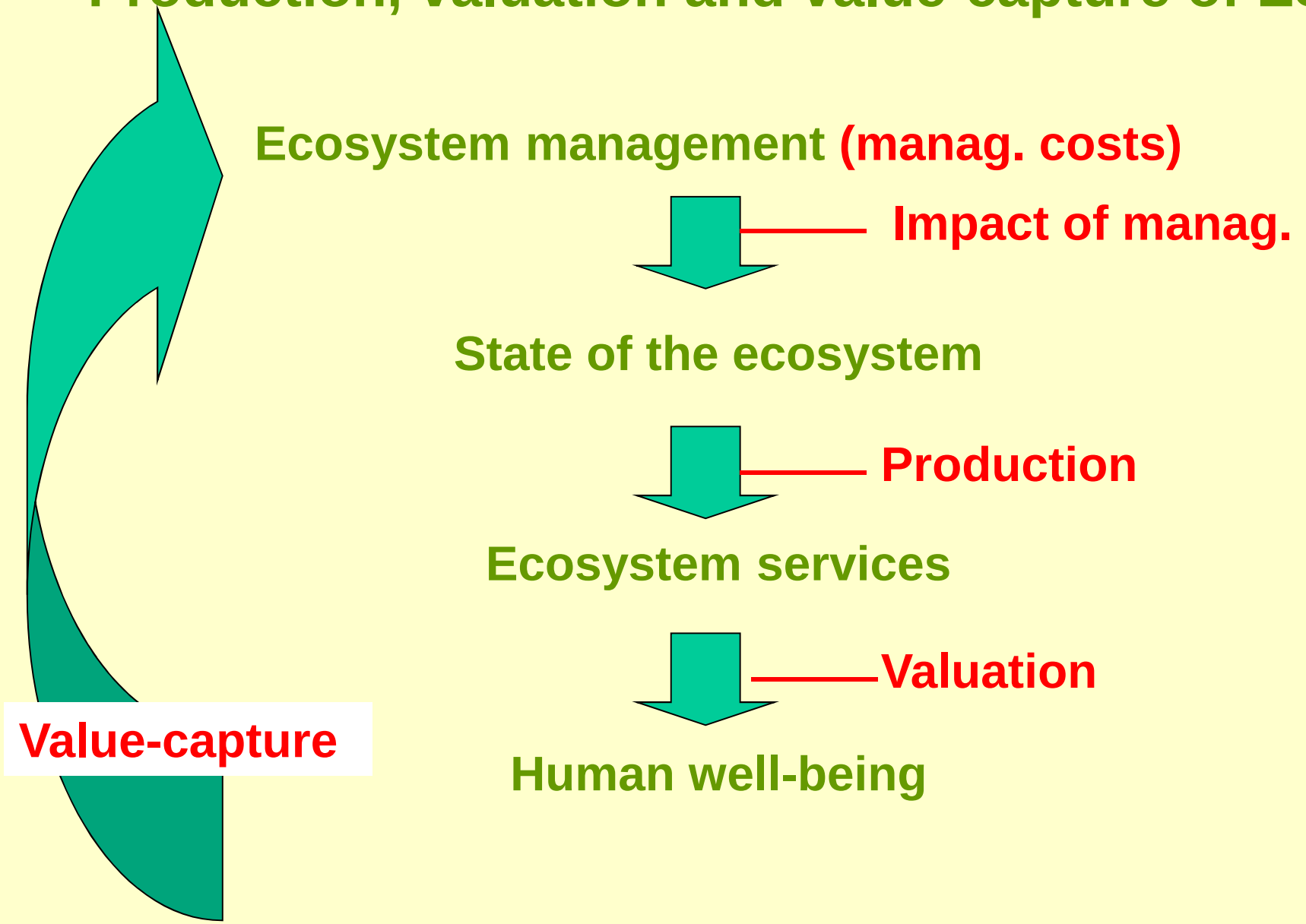
- production, valuation and value-capture of ecosystem services

- The Total Economic Value (TEV) of biodiversity and ecosystems

- Methods for economic valuation of biodiversity and ecosystem services

- Economic valuation of ecosystem services of Amazon rain forest

- Production, valuation and value-capture of ES



The economic value of biodiversity and ecosystem services

Biodiversity and ecosystem services have an economic value if they are simultaneiously useful and scarce.

If this is the case, an additional unit of biodiversity or ES has a positive effect on human well-being, that is: it has a marginal utility (or economic value).

The generalised decline of biodiversity implies that, more and more, a particular biodiversity component (gene, species ...) becomes scarce, and thus it acquires a marginal value, or mg utility.

In some cases, this scarcity (thus value) is global (e.g. a globally threatened gene or species).

In other cases, that scarcity (thus value) is only local or regional (e.g. a keystone species whose local extinction will lead to lower resilience of a local ecosystem).

Economic value – money metrics

Economic value refers to the impact of an ecosystem service (or, more precisely, of changes in that service) on human well-being.

Z_0 – existing level of the service (e.g.: more frequent flooding)

Z_1 – improved level of the service (e.g.: less frequent flooding)

Y – the individual's monetary income

U(Y, Z) – the individual's utility level

$U_0=U(Y, Z_0)$ – nível de bem-estar do indivíduo com cheias mais frequentes

$U_1=U(Y, Z_1)$ – nível de bem-estar do indivíduo com cheias menos frequentes

$\Delta U=U_1-U_0 > 0$ – individual's welfare gain when flood frequency declines (which is the value of the ecosystem service)

Economic value – money metrics

Directly measuring welfare (or welfare changes) of individuals is difficult or impossible – which leads us to resort to money metrics of welfare variation, e.g.: the compensating variation VC:

$$U(Y, Z_0) = U(Y - VC, Z_1)$$

VC is a money metrics of the individual's welfare change ΔU that we would like to measure but that we cannot directly measure – that is: it is a measurement of the value of the service.

If $\Delta U > 0$ (as in our example) then $VC > 0$ and it represents the maximum individual's willingness-to-pay (WTP) for the service;

If $\Delta U < 0$ (service loss) then $VC < 0$ and it represents the minimum amount the individual would require as a compensation (WTA) for the loss of the service.

Total Econmic Value (TEV)

The utility of biodiversity or ecosystems – its contribution to human well-being – can assume different forms: it may depend on direct or indirect use, current or future use, extractive vs non-extractive uses; and there is sometimes utility without any use.

Pearce and Moran (1994) have developed a system to classify different components of the Total Economic Value (TEV) of biodiversity and ecoststems.

Relevant components of the TEV:

- Direct use, current or future use, comercial or not, extractive or not. Examples: crop harvests, wood, non-wood forest products, biomass and fishery yields (extractive uses), or recreation, bathing and touristic use of ecosystems (non-extractive uses);

- Indirect use. Depends on particular ecological functions of ecosystems, such as soil and water conservation, waste assimilation and nutrient cycling, carbon sequestration or regional climate regulation by forests.

TEV (Cont.)

The sustainability of these functions in time depends on stable and resilient ecosystems, what generally means diverse ecosystems.

Below particular diversity thresholds (which are mostly not-well understood), those functions will no more be sustainably provided.

Ecosystem stability depends on the complexity of its food web, which depends on the species diversity (populations of different species control each other through feedback mechanisms associated to food-web biotic interactions).

On the other hand, ecosystem resilience (that is: the maximal disturbance it can absorb while keeping its working conditions) depends on species that, though seeming irrelevant, act as "spare parts" (Holling 1995).

TEV (Cont.)

Other components of the TEV of biodiversity are:

- Option value - our current willingness-to-pay to keep an option for future use. It is not the value of future use. It's an additional value beyond the expected value of future use. It is the value of reducing the risk about availabilty of the ecosystem for future use. It results from our aversion to risk when facing irreversibilities such as the loss of a tropical forest.

Example: conserving that forest with current costs (income foregone) to keep the option of using genetic resources (possible existing genes in the forest) to produce medicines or genetically improve crops.

- Non-use values, such as the legacy value of a threatened species we pass to future generations; or the existence value of a particularly unique (non-replaceable) species for para some people.

Example: donations by people to particular conservation funds that use symbolic species, as the Panda, as a communication strategy.

TEV (Cont.)

The different components of the TEV of biodiversity and ecosystems are not independent from each other.

Example: a direct extractive use, such as a crop harvest, depends on a set of ecological functions (that is indirect use), such as:

- the biological control of pests and diseases by predator or parasitoids that occur in the agro-ecosystem;

- the cycling of nutrients included in crop remains by bacteria and fungi.

How to use the TEV?

- **It is an accounting concept to measure all modes through which an ecosystem, such as a lake, forest or fishery, contributes to human well-being.**

- **Different management options for that ecosystem are then specified …**

- **… the TEV is estimated for each particular option…**

- **and we chose the management options that yields the maximum TEV, that is the one maximizing the ecosystem's contribution to human well-being.**

- To be able to estimate the TEV, we are required, first, to identify all possible components of the TEV – that is: the different channels through which that ecosystem may contribute to human well-being.

VET components (summary table):

- Use *values*
  - Direct use (either commercial or not, present or future use)
    - Extractive use
    - Non-extractive use
  - Indirect use (ecological and environmental functions)
- Non-use (or *passive-use) values*
  - Option value
  - Quasi-option value
  - Legacy (bequest, heritage) value and other altruistic value components
  - Existence value

-TEV is an anthropocentric framework, because it is oriented towards human well-being,

- Outside this anthropocentric frame, we could consider the values of the ecosystem in itself (intrinsic values), which are based e.g. on the right of non-human species themselves to exist independently of any kind of utility they may have for humans.

- Even if these values may exist, intrinsic values will be mostly irrelevant for human decisions if they are not taken by humans as valuable; and this is sufficient for these values to become part of the TEV.

-Economic values imply a trade off between costs and benefits of the different management options for a particular ecosystem taking human well-being as a basis for value measurement.

Economic valuation techniques

Concept to be measured: compensating variation (WTP, WTA) which includes all components of the TEV

Criteria used to classify valuation techniques:

- techniques with or without an economic-teory foundation;

- Techniques based on agents' actual decisions in real contexts which reveal value (revealed preference techniques) *versus* techniques based on hypothetical decisions of individuals facing hypothetical decision contexts (stated preference techniques)

- Direct versus indirect techniques as regards the analytical strategy that is used to reveal value

Examples of econimic techniques used for ecosystem-service valuation

- Substitution costs;
- Dose-response funtions using unit values for damage;
- Techniques using effects on production;
- *Averting behaviour models*
- Continent valuation and choice modelling;
- Travel cost models;
- Hedonic price models

Classification of economic valuation techniques

1. Techniques without an economic-theoretic foundation

- Substitution costs;
- Dose-response funtions using unit values for damage;
- Techniques using effects on production;

2. Techniques with an economic-theoretical foundation (preference based techniques)

a) Revealed-preferences techniques, where choices actually made by individuals in actual contexts are used as data

- Travel-cost models
- *Random utility models*
- Hedonic-price models
- *Averting behaviour models*

b) Stated-preference techniques, where individuals are asked to make hypothetical choices to reply to hypothetical choice scenarios

- Contingent valuation
- Choice modelling

Revealed preference techniques are preferred in some contexts because of their explicit link with actual, observed market prices.
However, these techniques are **useful only in the context of estimating use values**. (CE, 2001: p.4)

While these techniques may be used to estimate use and/or non-use values for a resource, they are the ***only* techniques available for estimating non-use values**. (CE, 2001: p.5).

Além disso têm uma muito maior **flexibilidade** para gerar cenários para avaliar bens futuros novos (não presentes no passado).