



Actual Problems of Landscape Sciences: Environment, Society, Politics



MARTIN-LUTHER-UNIVERSITÄT
HALLE-WITTENBERG



Dept. Sustainable Landscape Development, MLU

Martin Luther University Halle–Wittenberg

Faculties

Theology
Law, Economics and Business
Medicine
Philosophy (3)
Natural Sciences (3) — **Natural Sciences III**

Institutes

Agriculture & Nutritional Sciences
Computer Sciences
Geosciences and **Geography**

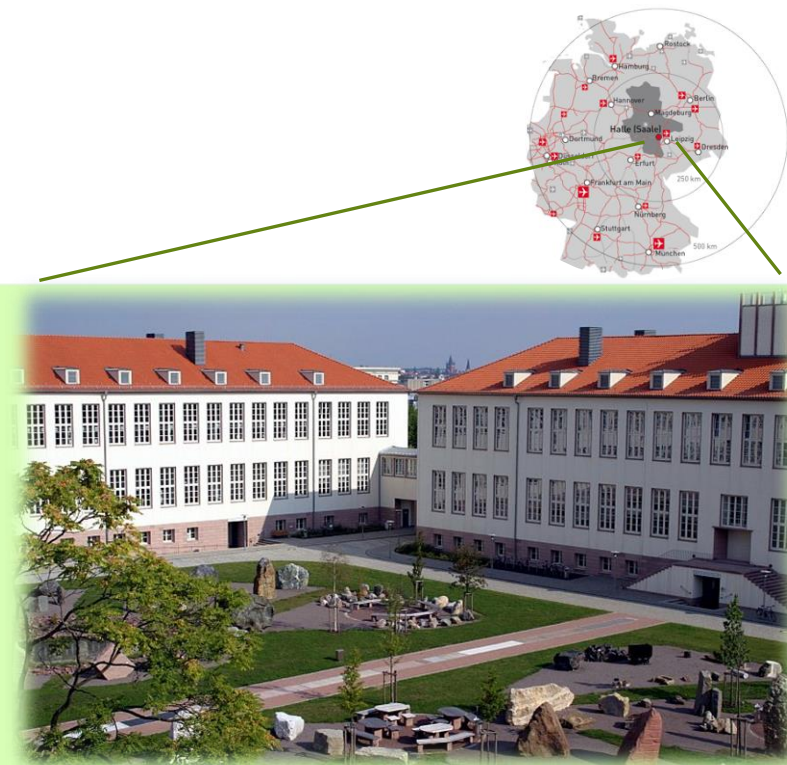
Departments

Applied Geology
Geodynamics
Mineralogy and Geochemistry
Petrology and
EconomicGeology
Human Georaphy
Geoecology
Digital Geography
Sustainable Landscape Development
Didactics
Catchment Hydrology
Computational Landscape Ecology

Geosciences

Geography

Shared (UFZ)



Dept. Sustainable Landscape Development

Institute of Geosciences and Geography, Martin-Luther-University Halle-Wittenberg, Germany

Staff

Head: Prof. Dr. Christine Fürst

Scientific Staff: Dr. Marcin Spyra (*habil.*),
Dr. Janina Kleemann (*habil.*),
Patrick Halka, Robert Reese,
Dr. Vera Schreiner

Project Staff: Martin Schultze, Dr. Nica Caló,
Robert Reese, Hongmi Koo

Lecturers: Dr. Jennifer Hauck (*habil.*),
Frank Pietzsch, Paul Ronning

Technical Staff: Michael v. Hoff, NN (geotech.)

Secretary: Isabell Stein

Staff

External habilitation:

Dr. Zhanli Sun (IAMO), Dr. Carsten Meyer (iDIV)

Others (world regions)

- Africa: Evelyn Asante Yeboah (DAAD), Stephen Kankam (self), Rediet Girma (ETH)
- Asia: Babu Dallakoti (self), Prof. Dr. Bolorma Baatsuri (UB, guest scientist) Praveen Kumar (DAAD), Zhichao He (CN),
- Europe: Kristin Leimer (IAMO), Sandra Ledermüller (vTI), Elena Wenz (ZALF), Alexander Froede (GIZ)
- Latin America: Andrea Pacheco (iDIV), Jocelyn Esquivel (Uni Concepcion), Prof. Dr. Daniel Rozas Vasquez (guest researcher, UT)
- Near East: Mohsen Zabihi, Milad Zhoolideh, Behrooz Nahrodei (IRN stip)

Equipment & Facilities

- Participatory tools (Touch Table, GISCAM); Soil Lab



Teaching

- Bsc. Geography
- Msc. Geography (120; 180)
- Msc. International Area Studies
- Msc. Management of Natural Resources
- Teaching degree Geography

International networks

ELI, ESP, Future Earth, GLP, Humboldt Association, IALE, IPBES, IUFRO

International students & scientists

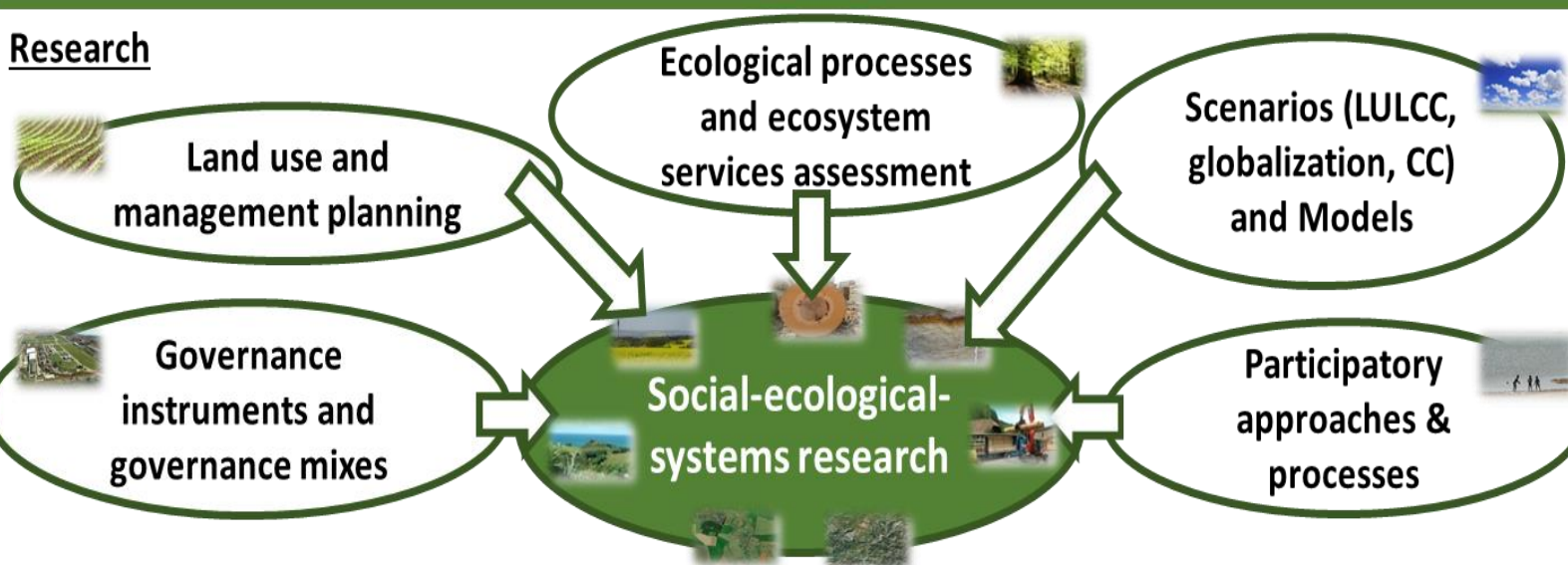
W & E-Africa, Europe, Near East, Latin-America, South-East & Central Asia

Contact

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Sustainable Landscape Development
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christine.fuerst@geo.uni-halle.de

Research



Regions: Global North (Europe, Canada, US), Global South (E & W-Africa, S-E & C-Asia, L-America)

Projects: INLAND, INTERACT, R4SES, RENATUR, SERVICES, SESASA, SPIBES (BMBF, EU); FF-HWI; Fondecyt (CL, fast track).



Your Background and disciplines?

Aims of the lectures

Ecosystem services assessment

- Challenges – why ecosystem services are useful in planning
- What are ecosystem services
- Which assessment frameworks do we know
- How good / reliable are they
- Integration – from indicators to assessment (ecosystem to landscape scale) – a multicriteria evaluation approach



Aims of the lectures

Ecosystem services assessment



Ecosystem services mapping and scenario development – GISCAME

- How to integrate the evaluation basics into a systemic approach
- How to build (participatory) scenarios
- How to integrate sectoral information (forestry, agriculture)
- How to come to holistic recommendations – trade-offs / spatial hotspots



Aims of the lectures

Ecosystem services assessment



Ecosystem services mapping and scenario development – GISCAME



Social-Ecological Systems modelling and policy recommendations

- Social-ecological systems – the concept
- Social-ecological system model types
- Integrative implementation example









Housing & Living

Recreation space

Drinking water

Energy

Food & Fodder



Loss of water regulation services



Natural disasters



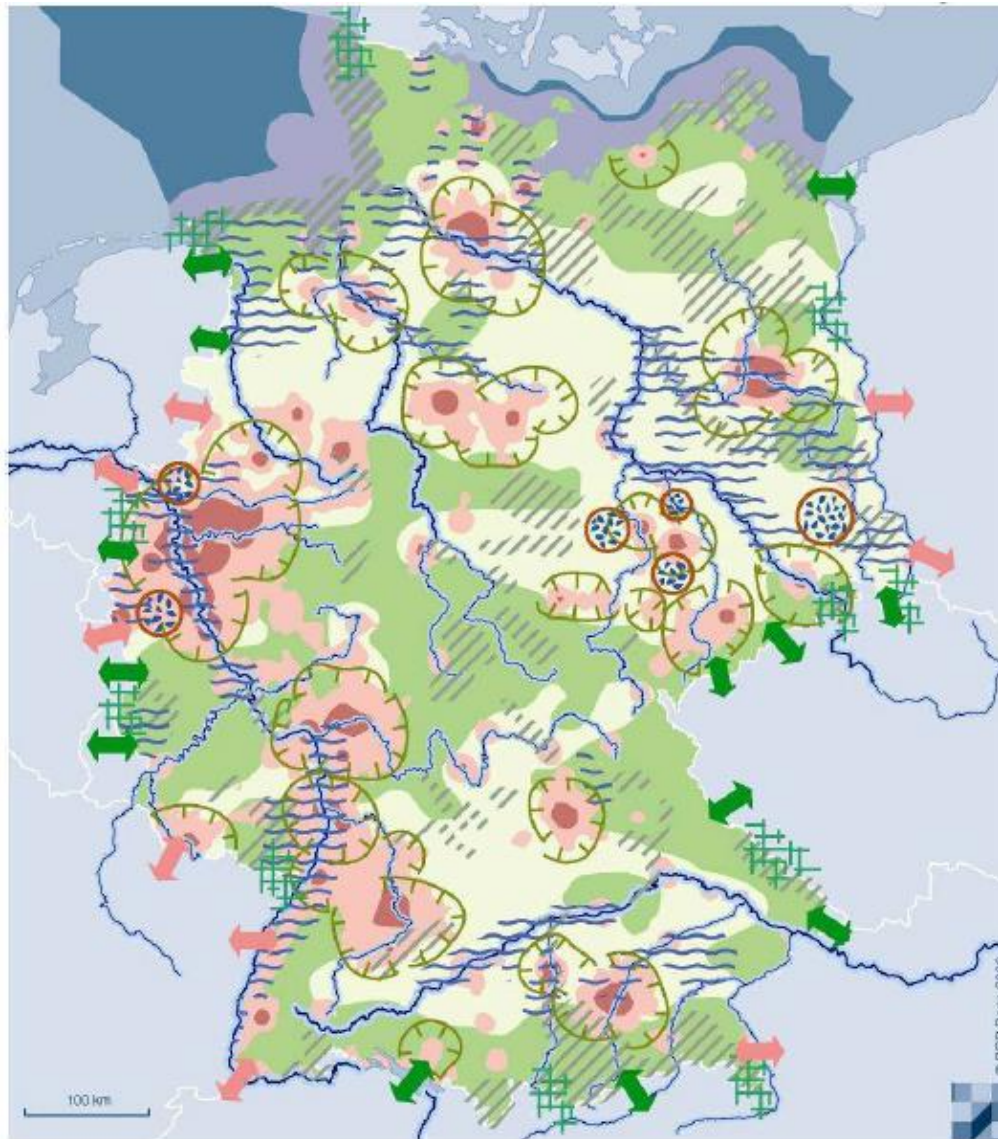
Challenges - why is there a need for an integrated concept?



Challenges - why is there a need for an integrated concept?



Implications?



Ressourcen bewahren

Natur

- Landschaften mit besonderem Naturschutzwert
- Beispiele für grenzüberschreitenden Naturschutz

Wasser

- bedeutende Grundwasservorkommen

Flusslandschaften

- Vorbeugender Hochwasserschutz in Flusskorridoren

Kulturlandschaften gestalten

Urbane Landschaften

- Zentrenentwicklung in Kernstädten
- Gestaltung suburbaner und verstädterter Räume
- Beispiele für grenzüberschreitende Siedlungsentwicklung
- Regionalparks und Freiraumverbünde zur siedlungsnahen Erholungsvorsorge

Rurale Landschaften

- mit hohem Potenzial für extensive Land- und Forstwirtschaft sowie Tourismus
- mit hohem Potenzial für Ackerbau, nachwachsende Rohstoffe und energetische Biomassennutzung
- Beispiele für grenzüberschreitende Landschafts- und Tourismusentwicklung
- Neue Seenlandschaften in rekultivierten Tagebauen

Marine Landschaften

- Raumordnung in der AWZ
- Raumordnung an der Küste und im Küstenmeer

Die Karte veranschaulicht das Leitbild. Die S stellen jedoch keine planerischen Festlegungen

Arguments for the delineation of spatial priorities / preference areas, nature conservation areas and identification of still available development space

Implications?

- Integrating **multiple scales** – i.e. **management practices** from agriculture and forestry, **information** on urban space, water bodies and streams and their pattern at landscape scales, i.e. it is not enough to plan (and assess ecosystem services) only on the basis of "land cover"

Functions & processes

Interventions



Non-irrigated arable land

Impacts

Aims (land owner ↔ society)

Functions & processes

Interventions



Non-irrigated arable land

Impacts

income / economic revenue ⇔ recreation space ⇔ water ⇔ habitats / biodiversity

Aims (land owner ⇔ society)

Functions & processes

Interventions

material & Energy input (in- / directly)
extraction of materials (biomass)



Non-irrigated arable land

Impacts



income / economic revenue ⇔ recreation space ⇔ water ⇔ habitats / biodiversity

Aims (land owner ⇔ society)

Functions & processes

nutrient, water, energy cycles(local / global), competition, growth, propagation, dead

Interventions

material & Energy input (in- / directly)
extraction of materials (biomass)



Impacts

income / economic revenue ⇔ recreation space ⇔ water ⇔ habitats / biodiversity

Aims (land owner ⇔ society)

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Non-irrigated arable land

Impacts

Habitat & species diversity, Productivity,
Competition, Competitiveness

income / economic revenue ⇔ recreation space ⇔ water ⇔ biodiversity

Aims (land owner ⇔ society)

Functions & processes

nutrient, water, energy cycles(local / global), growth, propagation, dead

Interventions

material & Energy input (in- / directly)
extraction of materials (biomass)

- 
- Habitat, connecting corridor
 - **provisioning**: food, fodder, (bio-)energy
 - **regulating**: water, climate, flooding, erosion
 - **cultural**: aesthetics, inspiration, recreation
 -

Impacts

Habitat & species diversity, Productivity,
Competition, Competitiveness

income / economic revenue ⇔ recreation space ⇔ water ⇔ biodiversity

Aims (land owner ⇔ society)

Funktionen & Prozesse

Stoff-, Wasser-, Energiekreisläufe (lokal / global), Wachstum, Fruktifikation, Tod

Einwirkung

Energie-, Materialeintrag (direkt, in-)
Entnahme von Materie

- 
- Habitat, verbindendes Element
 - **Bereitstellend:** Nahrungsmittel, Futter, Energieträger
 - **Regulierend:** Wasser-, Klimaregulation, On- / Off-site Risiken (Erosion, Massenverlagerung)
 - **Kulturell:** Erholung / Freizeit, Ästhetik
 -

Habitat- und Artenvielfalt, Produktivität,
Konkurrenz, (Über-)Lebensfähigkeit

Auswirkung(en)

Lebensgrundlagen, ökonomischer Ertrag, Lebensraum, Lebensqualität

Ziele

- 
- 
- Habitat, connecting corridor
 - **provisioning:** food, fodder, (bio-)energy
 - **regulating:** water, climate, flooding, erosion
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 -



natural ecosystems
(green infrastructure)

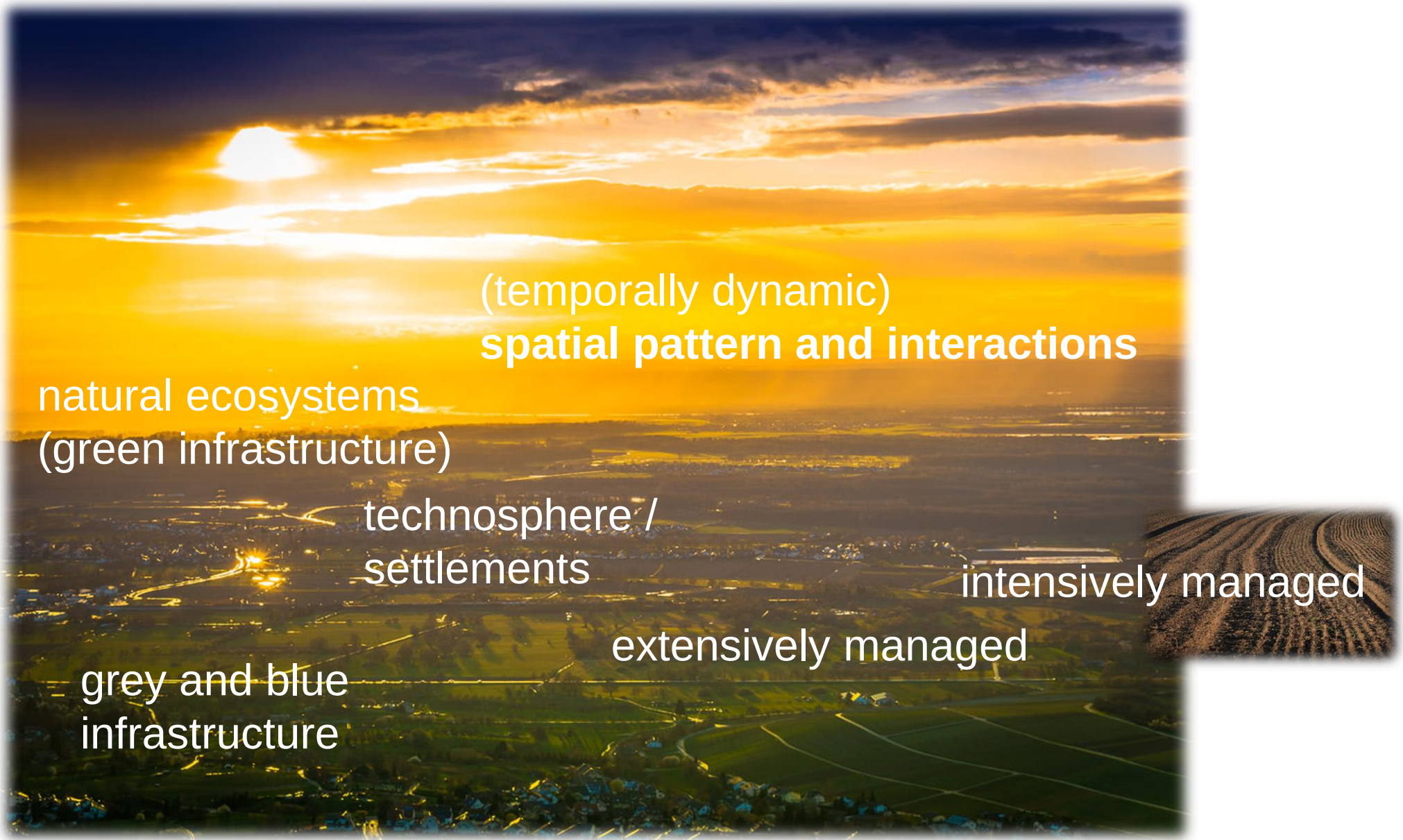
The image is an aerial photograph of a landscape at sunset. The sky is filled with orange and yellow light from the setting sun, with some dark clouds. Below the horizon, there are various land use types. In the foreground, there are green fields, some of which are labeled 'extensively managed'. There are also some urban areas with buildings and roads, labeled 'technosphere / settlements'. To the right, there are some agricultural fields, labeled 'intensively managed'. In the bottom left, there are some grey and blue areas, labeled 'grey and blue infrastructure'. The overall scene is a mix of natural and human-made environments.

technosphere /
settlements

intensively managed

grey and blue
infrastructure

extensively managed

An aerial photograph of a landscape at sunset. The sky is filled with orange and yellow clouds, with the sun low on the horizon. Below the horizon, a river flows through a green landscape. In the distance, there are mountains. The foreground shows a mix of green fields and some urban areas with lights. The text is overlaid on the image in white.

(temporally dynamic)
spatial pattern and interactions

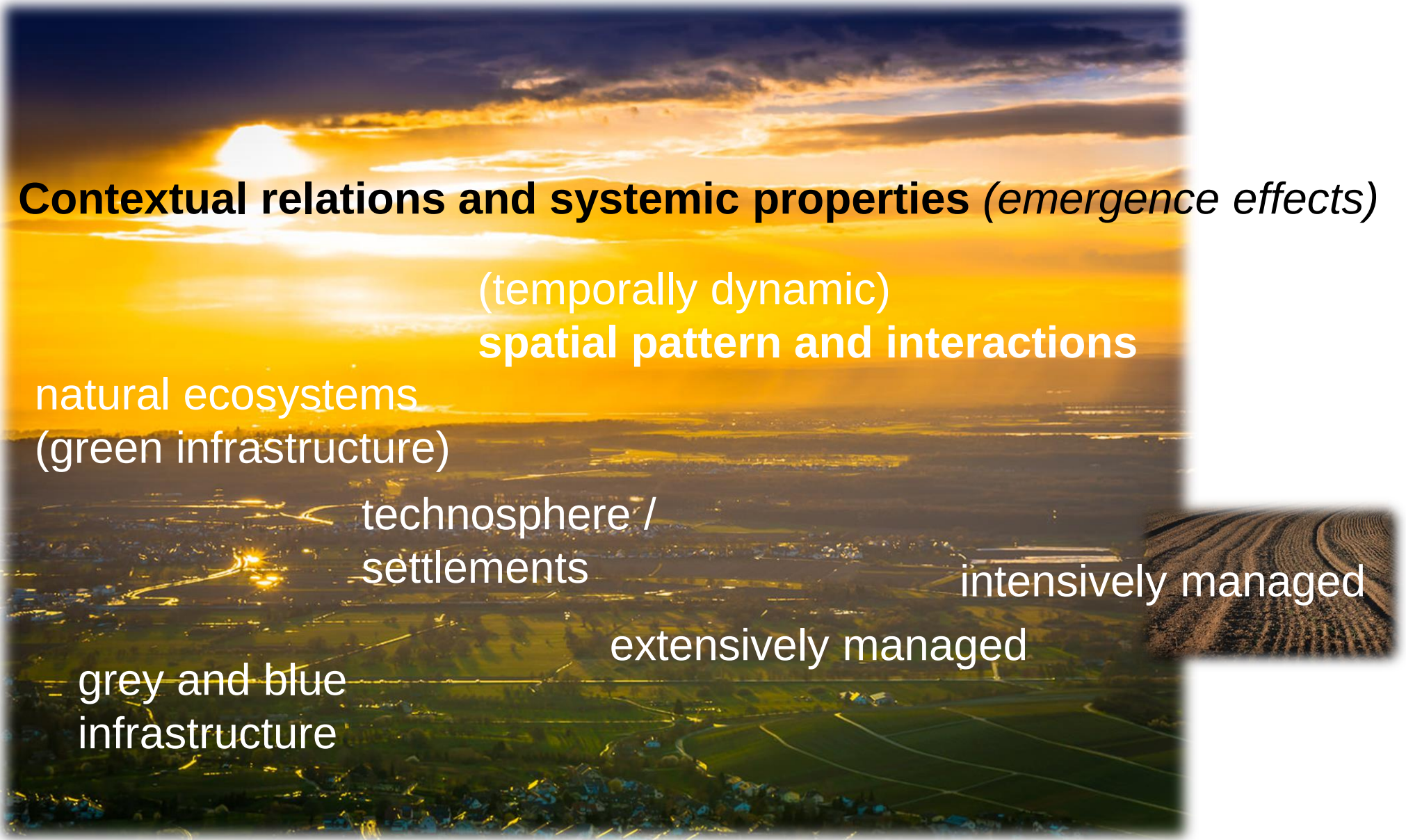
natural ecosystems
(green infrastructure)

technosphere /
settlements

intensively managed

grey and blue
infrastructure

extensively managed

An aerial photograph of a landscape at sunset. The sky is filled with orange and yellow clouds, with the sun low on the horizon. The landscape below shows a mix of green fields, urban areas with lights, and a river. Labels are overlaid on the image to identify different land use types and their interactions.

Contextual relations and systemic properties (*emergence effects*)

(temporally dynamic)

spatial pattern and interactions

natural ecosystems
(green infrastructure)

technosphere /
settlements

intensively managed

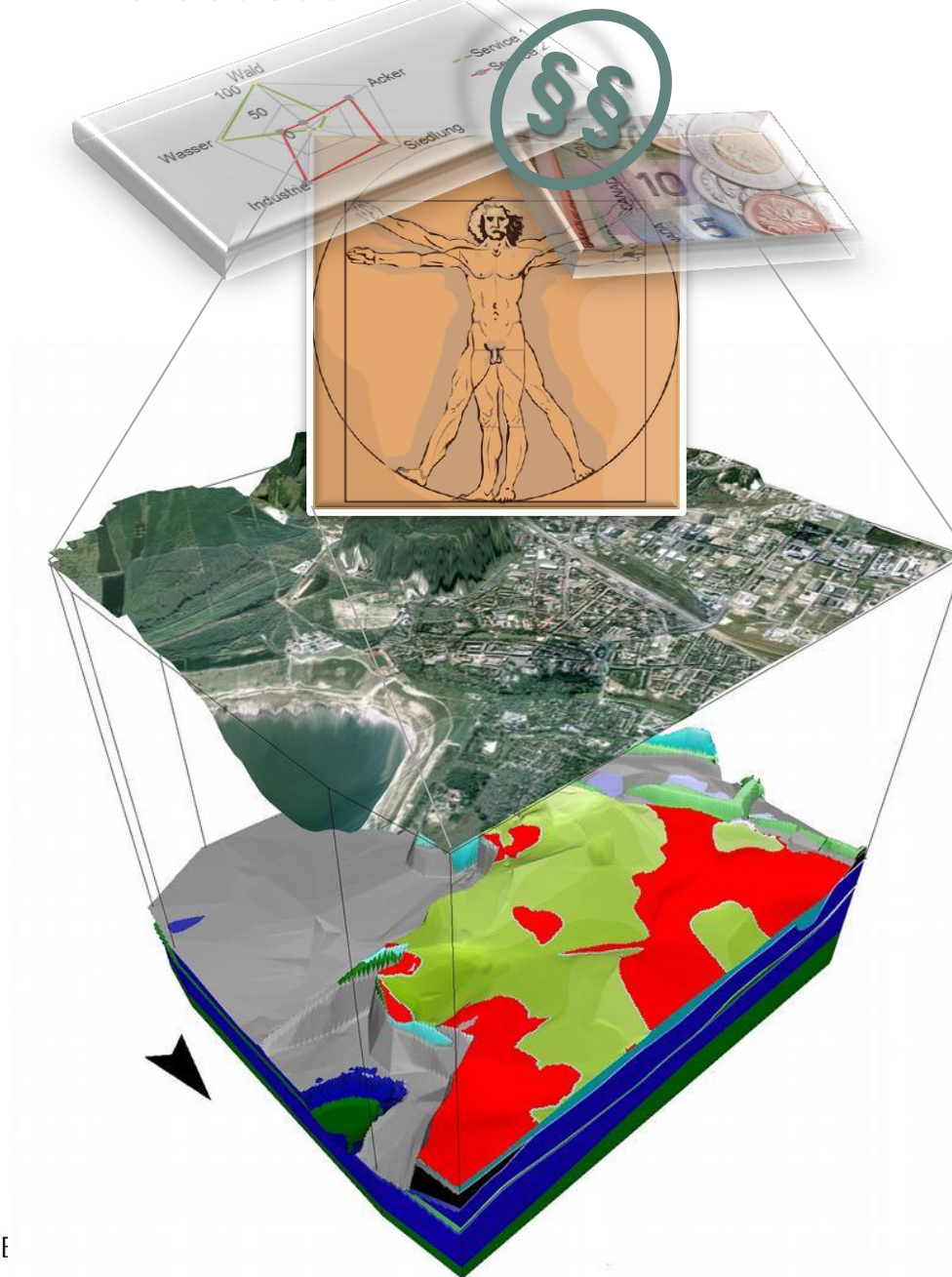
grey and blue
infrastructure

extensively managed

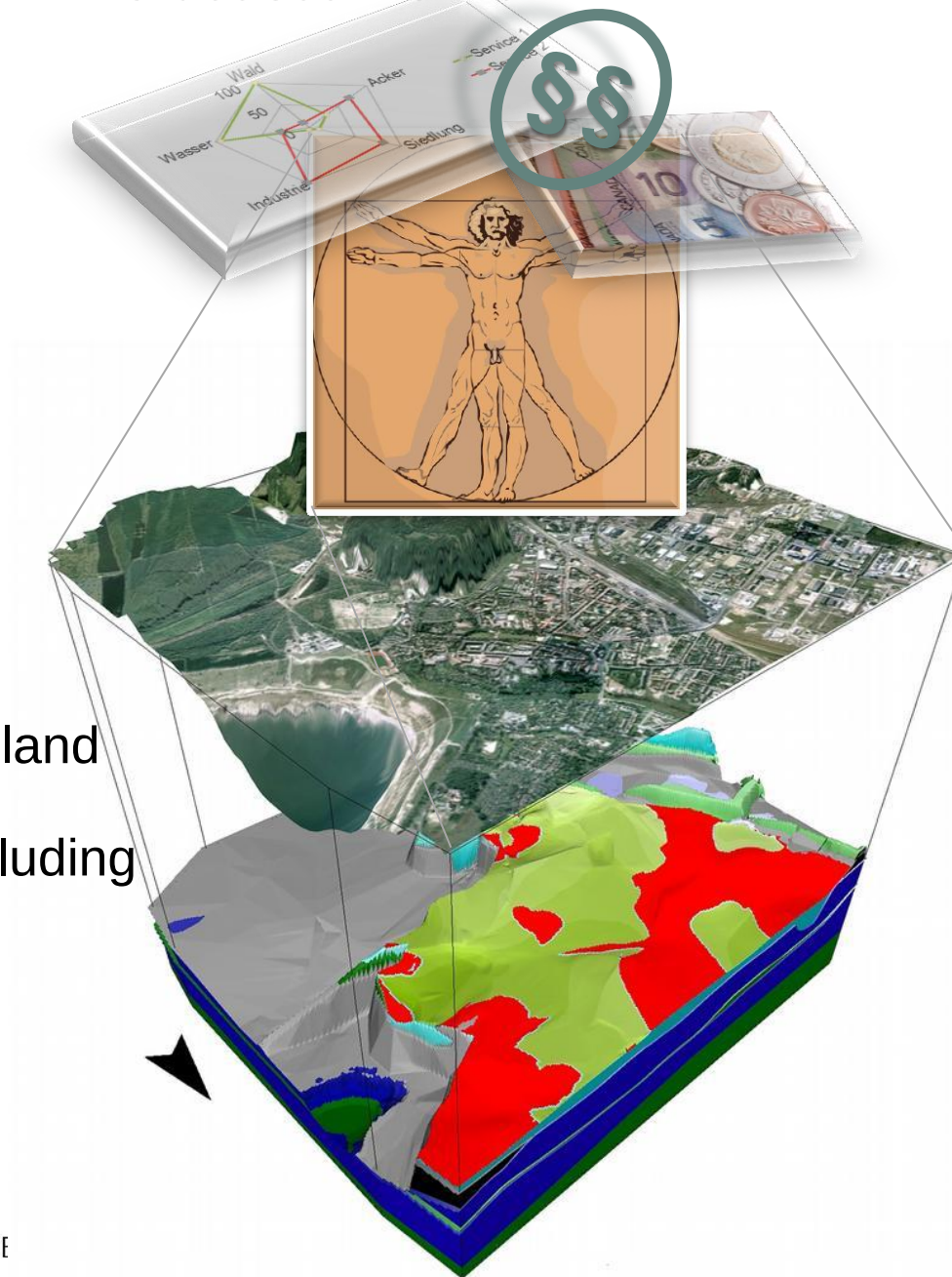
Implications?

- Integrating **multiple scales** – i.e. **management practices** from agriculture and forestry, **information** on urban space, water bodies and streams and their pattern at landscape scales, i.e. it is not enough to plan (and assess ecosystem services) only on the basis of "land cover"
- **Systemic understanding of spatial interactions** of human and nature and the impacts of **governance** (norms, standards, customs, money), **institutions & actors** (power play) and of **policy instruments** are working

Resulting challenges in ES assessments



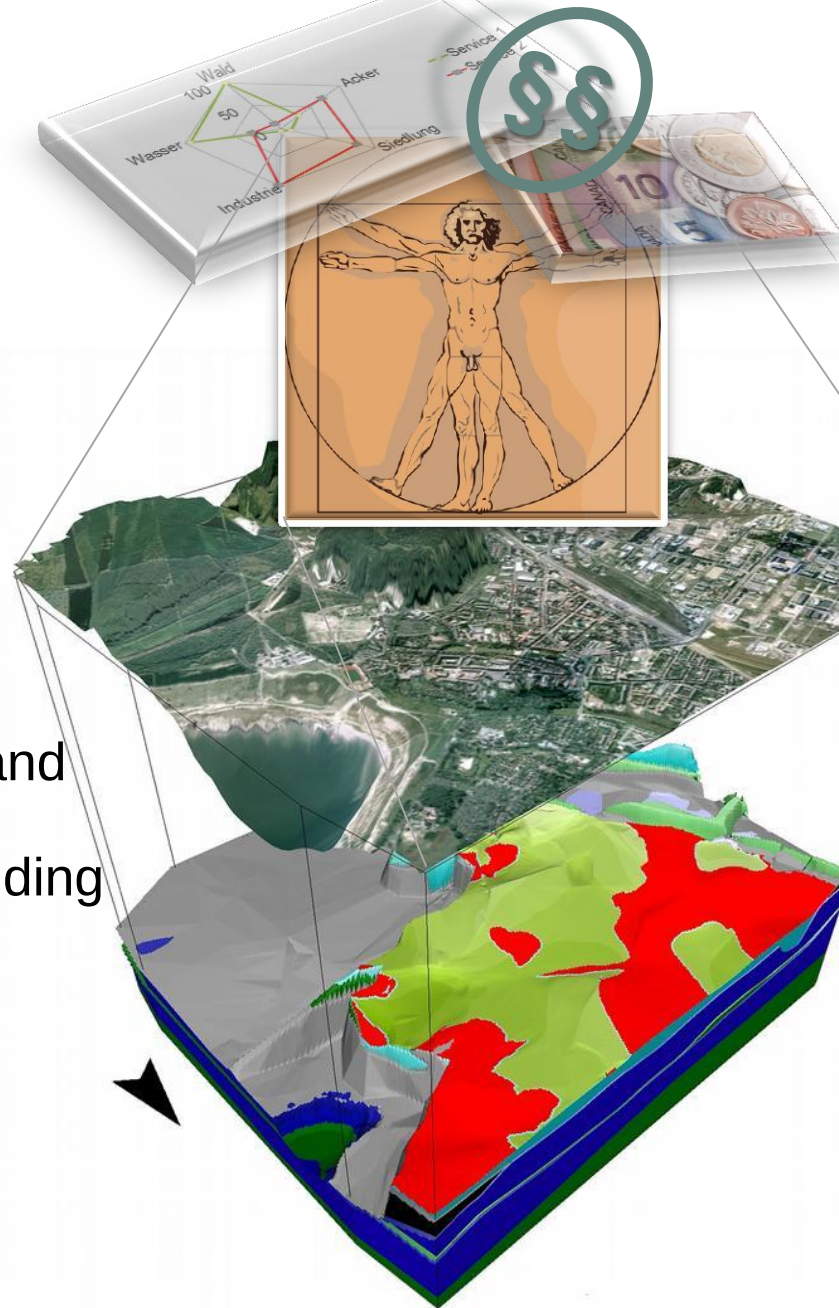
Resulting challenges in ES assessments



Integration of **highly heterogeneous data** on land use / management (soil, topography, climate) including land tenure (rights)



Resulting challenges in ES assessments



Integrated assessment
including telecoupled
connections, local and global
drivers, including the histories
of landscapes and scenarios
for their futures

Integration of **highly
heterogenous data** on land
use / management (soil,
topography, climate) including
land tenure (rights)

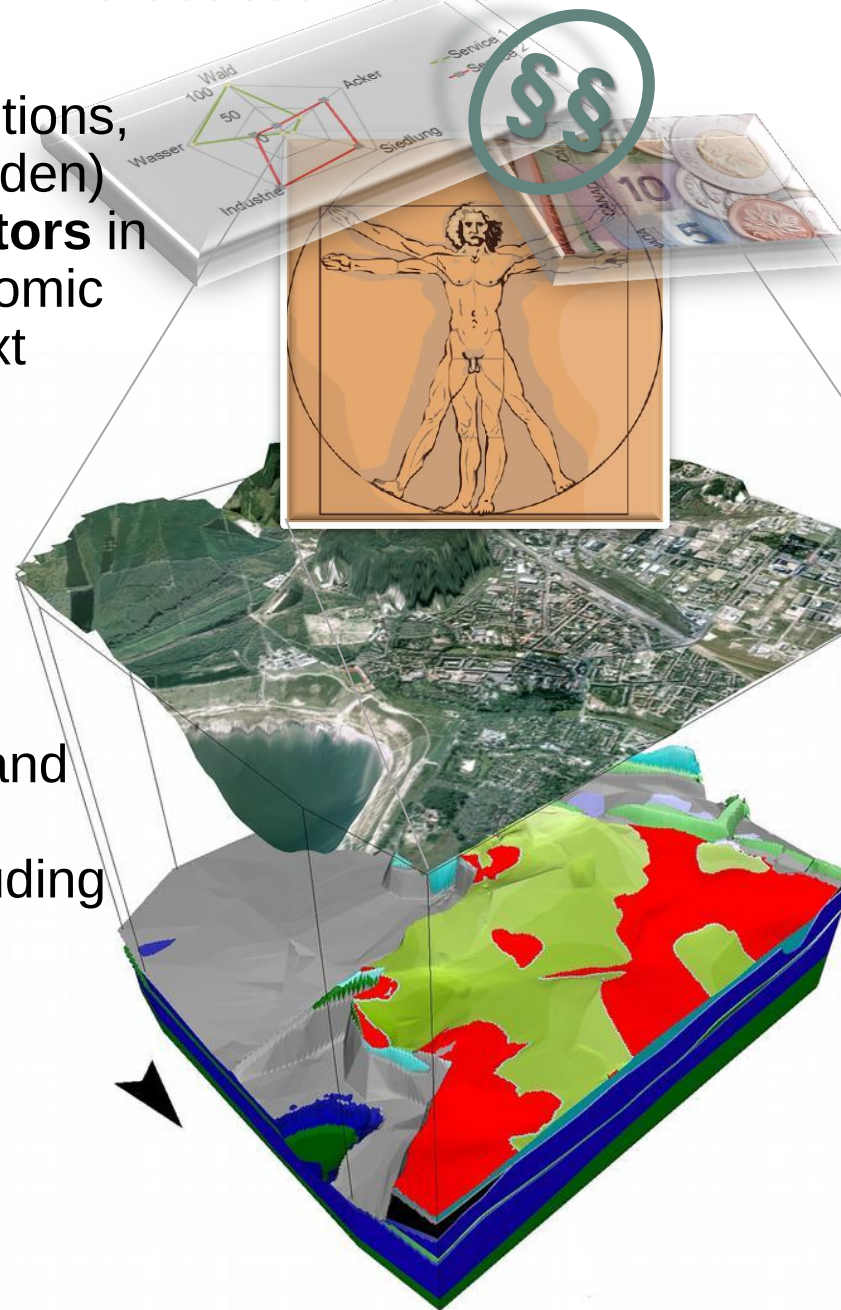


Resulting challenges in ES assessments

Integration of the perceptions, values / preferences, (hidden) targets of the different **actors** in their cultural, social-economic and environmental context

Integration of **highly heterogeneous data** on land use / management (soil, topography, climate) including land tenure (rights)

Integrated assessment including telecoupled connections, local and global drivers, including the histories of landscapes and scenarios for their futures



Back to integrated assessments and ES – some basics

- Hypothesis:** sustainably used cultural landscapes and ecosystems provide well balanced all human needs (*Sustainability principle*)

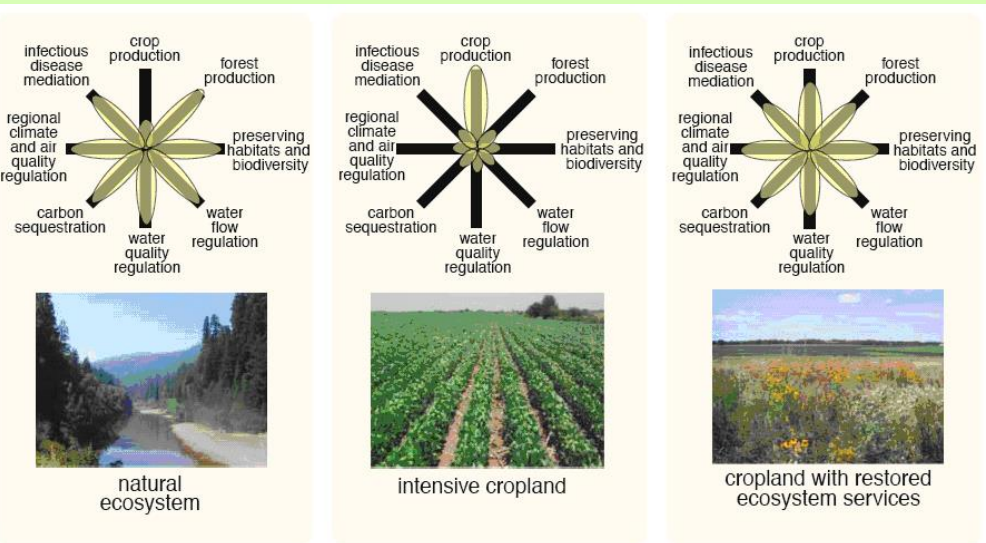
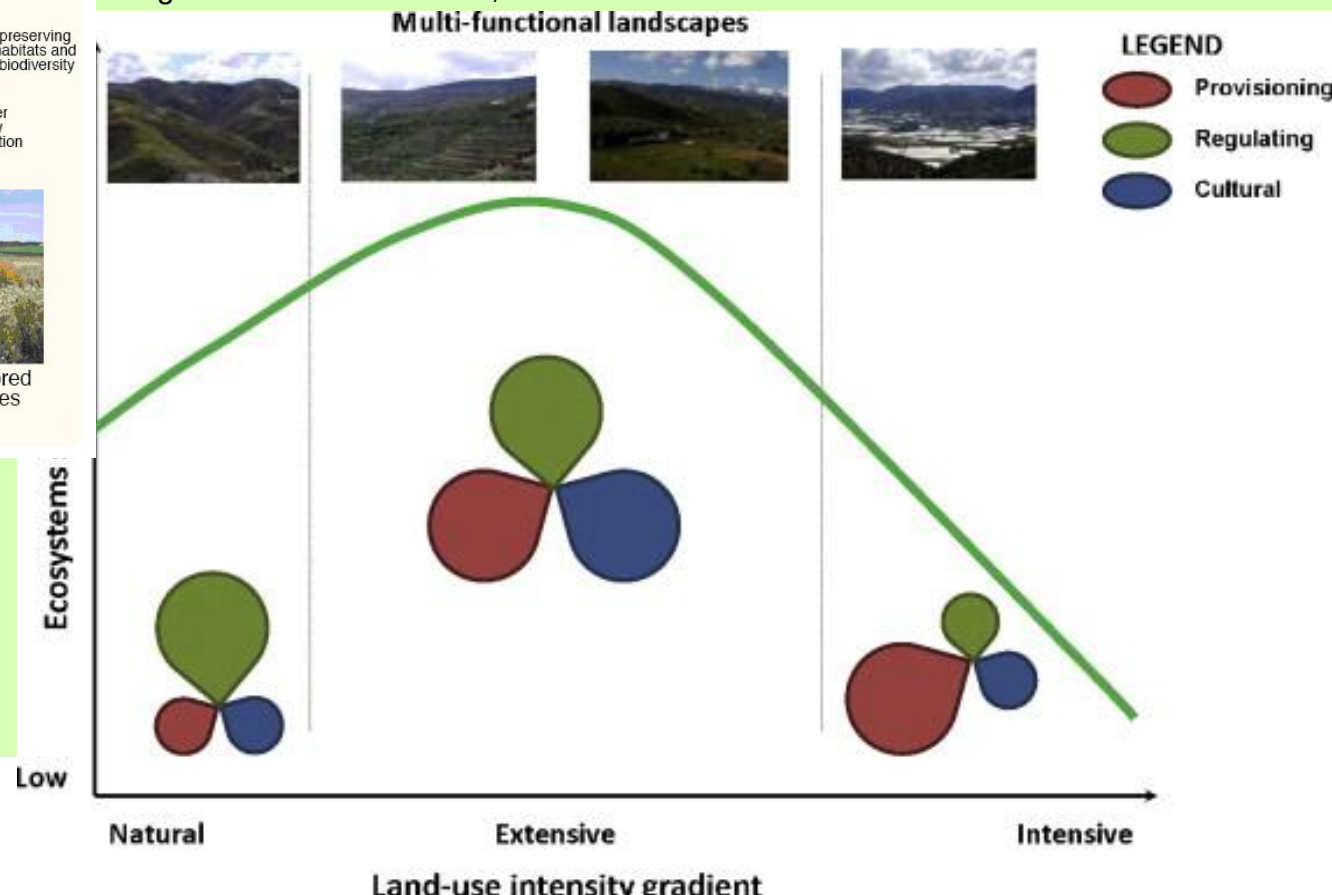


Fig: Garcia-Llorente et al., 2012



Foley and de Vries, 2005

Which impact assessment approaches do we know?

- **DPSIR-Scheme (EEA, 1999; 2007 – biodiversity losses)**

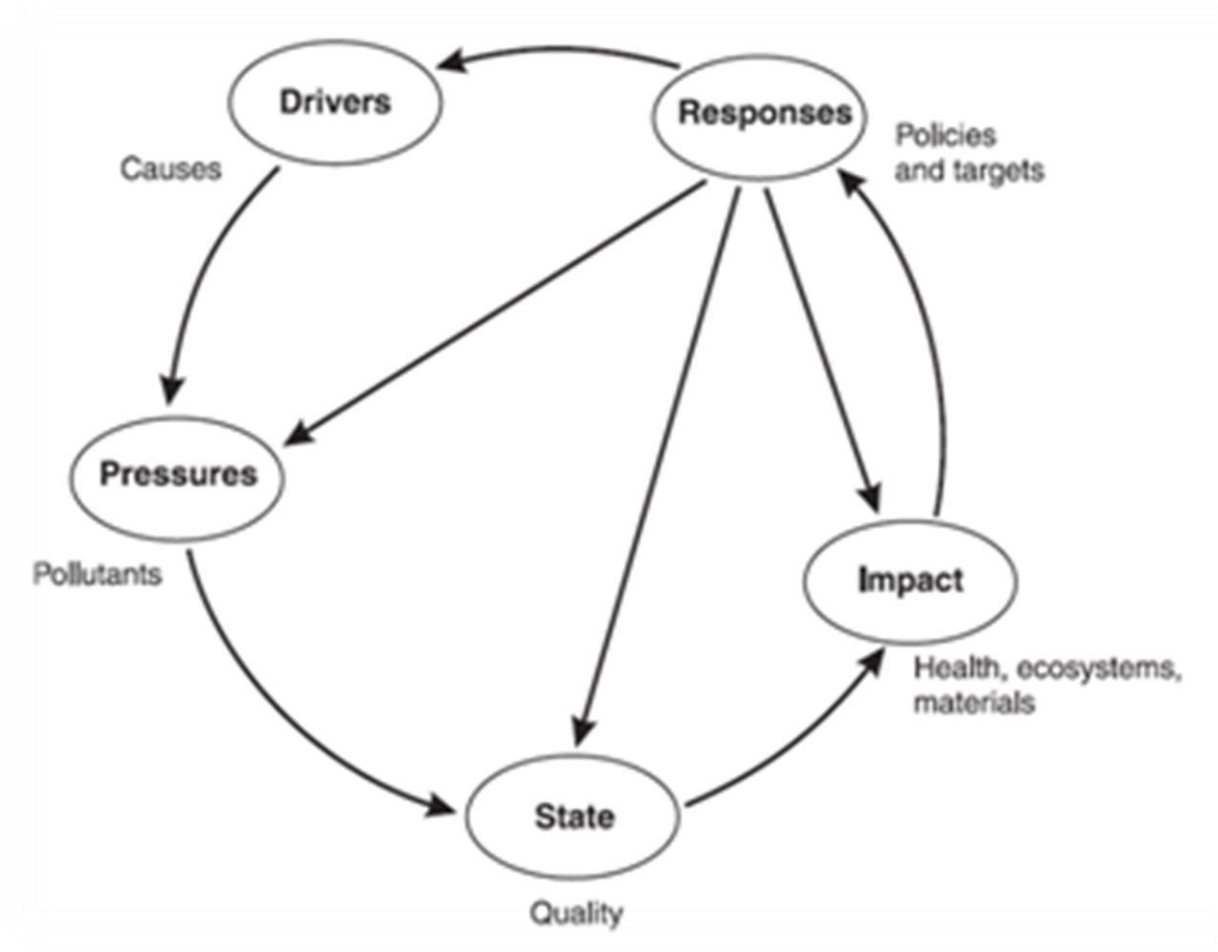
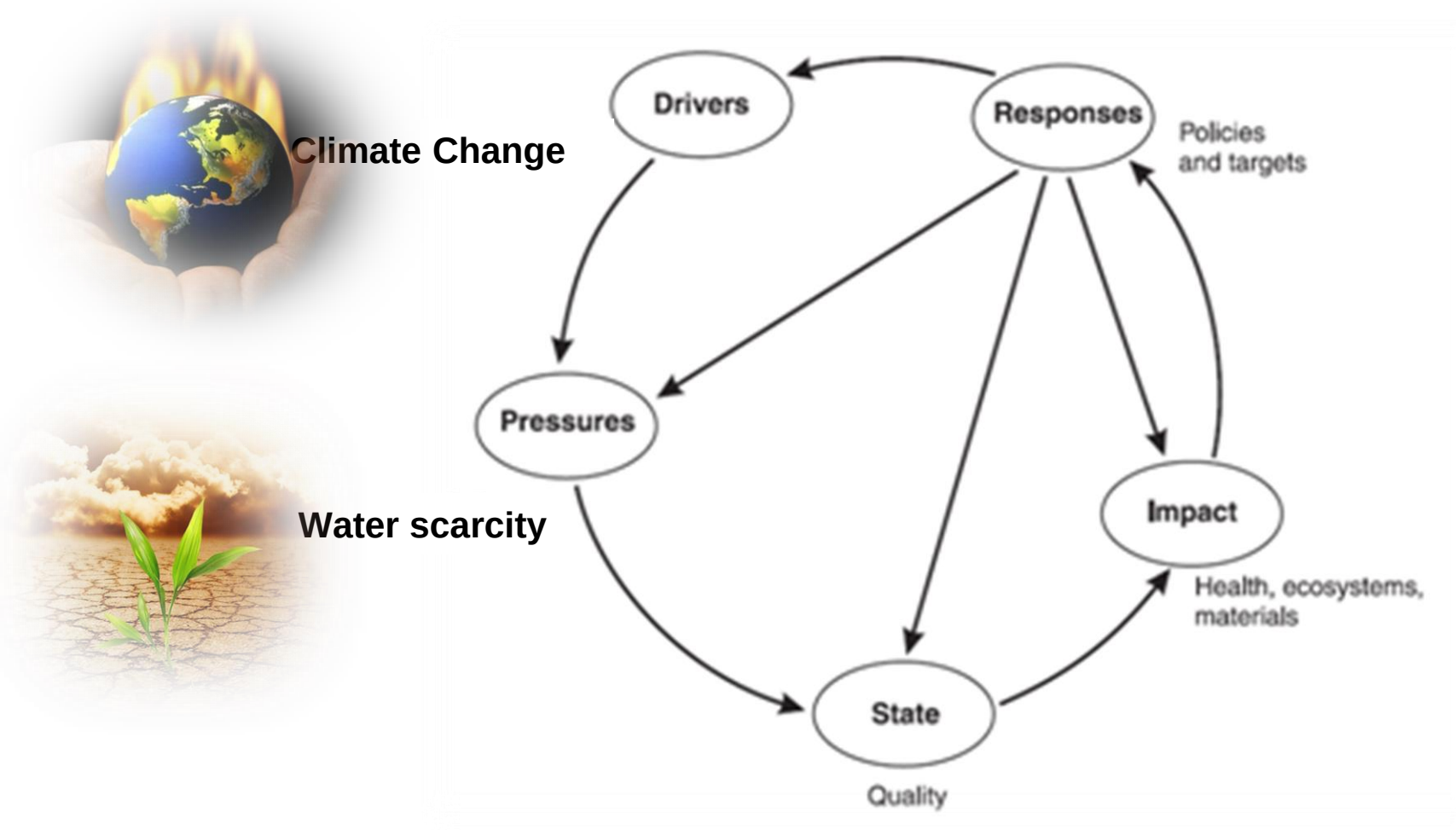


Fig: integrated-assessment.eu, accessed 06/2013, modified

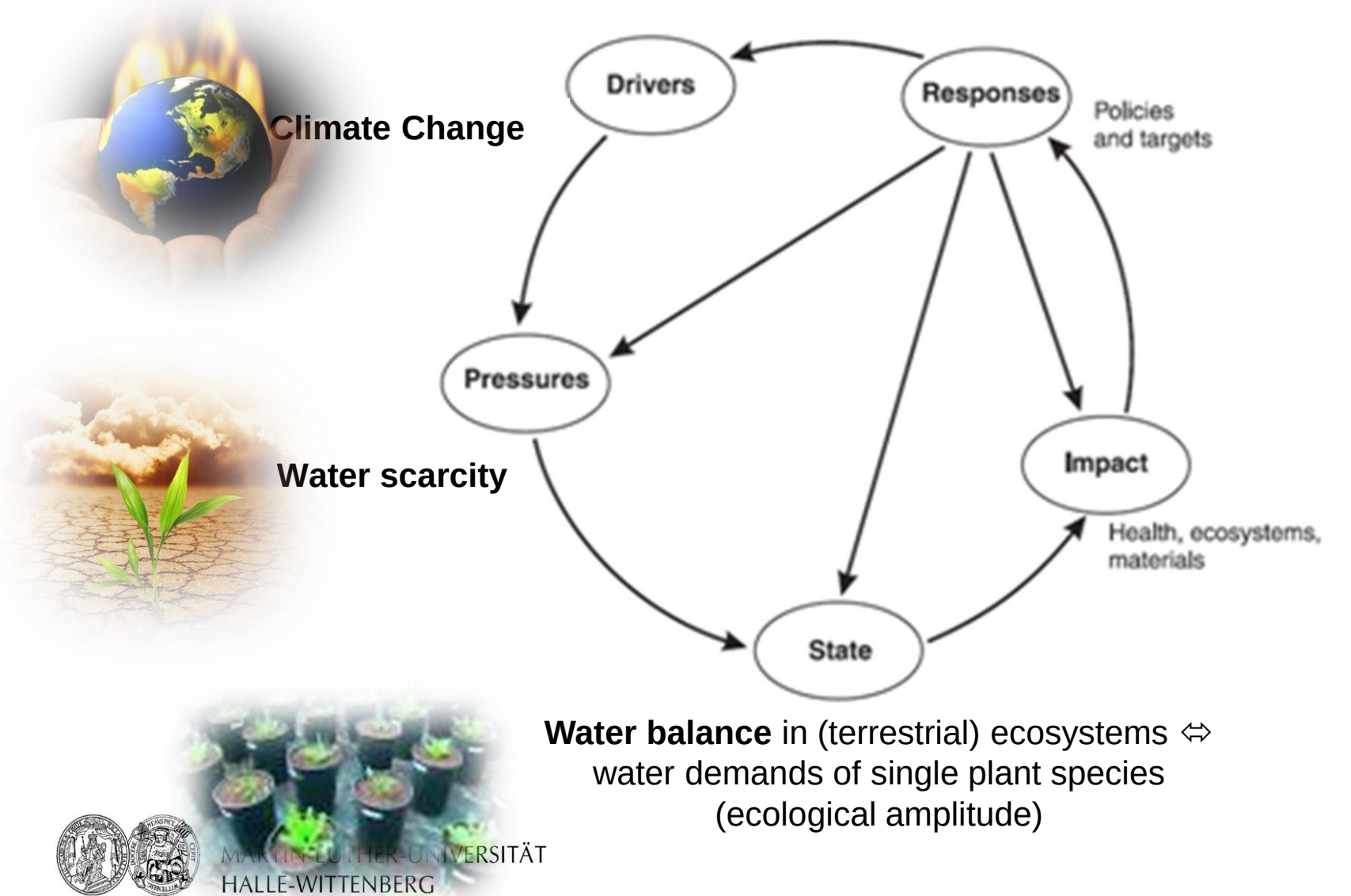
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- **DPSIR-Scheme (EEA, 1999; 2007 – biodiversity losses)**



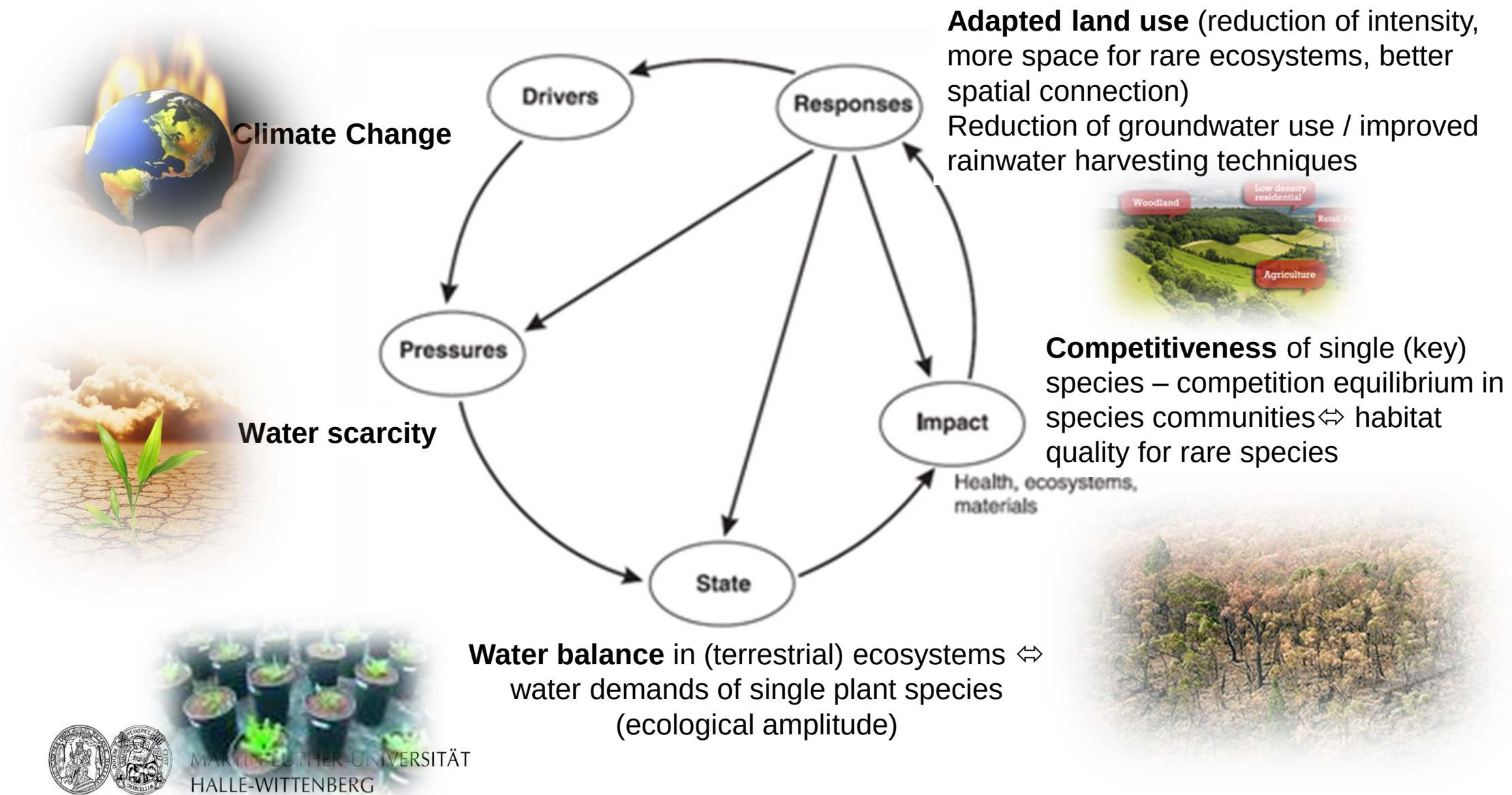
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- **DPSIR-Scheme (EEA, 1999; 2007 – biodiversity losses)**

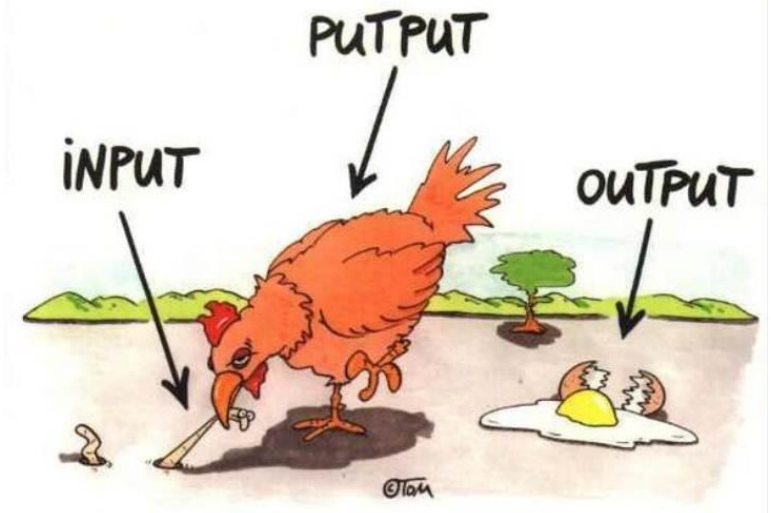
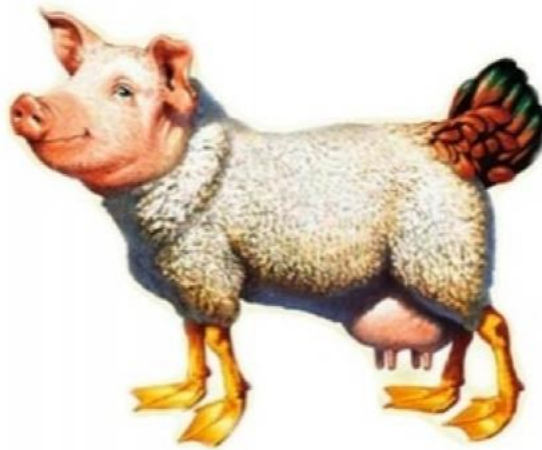


Which impact assessment approaches do we know?

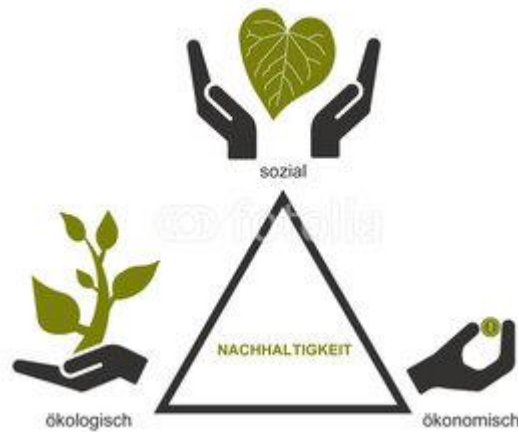
■ DPSIR-Scheme (EEA, 1999; 2007 – biodiversity losses)



And how do we evaluate?



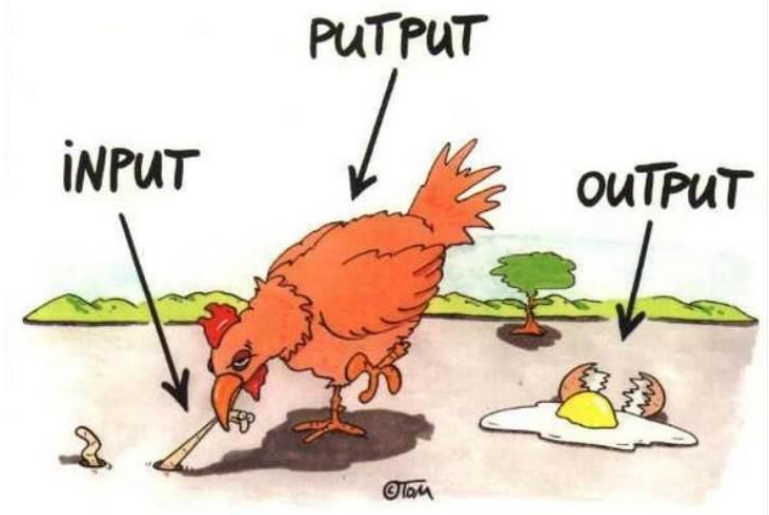
And how do we evaluate?



Sustainability



Multifunctionality



Ecosystem Services

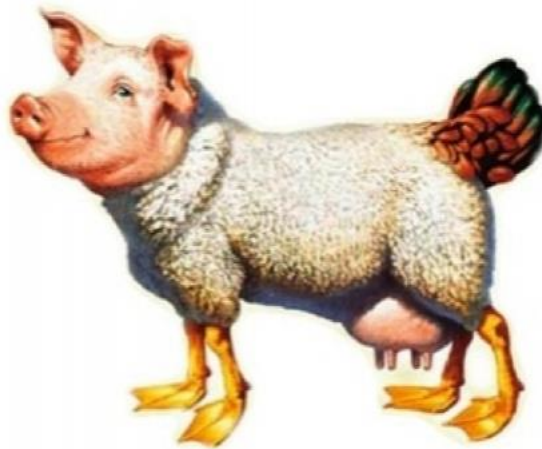
And how do we evaluate?



Sustainability

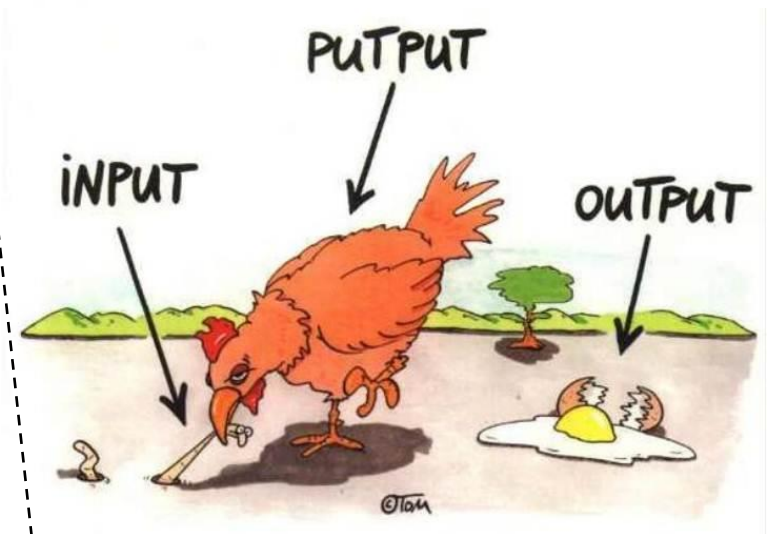
Indicators

Multicriteria evaluation



Multifunctionality

Expert knowledge



Ecosystem Services

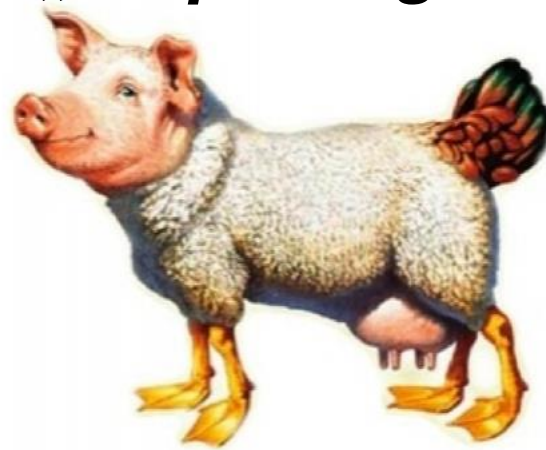
And how do we evaluate?



Sustainability

Balance?

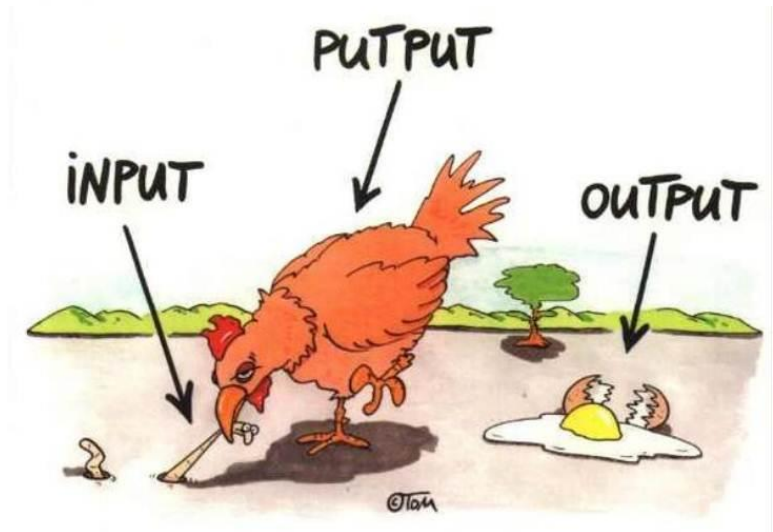
Egg-Milk-Meat-Wool
Producing Pig /
„Wopertinger“?



➡ Multifunctionality



➡ Transparency?



Ecosystem Services

Concepts

Ecosystem Services / Land-use Functions / Landscape services

- **Translation** of the **concept of sustainability** in integrated land use in terms that are comprehensive & holistic / can be better assessed to improve the communication between land use actors
- Especially in **regional context improved basis for integrated land use planning** (what is the impact / are the costs of changes, what is the specific contribution of each land use type in its spatial context, where should changes take place to have the greatest added value?)



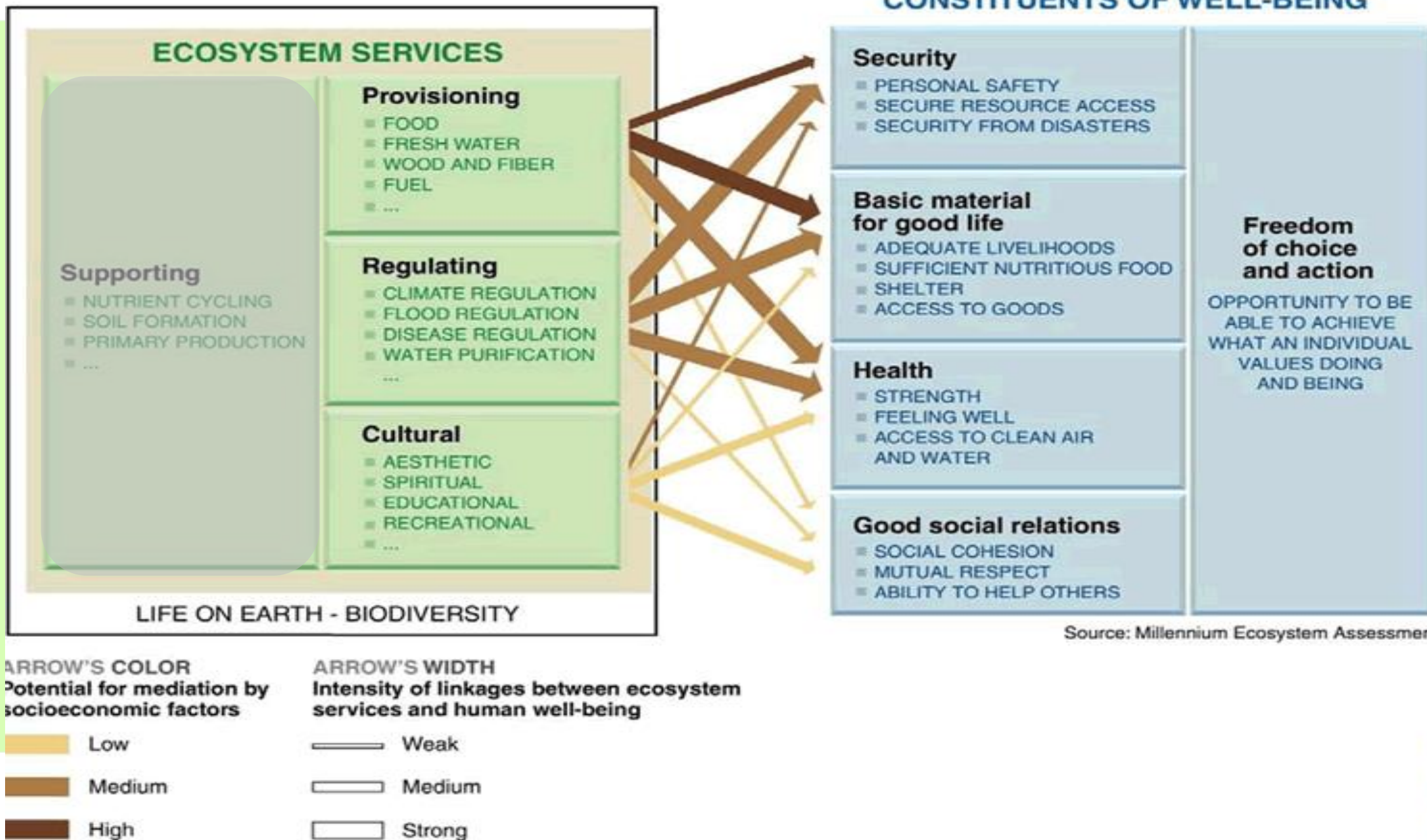
Concepts – Ecosystem Services

Conditions and Processes through which natural ecosystems, and the species that make them up, **sustain and fulfil human life** (Daily, 1997)

- **Benefits** human populations derive directly or indirectly **from ecosystem functions** (Costanza et al., 1997)
- **Components of nature**, directly enjoyed, consumed, or used to **yield human well-being** (Boyd und Banzhaf, 2007)
- **Aspects of ecosystems utilised** actively or passively to **produce human well-being** (Fischer et al., 2009)
- Direct or indirect **contributions of ecosystems** to human well-being (TEEB, 2010)



Concepts – Ecosystem Services

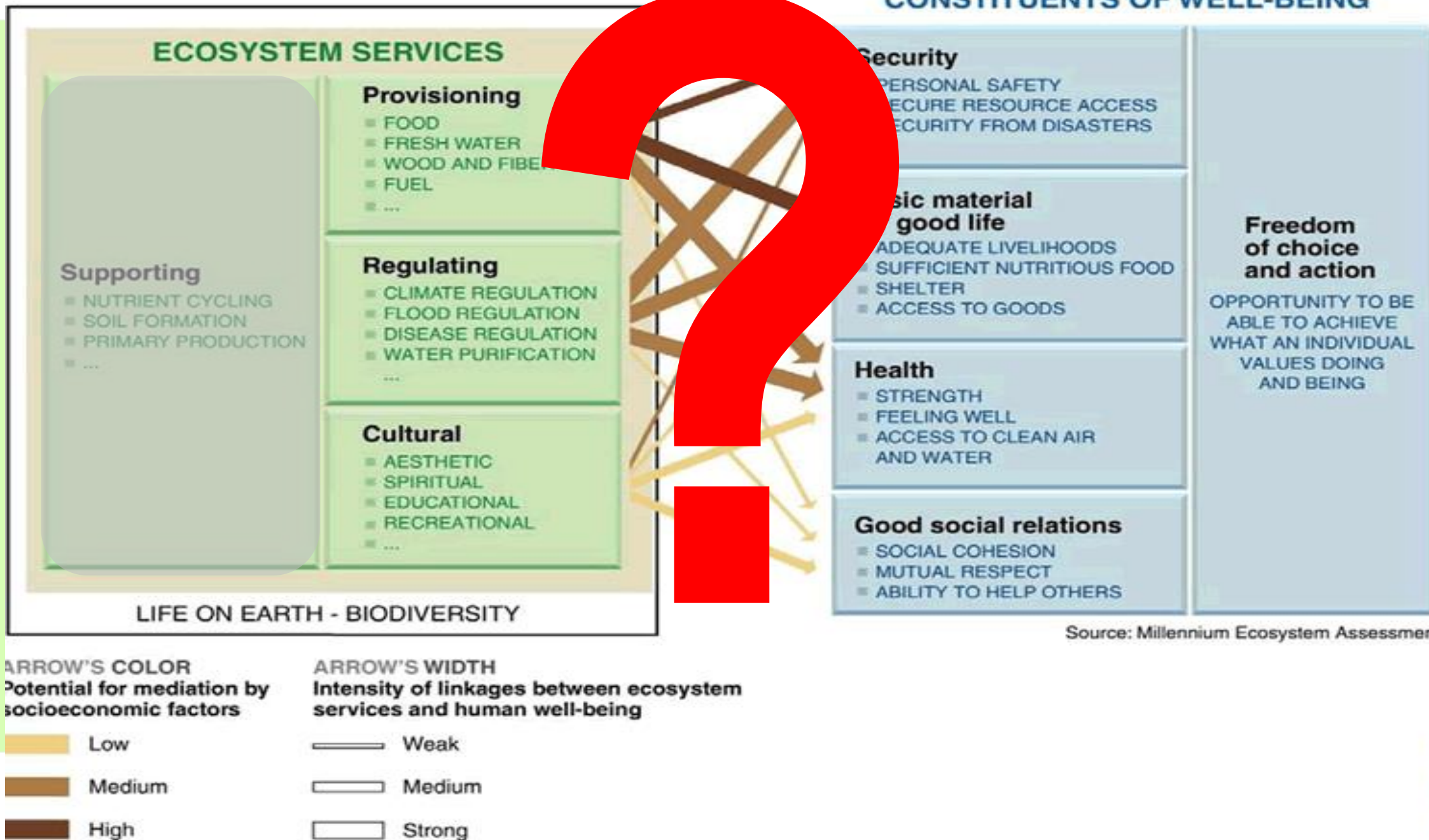


Ecosystem Services- results MEA

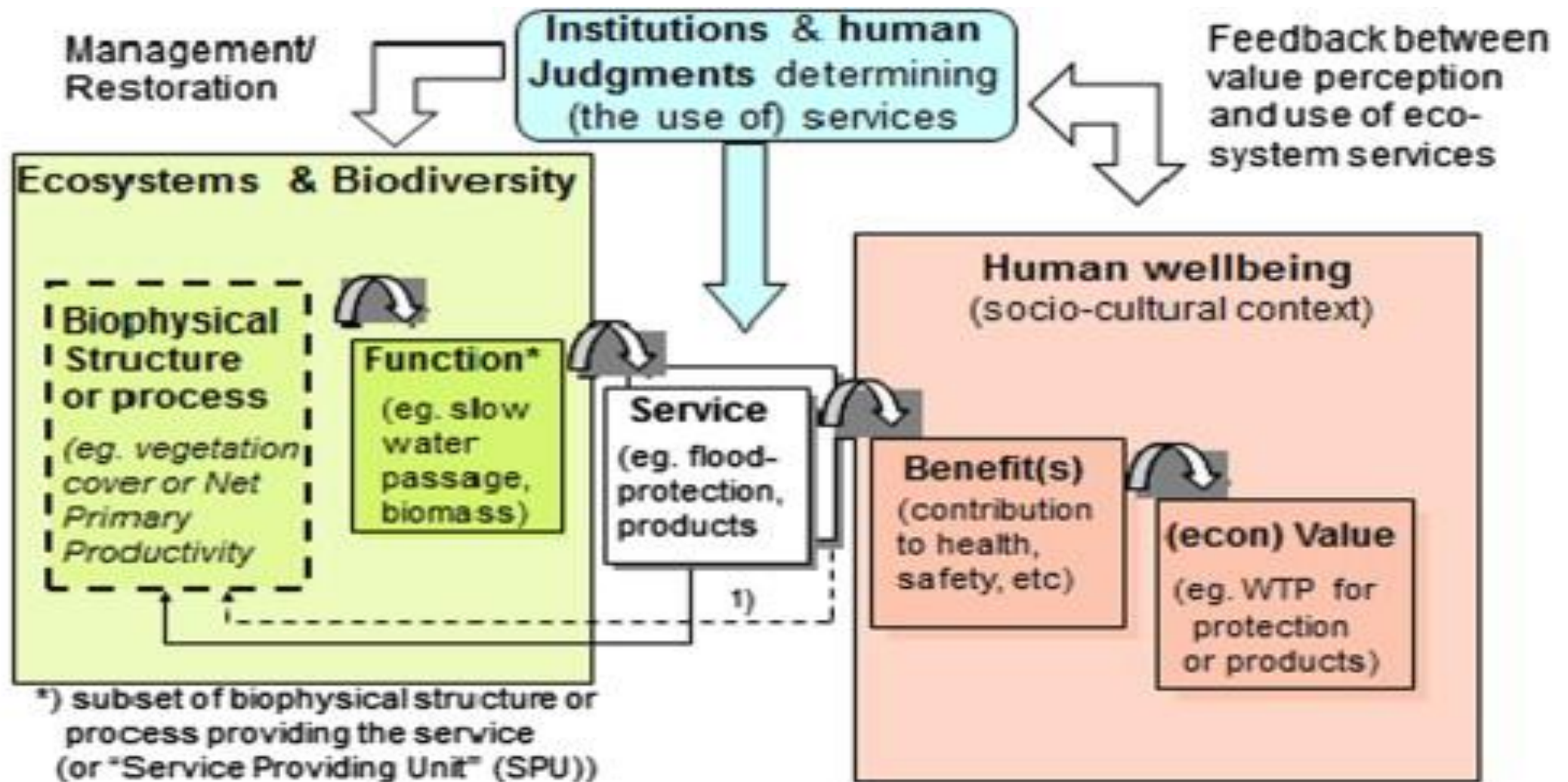
- **Threats for ecosystems and their services** were largely increased, especially since the last 50 years
- **Unequal trends for different services** by environmental / land use changes with more or less unclear effects
- **Achievment of UN Millenium development goals** is questionned (epidemics, hunger)
- **Institutional responsibilities** as well as **monetary basis** for **improving the condition of ecosystems and support their service provision** are largely **missing** (not planned / anchored in governance structures)



Concepts – Ecosystem Services



Concepts – The Economics of Ecosystems and Biodiversity TEEB



1) The use of services usually affect the underlying biophysical structures and processes, ecosystem service assessments should take these feedback-loops into account



Concepts – TEEB

Results of TEEB

Example tropical forests – assessment of ecosystem services

Ecosystem services

- Food, fibres, fuelwood
(provisioning services)
- Climate regulation
- Water regulation
(flood protection)
- Drinking water provision
- Pollination services

Value in USD / ha * a

timber 560, fuelwood 61,
non-timber products 41-70
Lescuyer (2007)

842 – 2.265 Lescuyer (2007)

24 Yaron (2001)

968 Van Beukering et al. (2003)

62 Priess et al. (2007)



Concepts – TEEB

Results of TEEB

Example tropical forests

But – discrepancies and
scale reference –
which decisions will be changed?

Ecosystem services

- Food, fibres, fuelwood
(provisioning services)
-
- Climate regulation
- Water regulation
(flood protection)
- Drinking water provision
- Pollination services



Value in USD / ha * a

○ Timber 560, fuelwood 61,
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Lescuyer (2007)

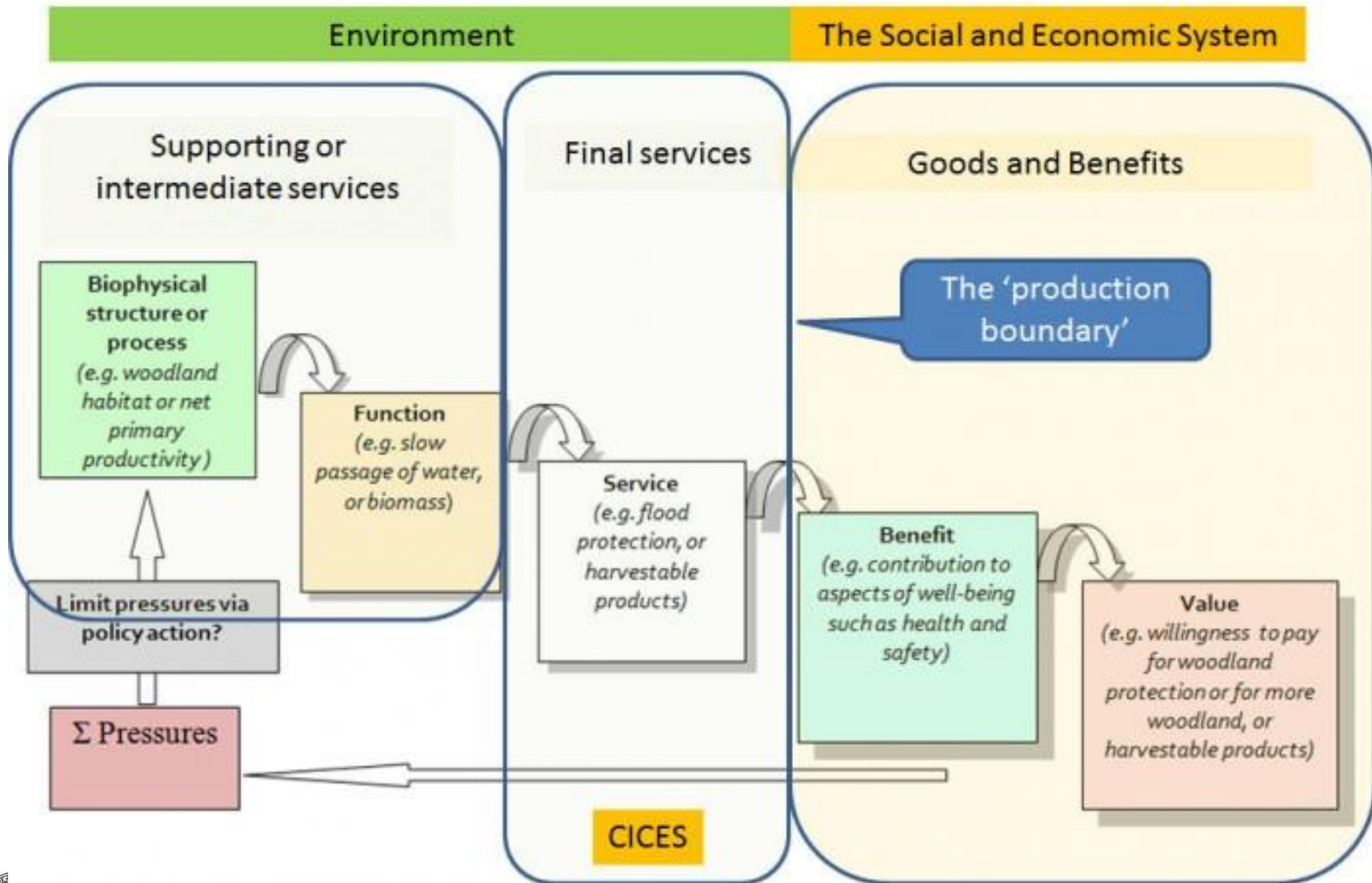
842 – 2.265 Lescuyer (2007)

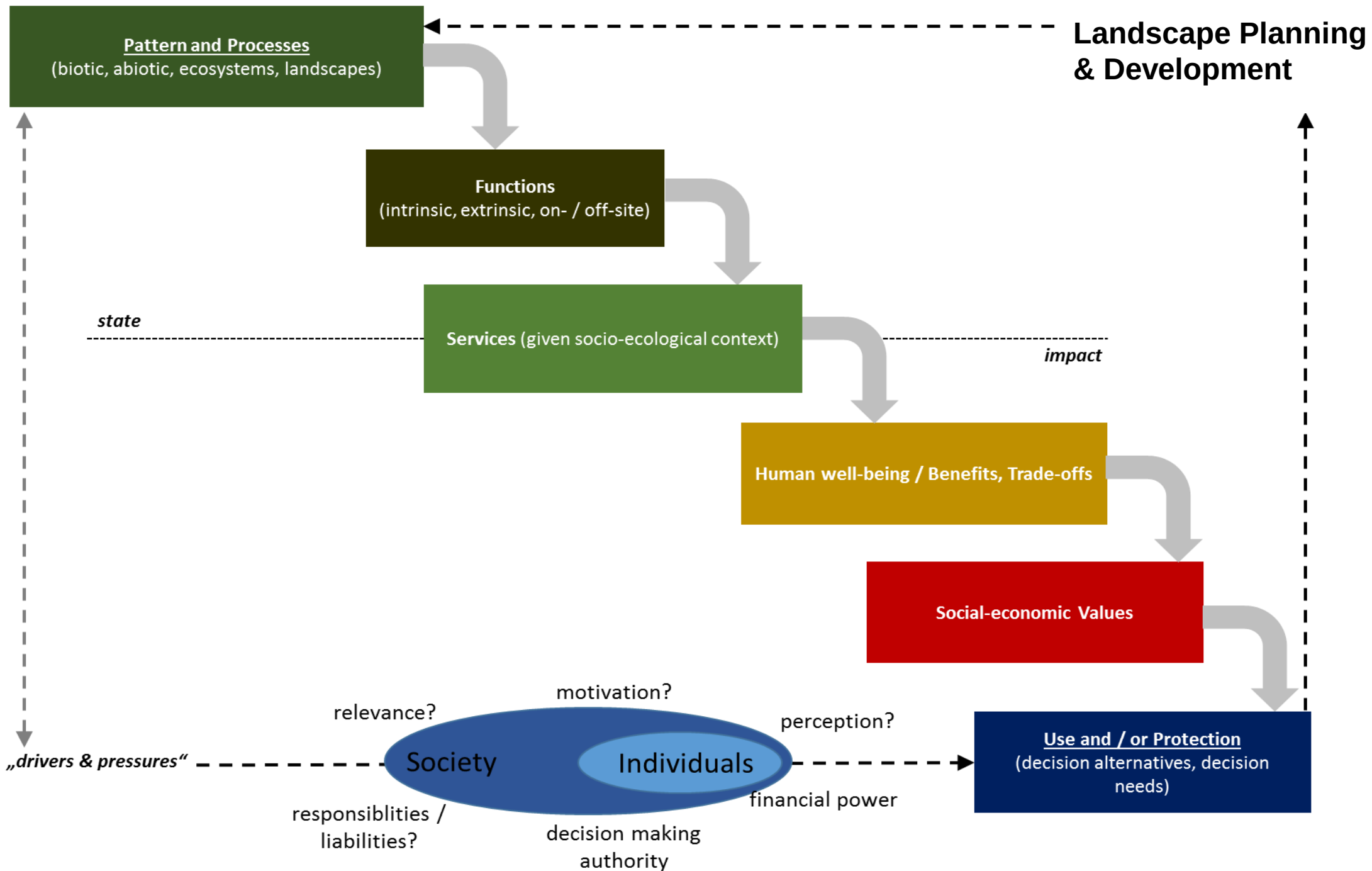
24 Yaron (2001)

968 Van Beukering et al. (2003)

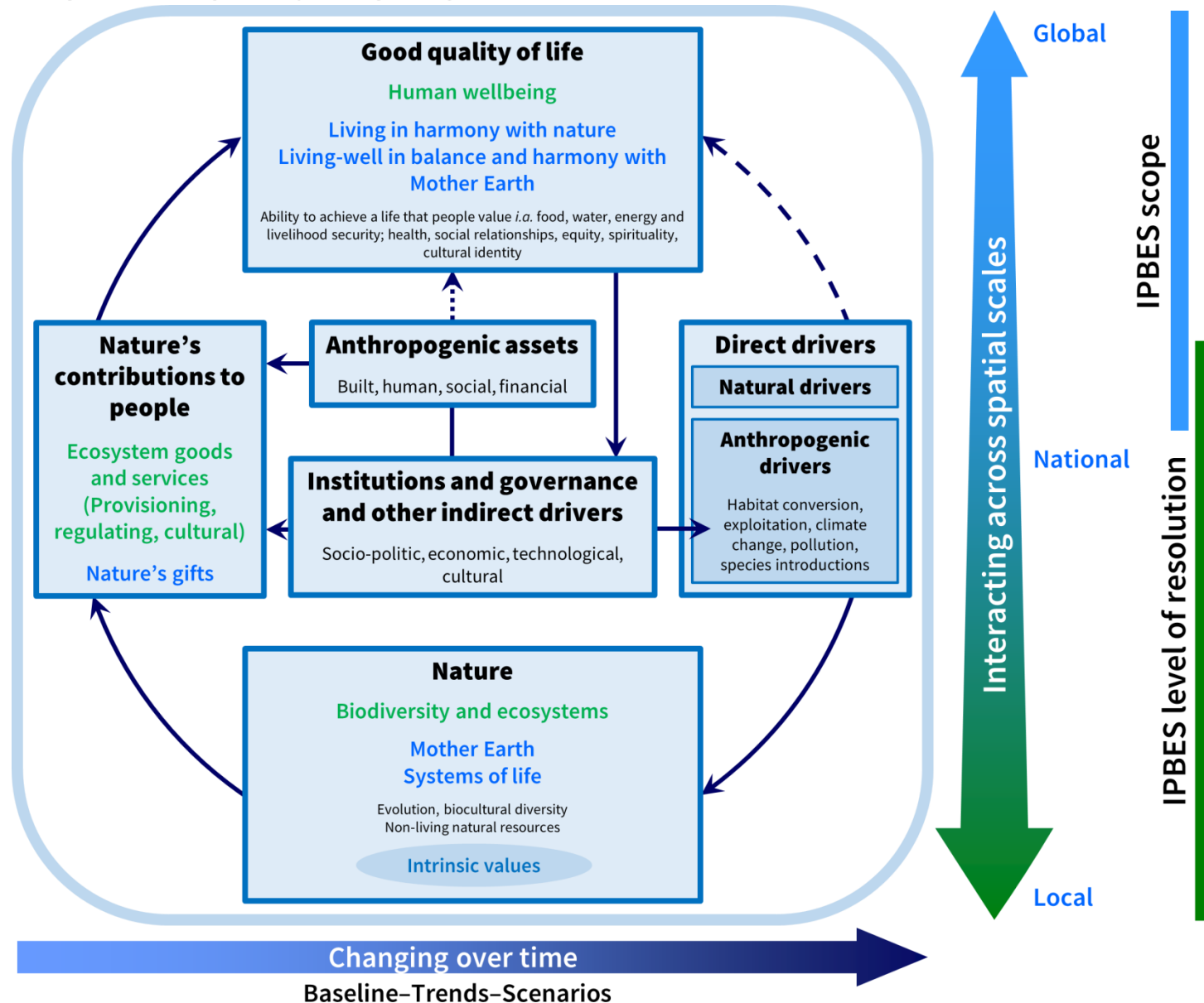
62 Priess et al. (2007)

Concepts – The CICES cascade





Concepts – The IPBES Framework



The concepts – a comparison

Concept	Spatial scales	Temporal scales	SES integration	Policy relevance
MEA (2005)	Global	History & current situation	Little	High
TEEB (2010)	Global and regional	Current situation & development	Partially	High
IPBES (2012 ff.)	Global and regional	Scenarios	From top down	Extremely High



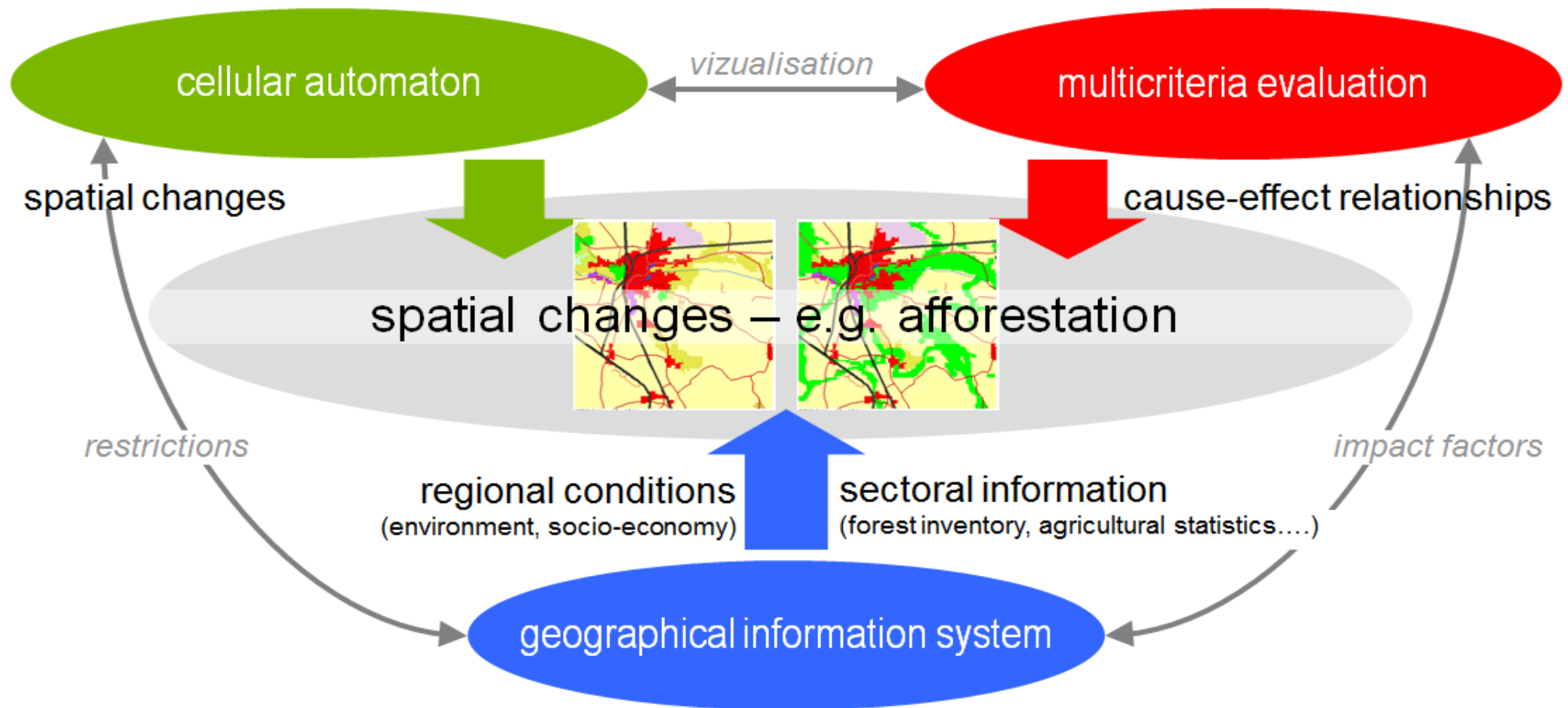
Working task for you!

- Which are the key **ecosystem services** in Tbilisi?
- Which **indicators** would you suggest for them
- How would you integrate the **landscape scale**?





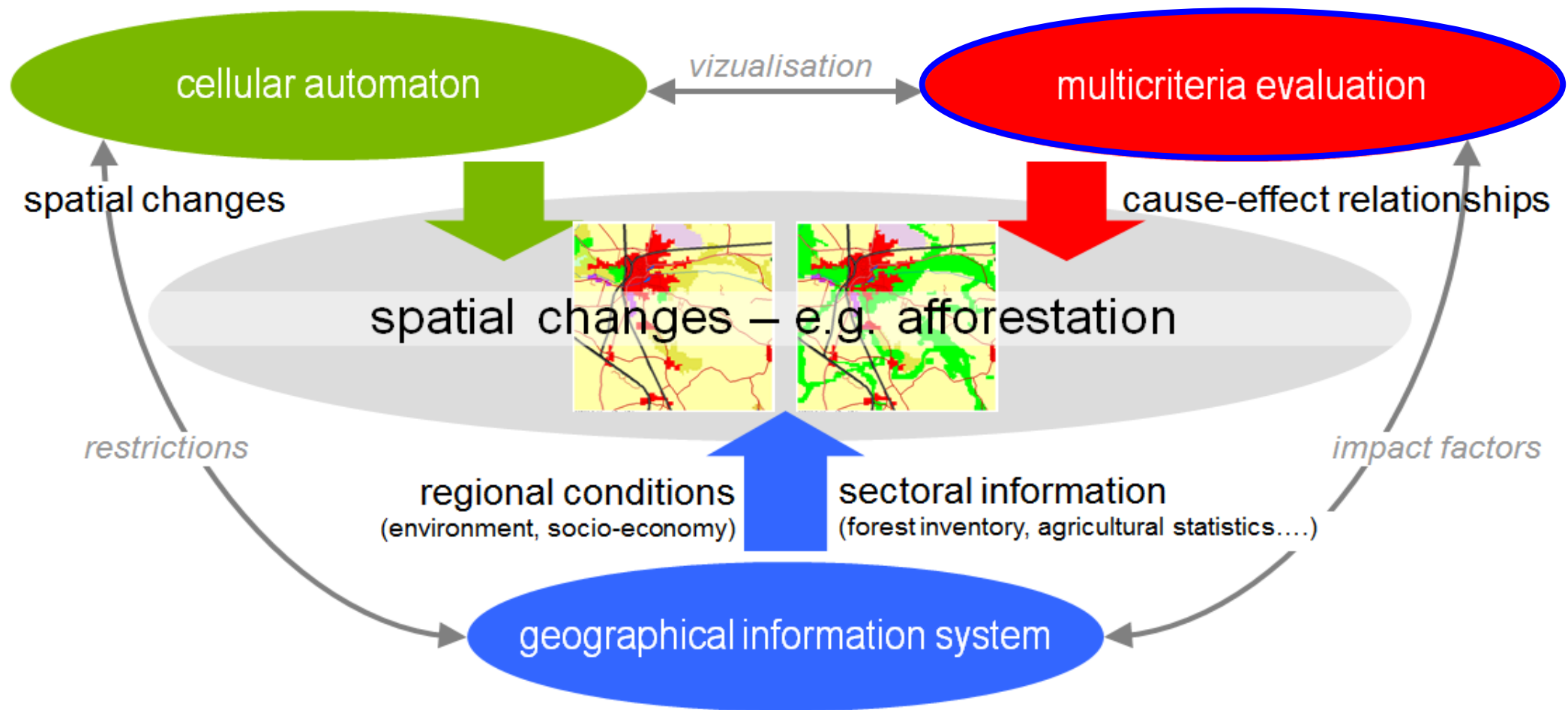
ES valuation, assessment and mapping – an integrated approach



GISCAM (Fürst et al., 2010 a, b)



ES valuation, assessment and mapping – an integrated approach

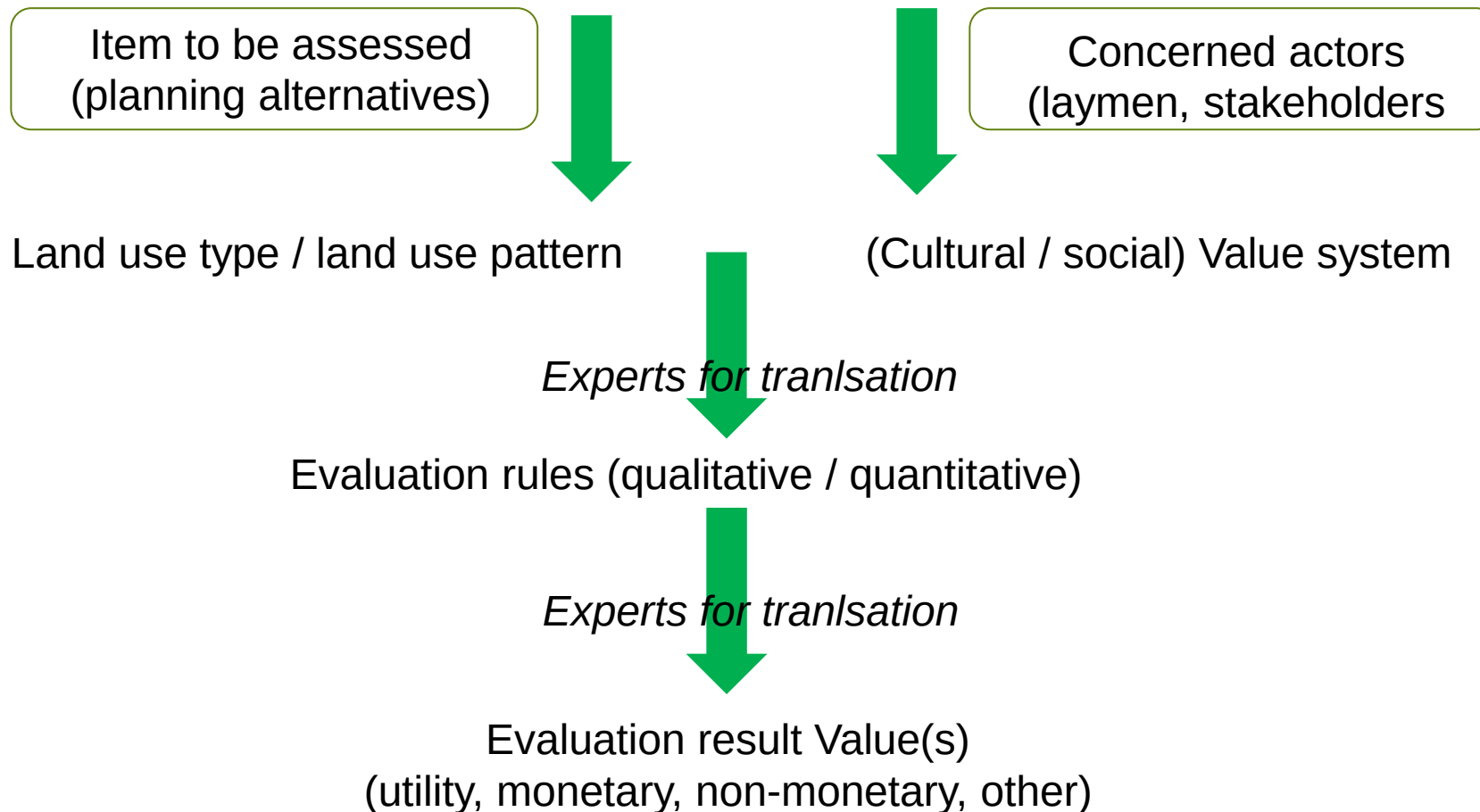


GISCAMÉ (Fürst et al., 2010 a, b)

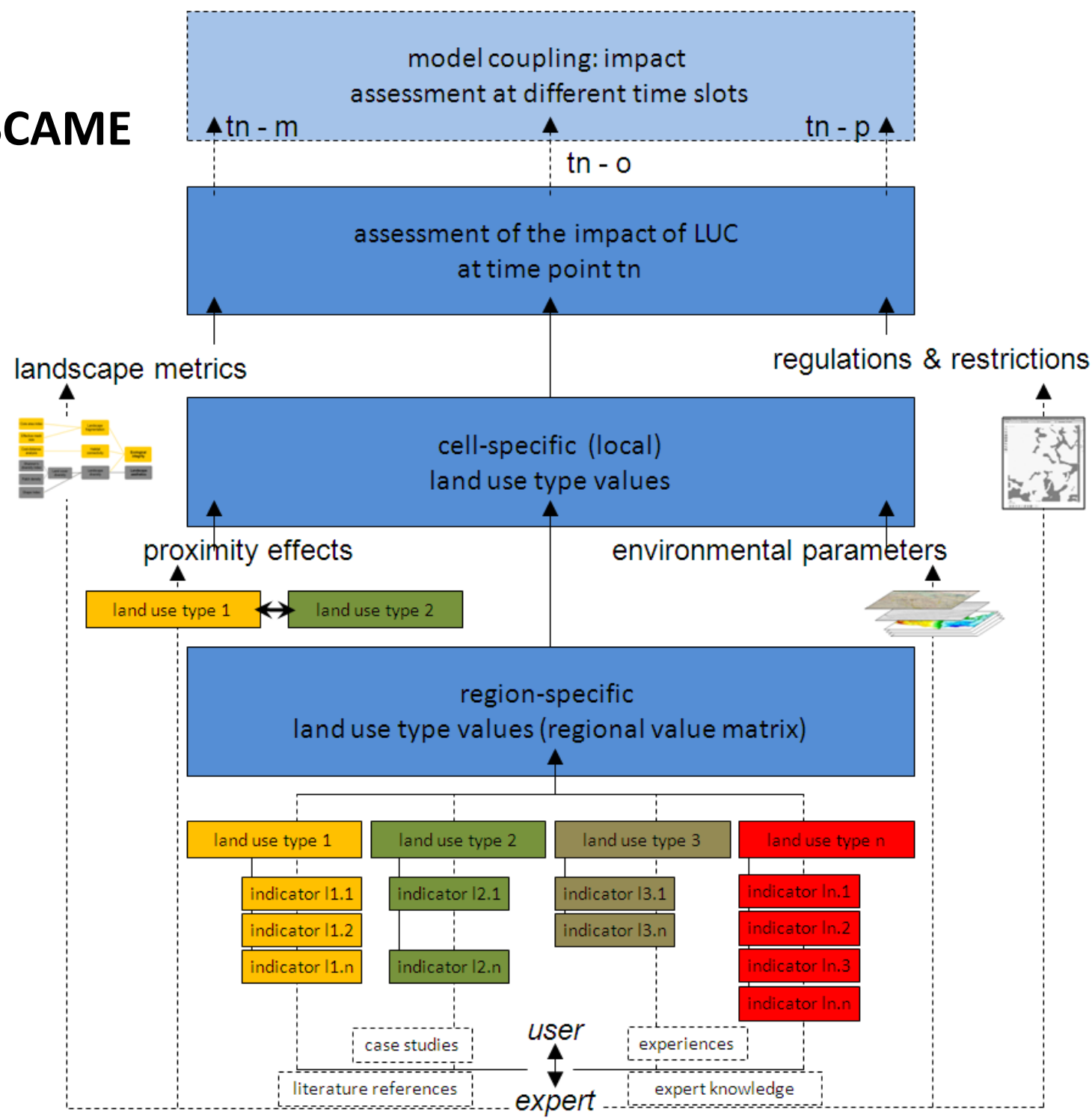


ES evaluation – how to?

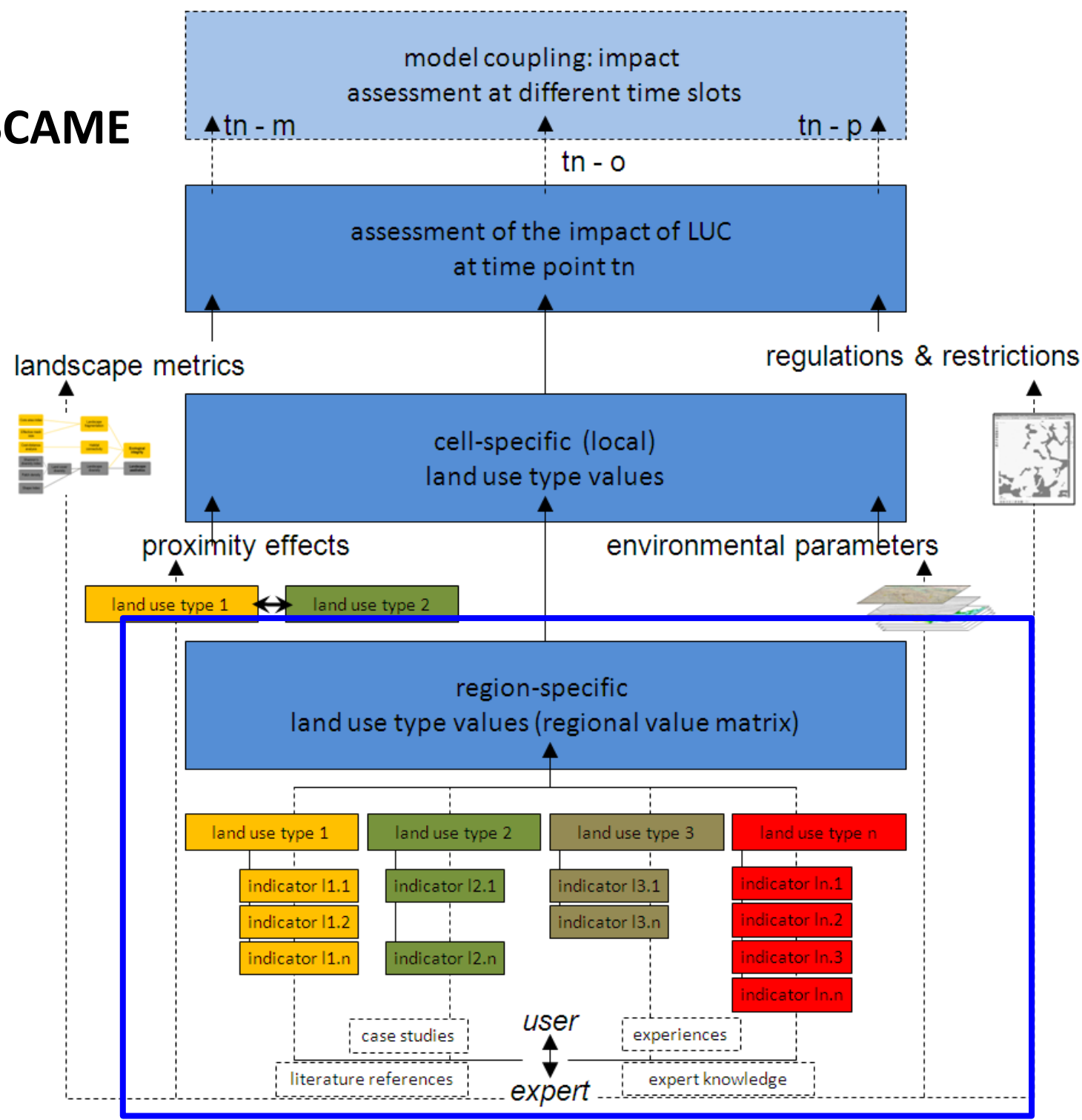
Cost-utility analysis (quantitative and qualitative aspects)



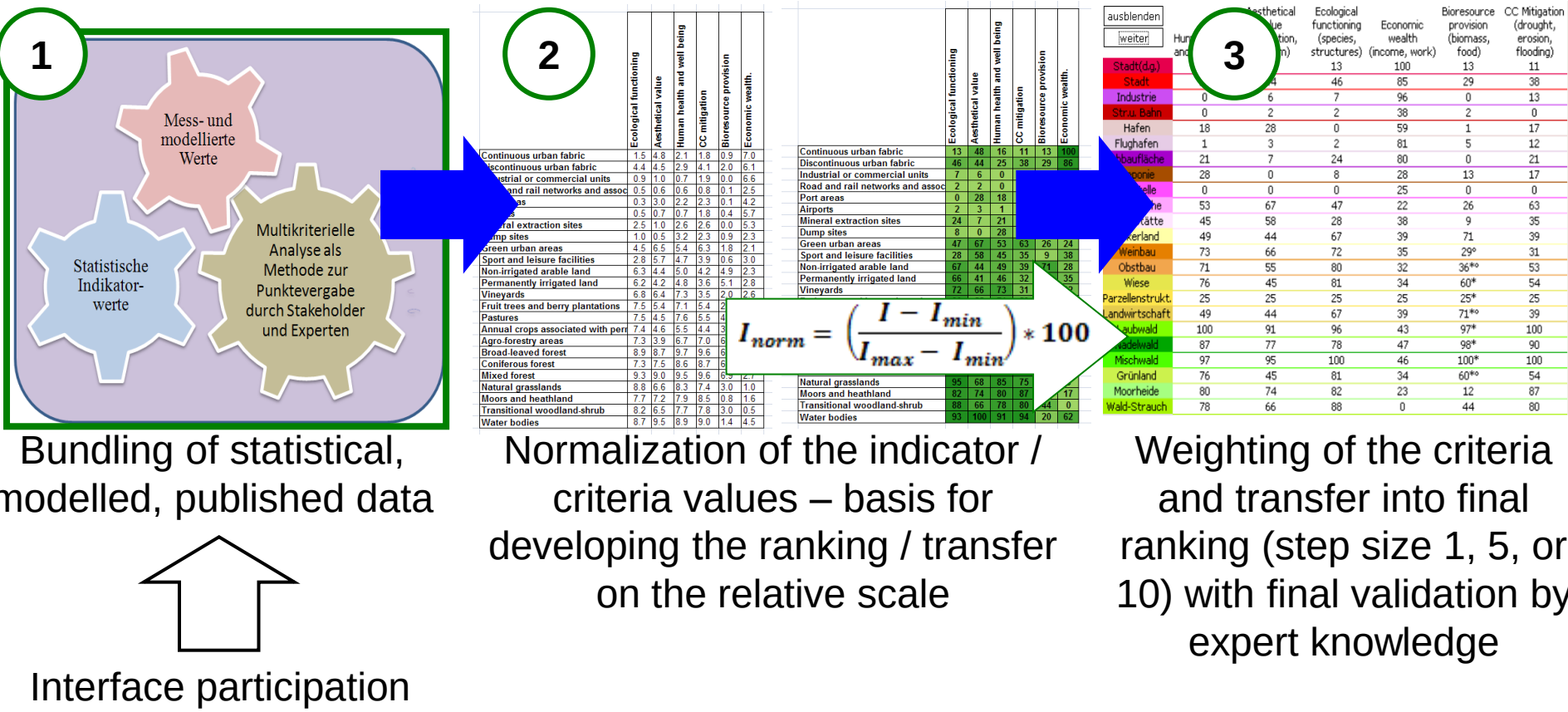
Example GISCAM



Example GISCAM



Example GISCAM



1



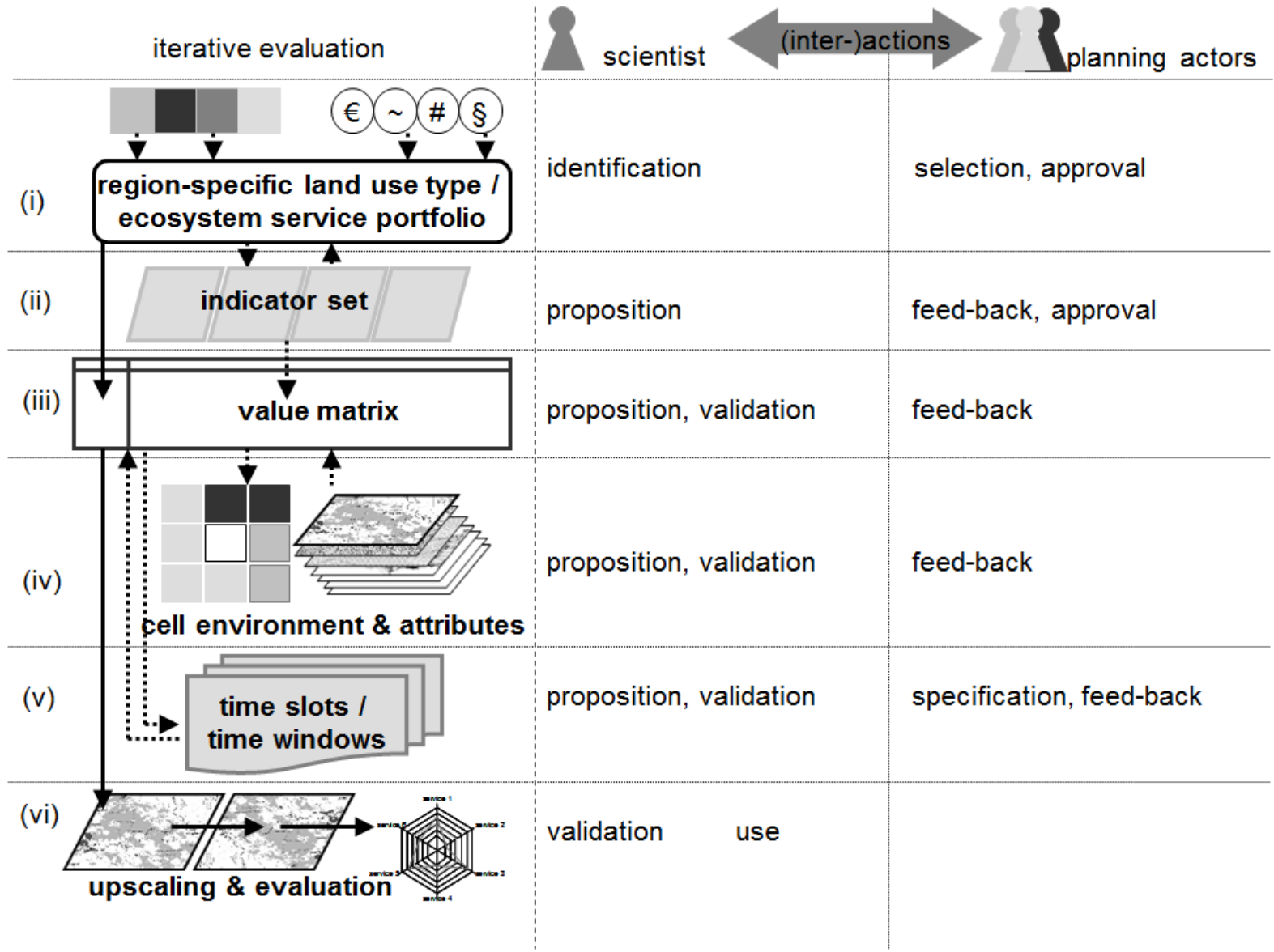
3

Weighting of the criteria
and transfer into final
ranking (step size 1, 5, or
10) with final validation by
expert knowledge

Weighting of the criteria
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Koschke et al. 2011; Fürst et al., 2012; in press

Example GISCAM



Fürst et al., 2012

1

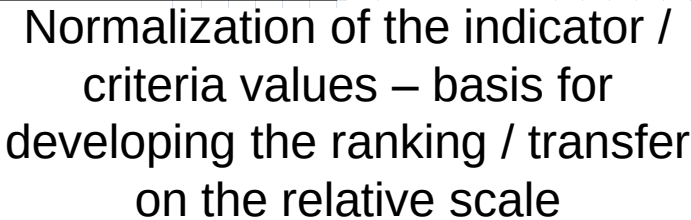
Mess- und modellierte Werte

Statistische Indikatorwerte

Multikriterielle Analyse als Methode zur Punktevergabe durch Stakeholder und Experten

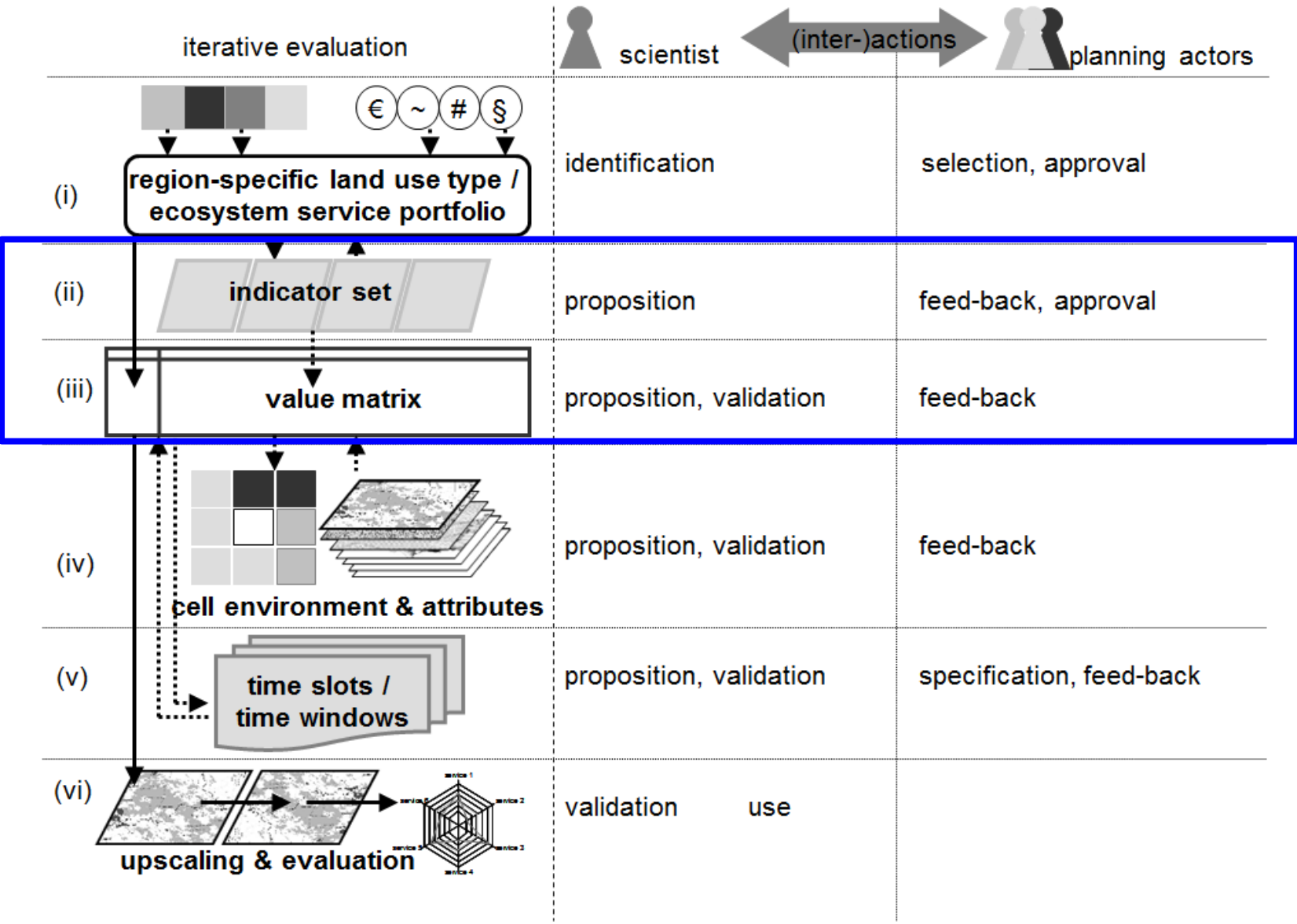
Bundling of statistical, modelled, published data

Interface participation



Weighting of the criteria
and transfer into final
ranking (step size 1, 5, or
10) with final validation by
expert knowledge

Example GISCAM



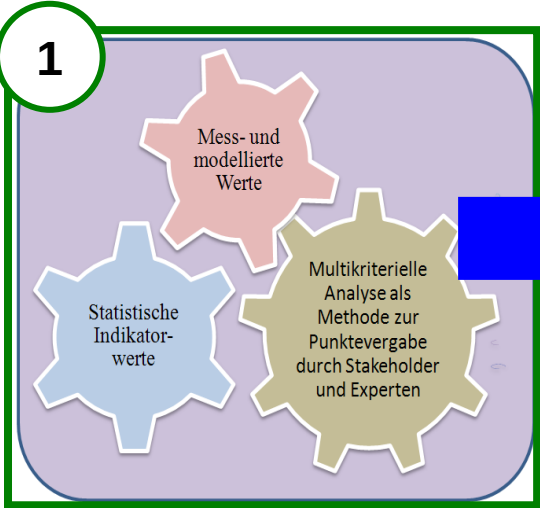
Fürst et al., 2012

Example GISCAM

Koschke et al. (2010), Burkhard et al. (2009), Costanza (1997), Daily (1997), de Groot et al. (2010), MEA (2005), Pérez-Soba et al. (2009)

Ecosystem services	Description	Criteria	Indicators
<i>Climate change mitigation</i>	Contribution of the land-use type to the reduction / mitigation of Climate Change driven risks such as water erosion, drought and flooding	• Water balance regulation • Contribution to local climate regulation • Contribution to global climate regulation • Soil erosion protection	• Water retention capacity [$\text{m}^3 * \text{ha}^{-1}$] Run-off coefficient [$\Psi$], soil sealing [%] • Albedo [%] • C-Sequestration: Storage of C in soil and biomass [kg C ha^{-1}] • C-factor (USLE)
<i>Ecological integrity</i>	Contribution of the land-use type to the ecological functioning	• Biological diversity • Functioning of matter and water cycles • Capacity for biological regulation	• Composition of flora and fauna communities in relation to the potential natural communities • N- and P export with seepage water [$\text{kg N/P} * \text{ha}^{-1}$] • Ground water recharge [$\text{m}^3 * \text{ha}^{-1}$], evapotranspiration • Number of / number of habitats for pest control species
<i>Bio-resource provision</i>	Contribution of the land-use type to the production of bio-resources (biomass and food)	• Production of plant biomass • Production of bio-resources from livestock	• Food and fodder from plants [$\text{t} * \text{ha}^{-1} * \text{a}^{-1}$] • Food from livestock [$\text{t} * \text{ha}^{-1} * \text{a}^{-1}$] • Biomass for industrial use / processing [$\text{t} * \text{ha}^{-1} * \text{a}^{-1}$] • Biomass for energy production [$\text{t} * \text{ha}^{-1} * \text{a}^{-1}$]
<i>Human health and well-being</i>	Contribution of the land-use type to the provision of essential resources (water, fresh air)	• Regulation of air quality • Regulation of water quality	• Cool air production [$\text{m}^3 * \text{ha}^{-1} * \text{h}^{-1}$] • Leaf area index (LAI => combing out of dust emissions) • N-export with seepage water [$\text{kg N ha}^{-1} * \text{a}^{-1}$]
<i>Aesthetical value</i>	Contribution of the land-use type to the attractiveness of the landscape	• Natural-aesthetical value • Recreation potential	• Number of visitors • Expert opinion / regional preferences
<i>Regional economy</i>	Contribution of the land-use to private and public income	• Return from land-based production • Contribution to private income and economic wealth • Contribution to regional tax revenue • Contribution to job provision	• Return from selling products from primary production [$\text{€} * \text{ha}^{-1} * \text{a}^{-1}$] or [$\text{€} * \text{t}^{-1} * \text{ha}^{-1} * \text{a}^{-1}$] • Average per capita income [$\text{€} * \text{a}^{-1}$] • Average tax revenue per capita [$\text{€} * \text{a}^{-1}$] • Number of inhabitants per hectare • Average tax revenue from industry / commerce [$\text{€} * \text{a}^{-1}$]

Example GISCAM



Bundling of statistical, modelled, published data

Interface participation

2

	Ecological functioning	Aesthetical value	Human health and well being	CC mitigation	Bioresource provision	Economic wealth
Continuous urban fabric	1.5	4.8	2.1	1.8	0.9	7.0
Discontinuous urban fabric	4.4	4.5	2.9	4.1	2.0	6.1
Industrial or commercial units	0.9	1.0	0.7	1.9	0.0	6.6
Road and rail networks and associated	0.5	0.6	0.6	0.8	0.1	2.5
Ports	0.3	3.0	2.2	2.3	0.1	4.2
Port areas	0.5	0.7	0.7	1.8	0.4	5.7
Mineral extraction sites	2.5	1.0	2.6	2.6	0.0	5.3
Dump sites	1.0	0.5	3.2	2.3	0.9	2.3
Green urban areas	4.5	6.5	5.4	6.3	1.8	2.1
Sport and leisure facilities	2.8	5.7	4.7	3.9	0.6	3.0
Non-irrigated arable land	6.3	4.4	5.0	4.2	4.9	2.3
Permanently irrigated land	6.2	4.2	4.8	3.6	5.1	2.8
Vineyards	6.8	6.4	7.3	3.5	2.0	2.6
Fruit trees and berry plantations	7.5	5.4	7.1	5.4	2.0	2.6
Pastures	7.5	4.5	7.6	5.5	4.4	3.0
Annual crops associated with perennials	7.4	4.6	5.5	4.4	3.0	3.0
Agro-forestry areas	7.3	3.9	6.7	7.0	6.6	3.0
Broad-leaved forest	8.9	8.7	9.7	9.6	8.9	3.0
Coniferous forest	7.3	7.5	8.6	8.7	8.9	3.0
Mixed forest	9.3	9.0	9.5	9.6	8.9	3.0
Natural grasslands	8.8	6.6	8.3	7.4	3.0	1.0
Moors and heathland	7.7	7.2	7.9	8.5	0.8	1.6
Transitional woodland-shrub	8.2	6.5	7.7	7.8	3.0	0.5
Water bodies	8.7	9.5	8.9	9.0	1.4	4.5

Normalization of the indicator / criteria values – basis for developing the ranking / transfer on the relative scale

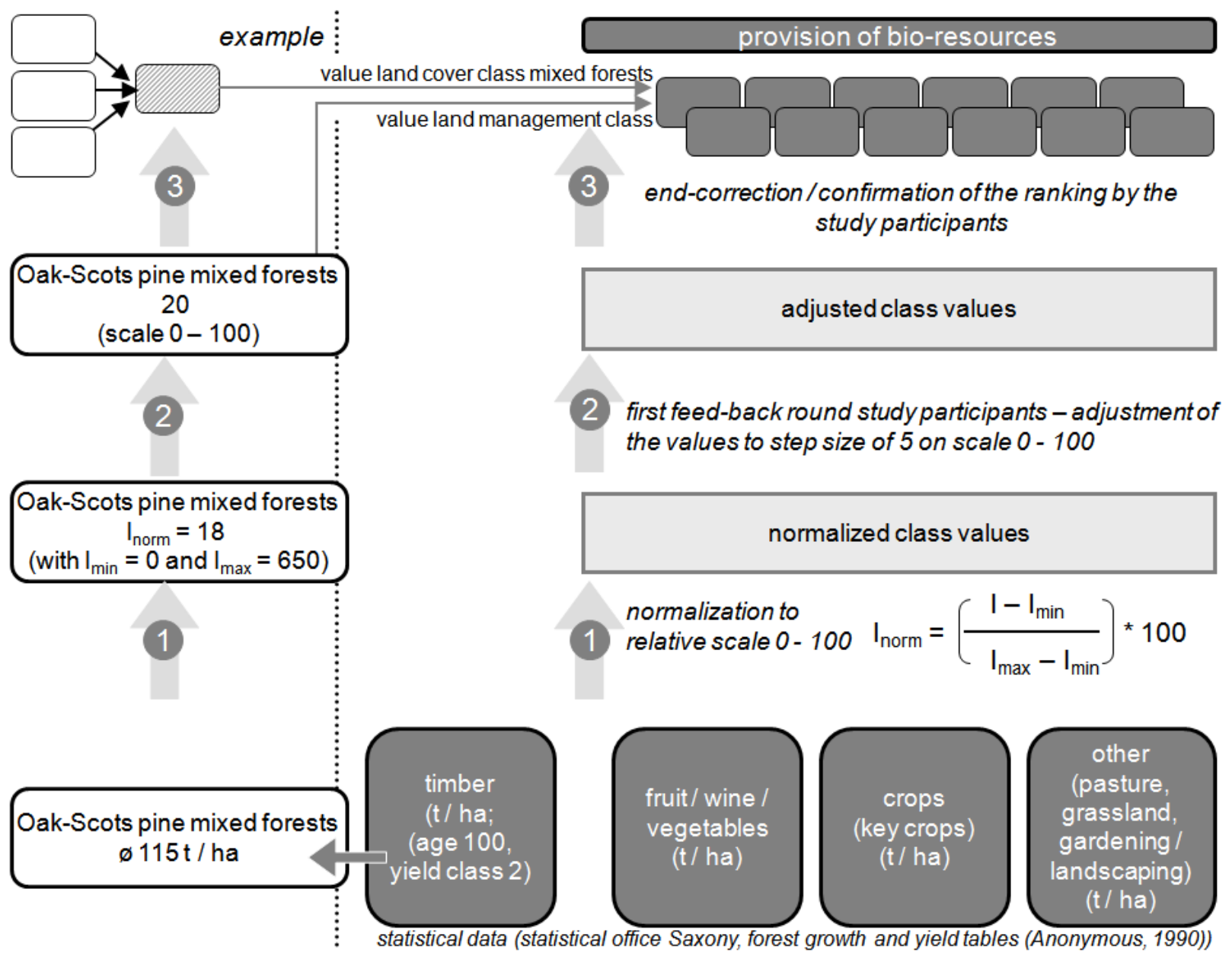
$$I_{norm} = \left(\frac{I - I_{min}}{I_{max} - I_{min}} \right) * 100$$

3

	Aesthetical value (species, structures)	Ecological functioning (income, work)	Bioresource provision (biomass, food)	CC Mitigation (drought, erosion, flooding)
Stadt(dg.)	13	100	13	11
Stadt	46	85	29	38
Industrie	6	7	96	0
Stru. Bahn	2	38	2	0
Hafen	28	59	1	17
Flughafen	3	81	5	12
Abbaufläche	7	80	0	21
Waldfläche	0	8	28	13
Waldfläche	0	0	25	0
Waldfläche	53	67	22	63
Waldfläche	45	58	38	9
Waldfläche	49	67	39	39
Weinbau	73	66	35	29*
Obstbau	71	55	32	36**
Wiese	76	45	81	34
Parzellenstrukt.	25	25	25	25*
Landwirtschaft	49	44	67	39
Laubwald	100	91	96	43
Nadelwald	87	77	78	47
Mischwald	97	95	100	46
Grünland	76	45	81	34
Moorheide	80	74	82	23
Wald-Strauch	78	66	88	0

Weighting of the criteria and transfer into final ranking (step size 1, 5, or 10) with final validation by expert knowledge

Example GISCAM



statistical data (statistical office Saxony, forest growth and yield tables (Anonymous, 1990))

Example GISCAM

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	10	20	0	-	-	3	0	71
Discontinuous urban fabric	0	0	1	6	0	17	66	50	-	-	18	0	36
Industrial or commercial units, ports	0	0	0	6	0	3	20	25	-	-	26	0	100
Road and rail, construction sites	0	0	0	25	0	3	20	6	-	-	27	0	0
Mineral extraction sites	0	0	0	6	0	5	20	69	-	-	27	0	43
Dump sites	0	0	0	6	0	0	20	69	-	-	33	0	71
Urban green, sport/leisure facilities	0	0	3	81	25	40	66	69	-	-	26	0	0
Non-irrigated arable land	56	0	1	81	6	21	0	81	-	-	3	100	57
Fruit trees and berry plantations	100	0	29	56	50	50	60	88	-	-	35	100	21
Pastures	36	0	3	81	36	81	70	88	-	-	4	40	7
Complex cultivation patterns	28	0	11	100	14	38	35	88	-	-	9	32	2
Land princip. occ. by agriculture	28	0	5	100	14	21	50	88	-	-	8	32	40
Broad-leaved forest	0	78	100	56	100	90	71	100	-	-	77	11	26
Coniferous forest	0	100	82	56	100	80	49	100	-	-	23	10	64
Mixed forest	0	89	88	56	100	100	60	100	-	-	100	11	34
Natural grasslands	12	0	3	81	22	92	100	88	-	-	14	11	0
Moors, heathland, inland marshes	0	0	3	56	23	46	100	100	-	-	14	0	0
Transitional woodland-shrub	0	0	16	56	50	100	100	100	-	-	14	0	0
Water courses, water bodies	0	0	0	100	0	0	39	100	-	-	0	0	2

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	0	0	0	0	25	10	0	90
Discontinuous urban fabric	10	10	10	10	0	10	5	15	5	35	25	5	80
Industrial or commercial units, ports	0	0	0	0	0	0	0	0	0	0	5	0	100
Road and rail, construction sites	0	0	0	0	0	0	0	0	0	0	5	0	55
Mineral extraction sites	0	0	0	0	0	5	0	0	0	0	10	45	50
Dump sites	0	0	0	0	0	0	0	10	0	0	5	0	20
Urban green, sport/leisure facilities	5	15	45	50	20	30	30	35	50	50	35	10	15
Non-irrigated arable land	100	25	35	40	40	35	20	30	25	25	30	100	50
Fruit trees and berry plantations	100	20	50	60	45	50	50	60	55	55	50	90	45
Pastures	60	10	50	55	45	60	50	60	60	65	60	60	30
Complex cultivation patterns	70	25	60	60	45	55	50	60	70	85	70	70	40
Land princip. occ. by agriculture	60	10	50	60	50	55	50	65	70	65	60	60	30
Broad-leaved forest	10	90	90	95	95	100	100	100	90	90	85	65	35
Coniferous forest	10	100	100	90	95	100	90	100	80	75	70	75	35
Mixed forest	10	100	100	95	95	100	100	100	95	95	95	70	35
Natural grasslands	15	0	50	60	65	80	80	90	80	85	90	20	10
Moors, heathland, inland marshes	5	15	50	60	70	90	85	90	90	90	95	0	10
Transitional woodland-shrub	10	30	70	65	70	75	80	95	90	90	90	25	10
Water courses, water bodies	30	0	20	65	20	70	45	0	90	90	45	35	30

Koschke et al., 2012; 2013

Example GISCAM

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	10	20	0	-	-	3	0	71
Discontinuous urban fabric	0	0	1	6	0	17	66	50	-	-	18	0	36
Industrial or commercial units, ports	0	0	0	6	0	3	20	25	-	-	26	0	100
Road and rail, construction sites	0	0	0	25	0	3	20	6	-	-	27	0	0
Mineral extraction sites	0	0	0	6	0	5	20	69	-	-	27	0	43
Dump sites	0	0	0	6	0	0	20	69	-	-	33	0	71
Urban green, sport/leisure facilities	0	0	3	81	25	40	66	69	-	-	26	0	0
Non-irrigated arable land	56	0	1	81	6	21	0	81	-	-	3	100	57
Fruit trees and berry plantations	100	0	29	56	50	50	60	88	-	-	35	100	21
Pastures	36	0	3	81	36	81	70	88	-	-	4	40	7
Complex cultivation patterns	28	0	11	100	14	38	35	88	-	-	9	32	2
Land princip. occ. by agriculture	28	0	5	100	14	21	50	88	-	-	8	32	40
Broad-leaved forest	0	78	100	56	100	90	71	100	-	-	77	11	26
Coniferous forest	0	100	82	56	100	80	49	100	-	-	23	10	64
Mixed forest	0	89	88	56	100	100	60	100	-	-	100	11	34
Natural grasslands	12	0	3	81	22	92	100	88	-	-	14	11	0
Moors, heathland, inland marshes	0	0	3	56	23	46	100	100	-	-	14	0	0
Transitional woodland-shrub	0	0	16	56	50	100	100	100	-	-	14	0	0
Water courses, water bodies	0	0	0	100	0	0	39	100	-	-	0	0	2

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	0	0	0	0	25	10	0	90
Discontinuous urban fabric	10	10	10	10	0	10	5	15	5	35	25	5	80
Industrial or commercial units, ports	0	0	0	0	0	0	0	0	0	0	5	0	100
Road and rail, construction sites	0	0	0	0	0	0	0	0	0	0	5	0	55
Mineral extraction sites	0	0	0	0	0	5	0	0	0	0	10	45	50
Dump sites	0	0	0	0	0	0	0	10	0	0	5	0	20
Urban green, sport/leisure facilities	5	15	45	50	20	30	30	35	50	50	35	10	15
Non-irrigated arable land	100	25	35	40	40	35	20	30	25	25	30	100	50
Fruit trees and berry plantations	100	20	50	60	45	50	50	60	55	55	50	90	45
Pastures	60	10	50	55	45	60	50	60	60	65	60	60	30
Complex cultivation patterns	70	25	60	60	45	55	50	60	70	85	70	70	40
Land princip. occ. by agriculture	60	10	50	60	50	55	50	65	70	65	60	60	30
Broad-leaved forest	10	90	90	95	95	100	100	100	90	90	85	65	35
Coniferous forest	10	100	100	90	95	100	90	100	80	75	70	75	35
Mixed forest	10	100	100	95	95	100	100	100	95	95	95	70	35
Natural grasslands	15	0	50	60	65	80	80	90	80	85	90	20	10
Moors, heathland, inland marshes	5	15	50	60	70	90	85	90	90	90	95	0	10
Transitional woodland-shrub	10	30	70	65	70	75	80	95	90	90	90	25	10
Water courses, water bodies	30	0	20	65	20	70	45	0	90	90	45	35	30

Koschke et al., 2012; 2013

Example GISCAM

■ How to fill knowledge gaps?

Benefit transfer

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	10	20	0	-	-	3	0	71
Discontinuous urban fabric	0	0	1	6	0	17	66	50	-	-	18	0	36
Industrial or commercial units, ports	0	0	0	6	0	3	20	25	-	-	26	0	100
Road and rail, construction sites	0	0	0	25	0	3	20	6	-	-	27	0	0
Mineral extraction sites	0	0	0	6	0	5	20	69	-	-	27	0	43
Dump sites	0	0	0	6	0	0	20	69	-	-	33	0	71
Urban green, sport/leisure facilities	0	0	3	81	25	40	66	69	-	-	26	0	0
Non-irrigated arable land	56	0	1	81	6	21	0	81	-	-	3	100	57
Fruit trees and berry plantations	100	0	29	56	50	50	60	88	-	-	35	100	21
Pastures	36	0	3	81	36	81	70	88	-	-	4	40	7
Complex cultivation patterns	28	0	11	100	14	38	35	88	-	-	9	32	2
Land princip. occ. by agriculture	28	0	5	100	14	21	50	88	-	-	8	52	40
Broad-leaved forest	0	78	100	56	100	90	71	100	-	-	77	11	26
Coniferous forest	0	100	82	56	100	80	49	100	-	-	23	10	64
Mixed forest	0	89	88	56	100	100	60	100	-	-	100	11	34
Natural grasslands	12	0	3	81	22	92	100	88	-	-	14	11	0
Moors, heathland, inland marshes	0	0	3	56	23	46	100	100	-	-	14	0	0
Transitional woodland-shrub	0	0	16	56	50	100	100	100	-	-	14	0	0
Water courses, water bodies	0	0	0	100	0	0	39	100	-	-	0	0	2

Expert-based assessment

	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	0	0	0	0	25	10	0	90
Discontinuous urban fabric	10	10	10	10	0	10	5	15	5	35	25	5	80
Industrial or commercial units, ports	0	0	0	0	0	0	0	0	0	0	5	0	100
Road and rail, construction sites	0	0	0	0	0	0	0	0	0	0	5	0	55
Mineral extraction sites	0	0	0	0	0	5	0	0	0	0	10	45	50
Dump sites	0	0	0	0	0	0	0	10	0	0	5	0	20
Urban green, sport/leisure facilities	5	15	45	50	20	30	30	35	50	50	35	10	15
Non-irrigated arable land	100	25	35	40	40	35	20	30	25	25	30	100	50
Fruit trees and berry plantations	100	20	50	60	45	50	50	60	55	55	50	90	45
Pastures	60	10	50	55	45	60	50	60	60	65	60	60	30
Complex cultivation patterns	70	25	60	60	45	55	50	60	70	85	70	70	40
Land princip. occ. by agriculture	60	10	50	60	50	55	50	65	70	65	60	60	30
Broad-leaved forest	10	90	90	95	95	100	100	100	90	90	85	65	35
Coniferous forest	10	100	100	90	95	100	90	100	80	75	70	75	35
Mixed forest	10	100	100	95	95	100	100	100	95	95	95	70	35
Natural grasslands	15	0	50	60	65	80	80	90	80	85	90	20	10
Moors, heathland, inland marshes	5	15	50	60	70	90	85	90	90	90	95	0	10
Transitional woodland-shrub	10	30	70	65	70	75	80	95	90	90	90	25	10
Water courses, water bodies	30	0	20	65	20	70	45	0	90	90	45	35	30

Example GISCAM

■ How to fill knowledge gaps?

Benefit transfer

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	10	20	0	-	-	3	0	71
Discontinuous urban fabric	0	0	1	6	0	17	66	50	-	-	18	0	36
Industrial or commercial units, ports	0	0	0	6	0	3	20	25	-	-	26	0	100
Road and rail, construction sites													
Mineral extraction sites													
Dump sites													
Urban green, sport/leisure facilities													
Non-irrigated arable land													
Fruit trees and berry plantations													
Pastures													
Complex cultivation patterns													
Land princip. occ. by agriculture													
Broad-leaved forest	0	78			100	90	71	100	-	-	77	11	26
Coniferous forest	0		82	56	100	80	49	100	-	-	23	10	64
Mixed forest	0	89	88	56	100	100	60	100	-	-	100	11	34
Natural grasslands	12	0	3	81	22	92	100	88	-	-	14	11	0
Moors, heathland, inland marshes	0	0	3	56	23	46	100	100	-	-	14	0	0
Transitional woodland-shrub	0	0	16	56	50	100	100	100	-	-	14	0	0
Water courses, water bodies	0	0	0	100	0	0	39	100	-	-	0	0	2

Transfer of results from other model regions (literature analysis, look-up tables)

Expert-based assessment

CLC-classes	1 Food and fiber	2 Wood/Timber	3 Regulation of air quality	4 Climate regulation (local)	5 Climate regulation (global)	6 Water (balance) regulation	7 Water purification	8 Soil erosion protection	9 Recreation and ecotourism	10 Aesthetic	11 Biodiversity	12 Returns from land-based pr.	13 Contrib. to reg. tax revenue
Continuous urban fabric	0	0	0	0	0	0	0	0	0	25	10	0	90
Discontinuous urban fabric	10	10	10	10	0	10	5	15	5	35	25	5	80
Industrial or commercial units, ports	0	0	0	0	0	0	0	0	0	0	5	0	100
Road and rail, construction sites	0	0											55
Mineral extraction sites	0	0											50
Dump sites	0	0											20
Urban green, sport/leisure facilities	5	15											15
Non-irrigated arable land	100	25											50
Fruit trees and berry plantations	100	20											45
Pastures	60	10											30
Complex cultivation patterns	70	25											40
Land princip. occ. by agriculture	60	10											30
Broad-leaved forest	10	90	90		100	100	100	90	90	85	65		35
Coniferous forest	10	100	100	95	100	100	90	100	80	75	70	75	35
Mixed forest	10	100	100	95	95	100	100	100	95	95	95	70	35
Natural grasslands	15	0	50	60	65	80	80	90	80	85	90	20	10
Moors, heathland, inland marshes	5	15	50	60	70	90	85	90	90	90	95	0	10
Transitional woodland-shrub	10	30	70	65	70	75	80	95	90	90	90	25	10
Water courses, water bodies	30	0	20	65	20	70	45	0	90	90	45	35	30

Assessment with experts from Regional planning and from different land-use sectors (Delphi design)

Example GISCAMÉ

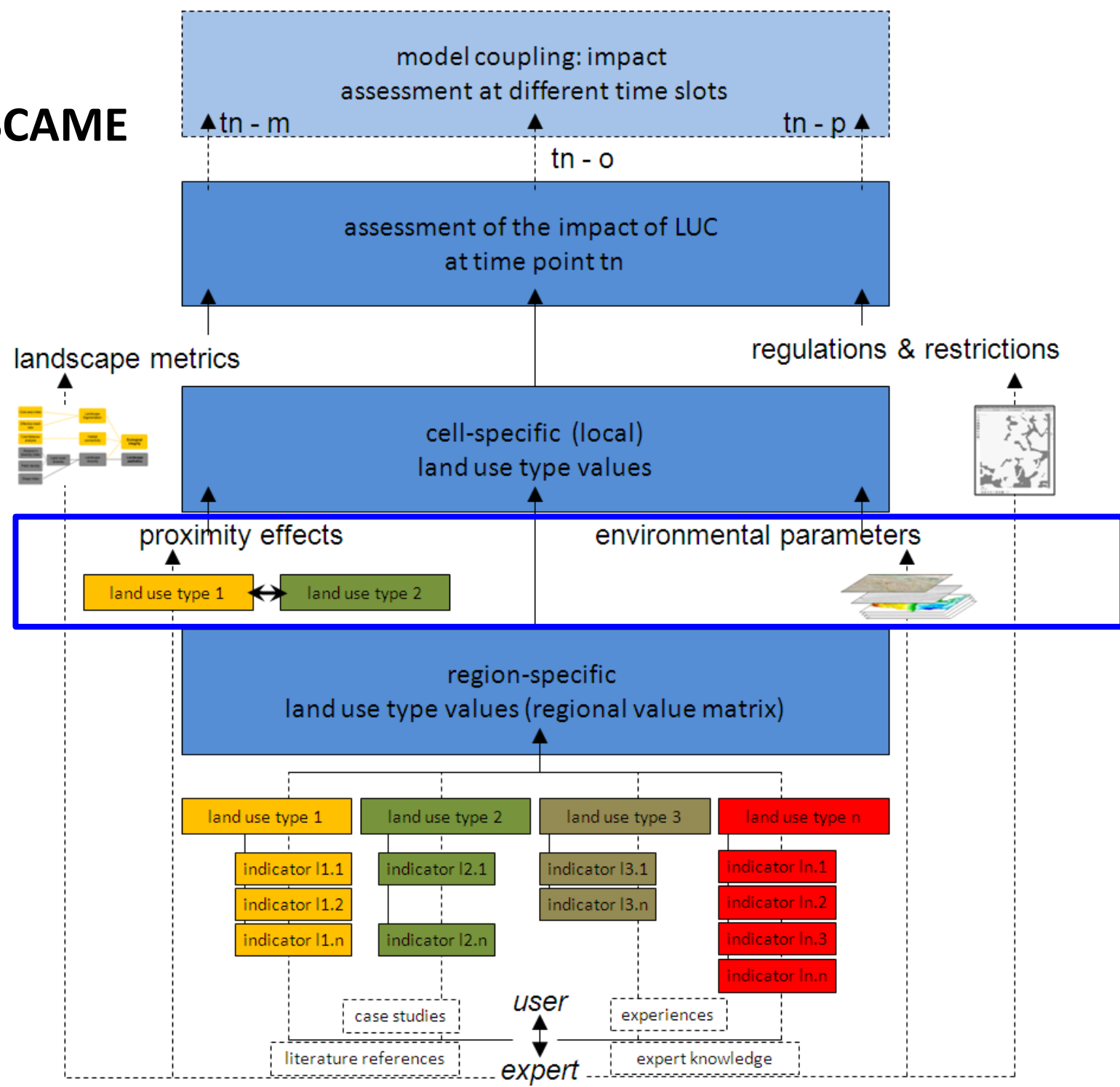
LUT Set: | LUF Set:

Evaluation matrix LUC/LCC

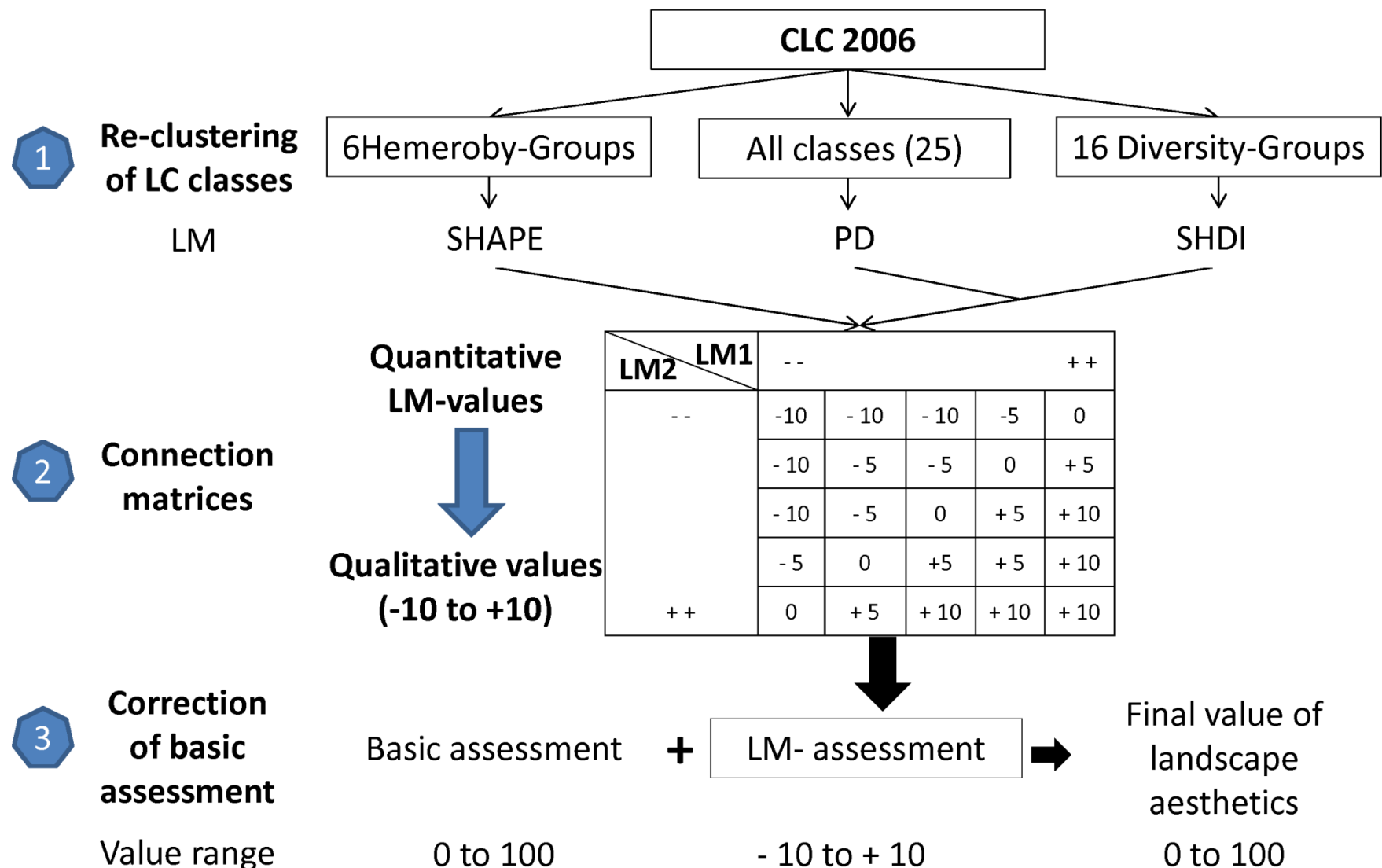
☐ land use type (LUT) ☒ **land use function (LUF)** | time axis: --standard-- | environmental influences: ----- | proximity effect: -----

	save save as save as time axis delete						
parameter function	Provision of food and fiber	Provision of biomass	Soil erosion protection	Drought risk regulation	Ecological integrity	Flood regulation	Returns from land-based p
Very dense urb. fab.	0	0	100	50	0	0	0
Dense urban fabric	0	0	100	63	0	25	0
Loose urban fabric	0	0	100	75	0	50	0
Very loose urb. fab.	0	0	100	88	0	75	0
Big buildings	0	0	100	50	0	0	0
Sealed surfaces	0	0	100	50	0	0	0
Fallow land, ruderal areas	0	0	100	100	65	100	0
Hedges, tree rows	0	11	100	100	85	97	0
Wetlands	0	0	100	99	100	97	0
Viticulture	17	34	67	75	15	63	100
	Provision of food and fiber	Provision of biomass	Soil erosion protection	Drought risk regulation	Ecological integrity	Flood regulation	Returns from land-based production
Orchards	100	34	67	92	15	97	100
Hop	0	0	0	68	15	50	0
Bare rock	0	0	100	75	100	50	0
Excavation material	0	0	23	75	0	50	0
Open-cast mining	0	0	23	75	0	50	0
Sand	0	0	23	75	0	50	0
Bridges	0	0	100	75	0	50	0
Greenhouses	0	0	100	50	0	0	0
Urban open space, leisure faci	0	0	100	100	15	100	0
Grassland (Pastures)	13	26	100	100	15	100	36
	Provision of food and fiber	Provision of biomass	Soil erosion protection	Drought risk regulation	Ecological integrity	Flood regulation	Returns from land-based production
Afforestation, succession area	0	27	100	99	80	97	0
Beech, mix. decid. forest >20%	0	59	100	94	100	97	16
Beech, mix. conif. forest >20%	0	64	100	96	90	97	14
Beech, pure stand	0	63	100	99	100	97	15
Beech	0	63	100	99	90	97	15
Oak, mix. decid. forest >20%	0	59	100	94	100	97	16
Oak, mix. conif. forest >20%	0	58	100	89	90	97	16
Oak, pure stand	0	48	100	84	100	97	17

Example GISCAM



Example GISCAM

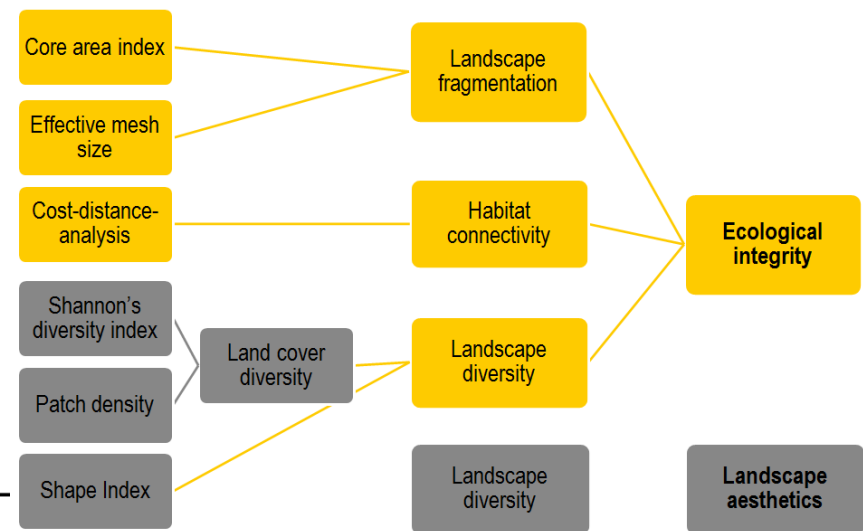


Example GISGAME

Landscape fragmentation		CAI of "natural" Patches (Buffer 100 m) [%]				
		0 - 5	>5 – 10	>10 - 15	>15 - 20	>20
M _{eff} [km²]	0 – 1	-10	-10	-10	-5	0
	>1 – 2,5	-10	-5	-5	0	5
	>2,5 – 5	-10	-5	0	5	10
	>5 – 10	-5	0	5	5	10
	>10	0	5	10	10	10

Hab. connect. (%)	Bewertung
0 - 5	-10
5 - 10	-5
10 - 15	0
15 - 20	5
> 20	10

Landscape diversity		SHAPE ()				
		<0,5	>0,5 – 1	>1 – 10	>10 – 100	>100
SHDI ()	< 0,5	-10	-10	-10	-5	0
	> 0,5 - 1	-10	-5	-5	0	5
	> 1 - 1,25	-10	-5	0	5	10
	> 1,25 - 1,5	-5	0	5	5	10
	> 1,5	0	5	10	10	10

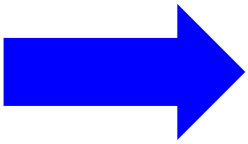


1. pre-calculation with FRAGSTATS (regionally typical value ranges); separation into subranges related to qualitative reduction / increase of the service
2. Integration by „ecological connection matrices“

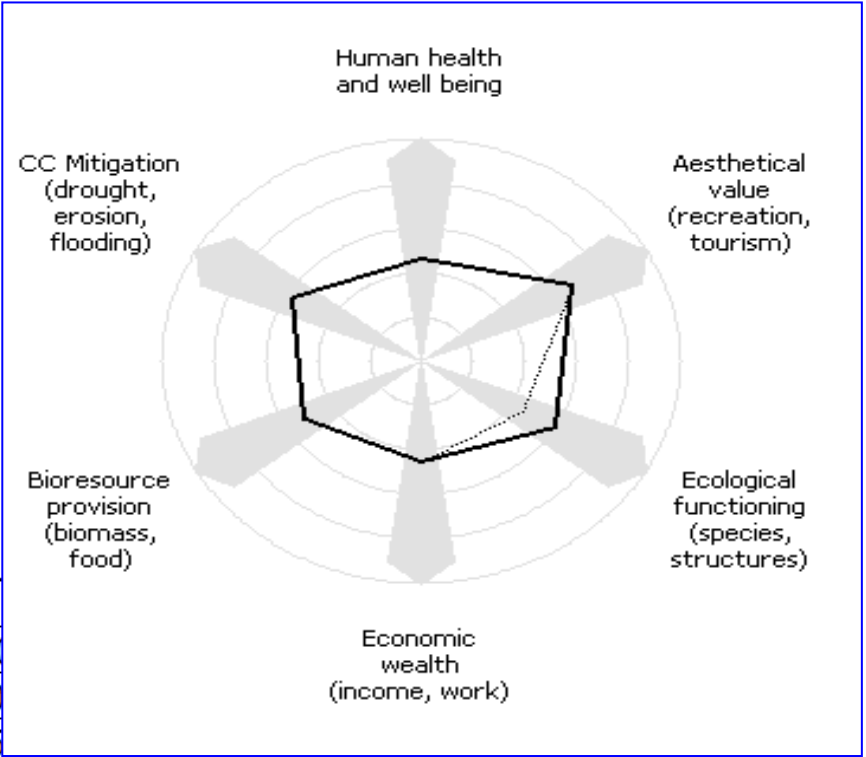
Example GISCAM

Landscape fragmentation		CAI of "natural" Patches (Buffer 100 m) [%]				
		0 - 5	>5 - 10	>10 - 15	>15 - 20	>20
M_{eff} [km ²]	0 - 1	-10	-10	-10	-5	0
	>1 - 2,5	-10	-5	-5	0	5
	>2,5 - 5	-10	-5	0	5	10
	>5 - 10	-5	0	5	5	10
	>10	0	5	10	10	10

Hab. connect. (%)	Bewertung
0 - 5	-10
5 - 10	-5
10 - 15	0
15 - 20	5
> 20	10



Landscape diversity		SHAPE ()				
		<0,5	>0,5 - 1	>1 - 10	>10 - 100	>100
SHDI ()	< 0,5	-10	-10	-10	-5	0
	> 0,5 - 1	-10	-5	-5	0	5
	> 1 - 1,25	-10	-5	0	5	10
	> 1,25 - 1,5	-5	0	5	5	10
	> 1,5	0	5	10	10	10



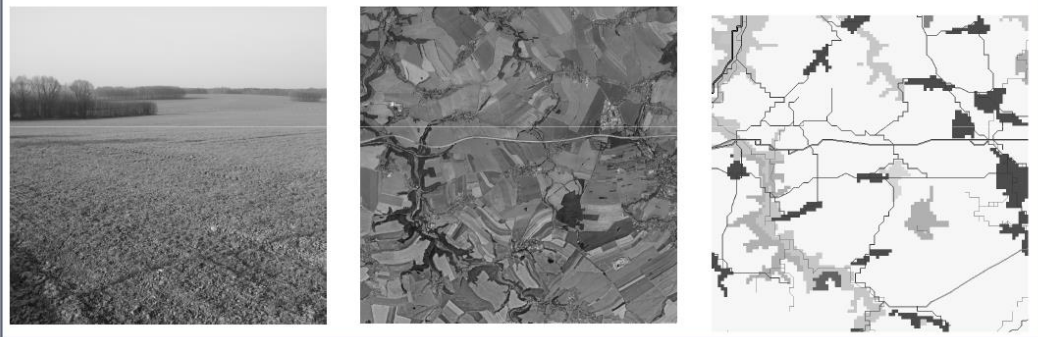
1. pre-calculation with FRAGSTATS (regionally typical value ranges); separation into subranges related to qualitative reduction / increase of the service
3. Qualitative reduction / increase of the service (+ / - 30 value points max.)

Example GISCAME

- Validation / further refining for aesthetics



Survey with 153 stakeholders to compare outcomes based on GISCAME and visual assessment of photos, satellite photos and maps



Example GISCAMÉ

- **Assessment bias** (subjective criteria) became **smaller the more abstract** (photo $\Leftrightarrow$ map) **landscape was presented** ($\Rightarrow$ common understanding of which pattern is „attractive“)
- **Professional background** (laymen – stakeholders – planning experts) had an influence, but not so much criteria such as age or gender.
- Visual assessment and landscape metrics based assessment were correlated (with some interpretation problems)

