# Sustainability indicators for socio-ecological systems

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Paul Cézanne: Montaigne Sainte-Victoire, 1886-1890

# Presentation Structure

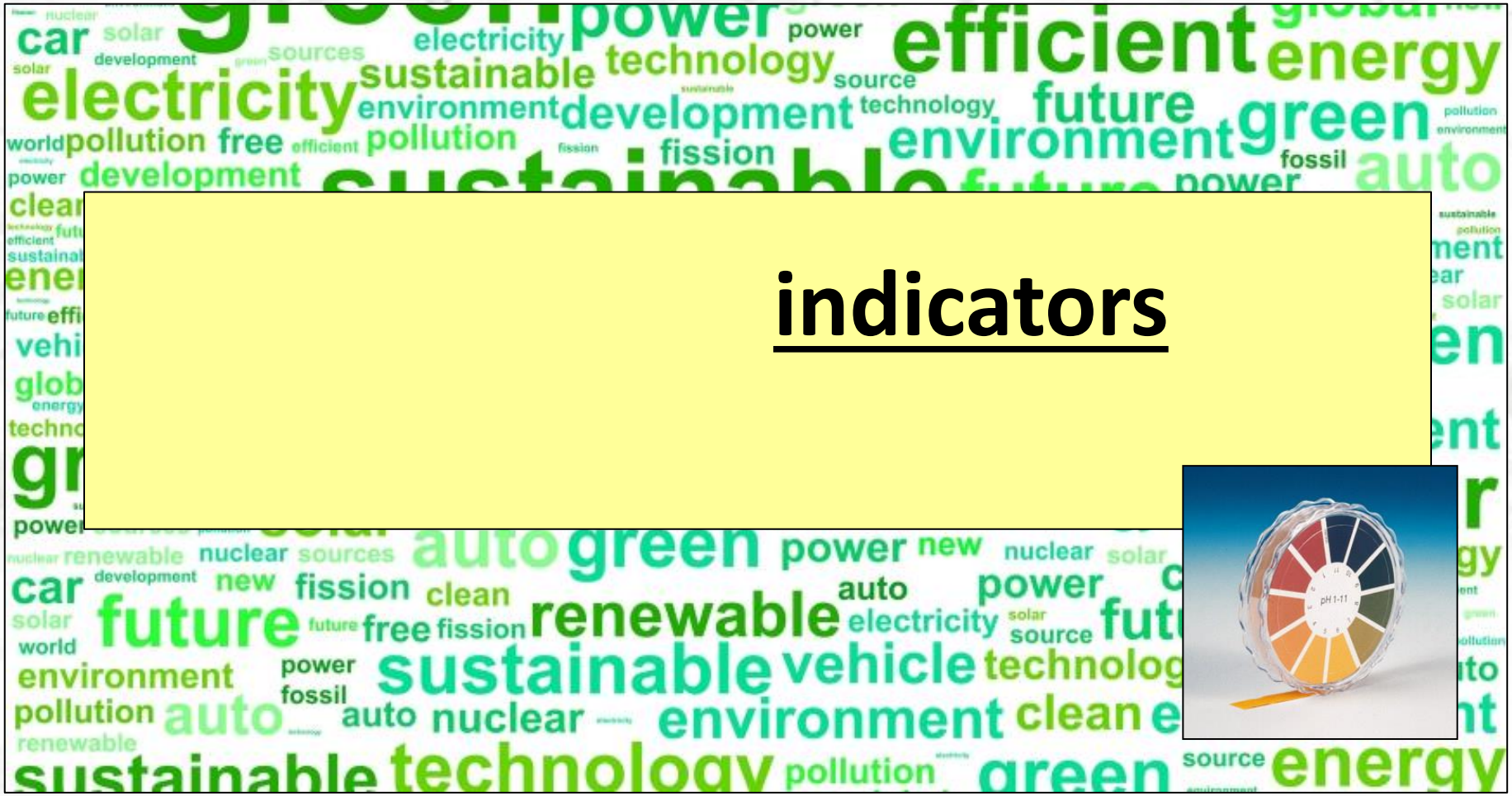
- What are indicators and why do we need them?
- What are socio-ecological systems?
- What is sustainability?
- How to indicate sustainability?
- Which is the role of systems approaches?
- How to apply ecosystem theoretical concepts for sustainability indication?
- How to indicate the contributions of ecosystems for „human“ sustainability?

# Some terminology ahead

# Sustainability indicators for socio-ecological systems

http://www.rand.org/blog/2014/06/5

# Some terminology ahead




**indicators**

http://www.rand.org/blog/2014/06/5

ROAD SUBJECT TO
FLOODING
INDICATORS SHOW DEPTH

m
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2

Crocodile Safety
DANGER
Crocodiles inhabit this area.
Attacks cause injury or death.
- Keep away from the water's edge.
- Do not enter the water.

# What is an indicator?

**A variable which provides aggregated information on a certain phenomenon,**

… which is seleted on the base of a specific ***management purpose***,

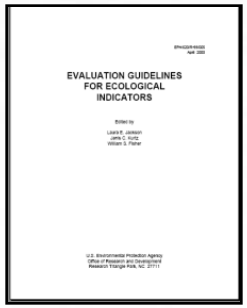
… with an integrating, ***synoptical value*,**

… which shows the **difference between an existing state and an *aspired target* state**,

**A depiction of qualities/quantities/states/interactions which are not directly accessible.**

WIGGERING, H. & F. MÜLLER (eds.) (2003):
Umweltziele und Indikatoren. Springer - Verlag, Berlin, Heidelberg, New York.

http://www.epa.gov/emap/html/pubs/docs/resdocs/ecol_ind.pdf



**Good indicator sets should provide…..**

- a clear representation of the **indicandum by the indicator**
- a clear proof of relevant **cause - effect relations**
- an optimal **sensitivity** of the representation
- information for adequate **spatio-temporal scales**
- a very high **transparency** of the derivation strategy (incl. a documentation of „distance from optimum“)
- a high degree of **validity** and representativeness of the available data sources
- a high degree of **comparability** in and with indicator sets
- an optimal degree of **aggregation** (correct vs. understandable)
- a good fulfilment of **statistical requirements**

**Scientific correctness of indicators – some characteristics**

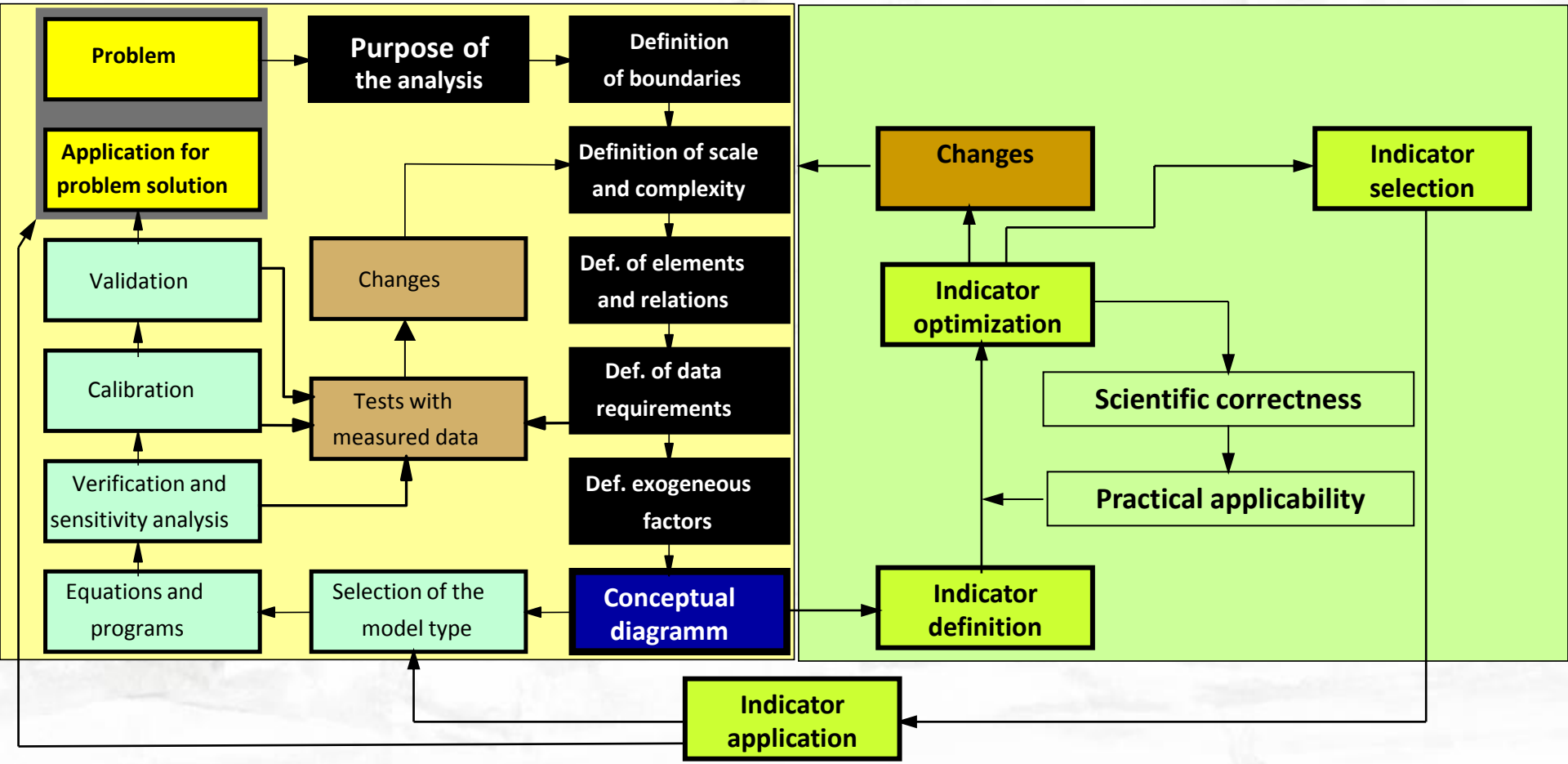
WIGGERING, H. & F. MÜLLER (eds.) (2003):
Umweltziele und Indikatoren. Springer - Verlag, Berlin, Heidelberg, New York.

**Good indicator sets should provide …..**

- information and estimations of the **normative loadings**
- high **political relevance** concerning the decision process
- high **comprehensibility** and public **transparency**
- direct **relations to management** actions
- an orientation towards **environmental targets**
- a high utility for **early warning** purposes
- a satisfying **measurability**
- a high **degree of data availability**
- information on **long – term trends** of development

**Practical applicability of indicators – some characteristics**

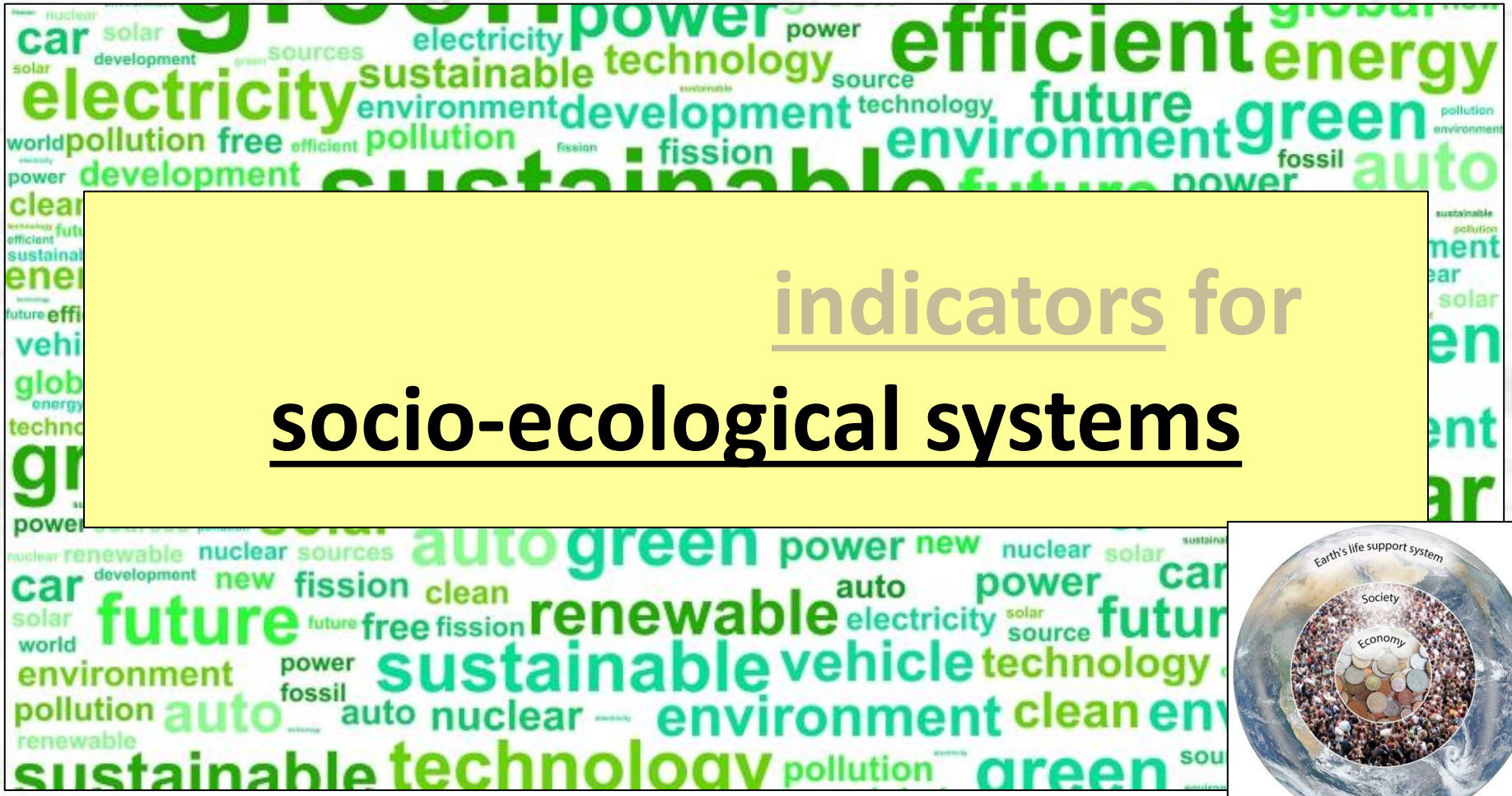
# Basic steps of systems-based indicator derivation




Modelling and scenarios construction

Indicator derivation

# Some terminology ahead




indicators for

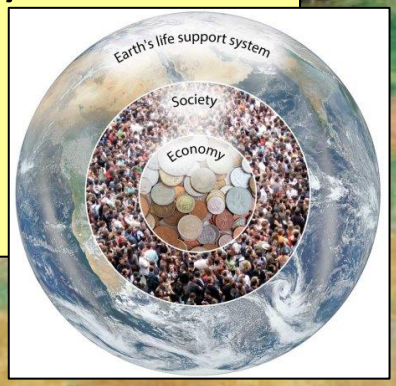
**socio-ecological systems**

http://www.rand.org/blog/2014/06/5

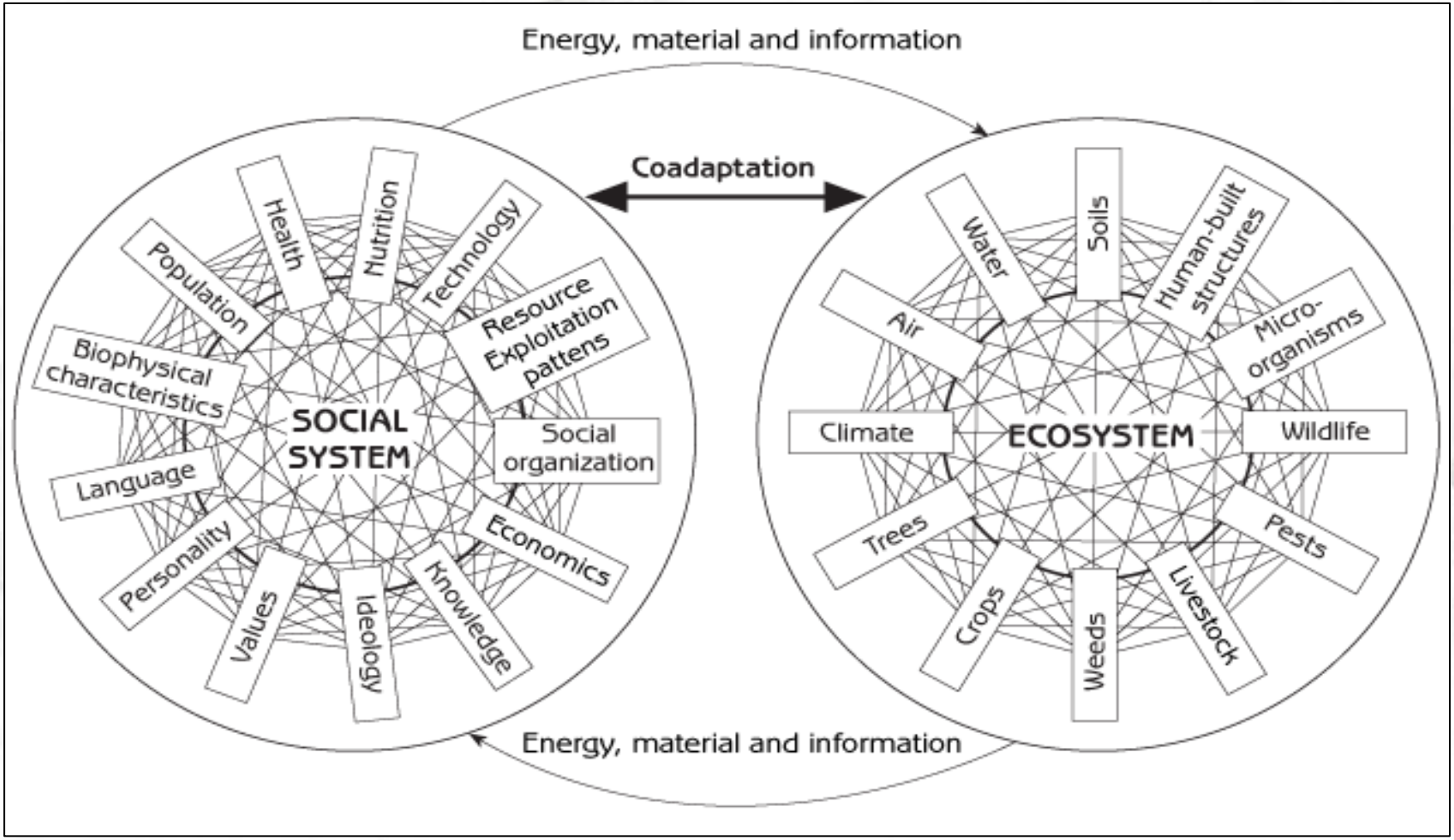
# What are socio-ecological systems?

**The concept of coupled human-environment systems recognizes that the social, economic, and cultural well-being of people depends not only on their relations with other people, but with the physical and biological environment as well.** These relations transcend the environment **as stocks of resources** (e.g., fresh water) to **the capacity of the environment to function as a life support system** (e.g., climate).

*Sustainability Science DGS*



# Elements of socio-ecological systems




Marten, G. (2001): Human Ecology - Basic Concepts for Sustainable Development, Earthscan Publications

# Some terminology ahead

## Sustainability indicators for socio-ecological systems

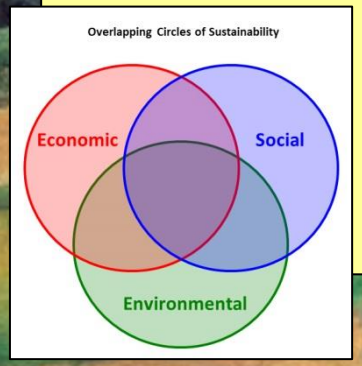
http://www.rand.org/blog/2014/06/5

# What is sustainable development?

… “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

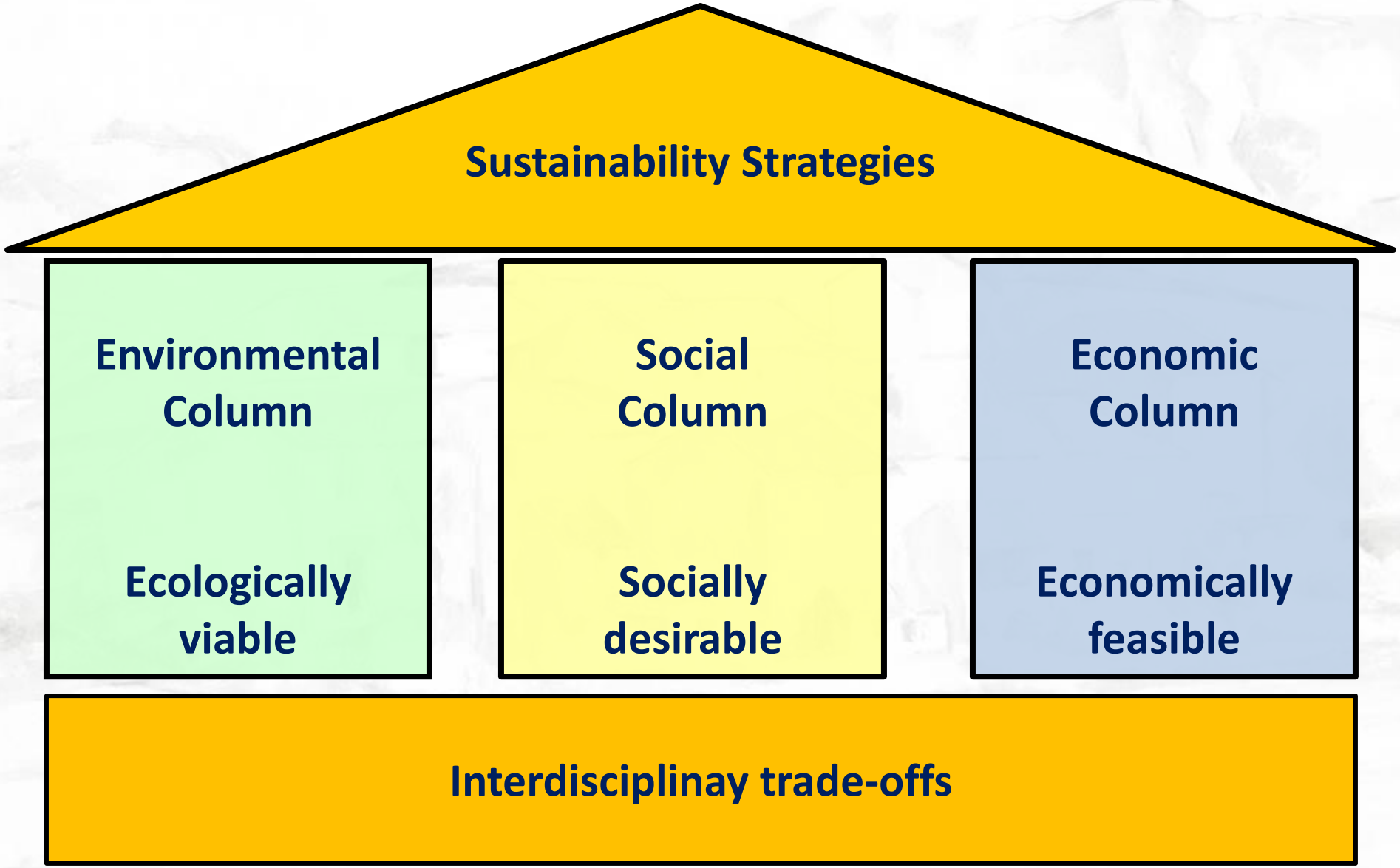
…”acting in a way that is economically profitable, socially acceptable and environmentally compatible.”

*(Agenda 21, Rio Declaration)*

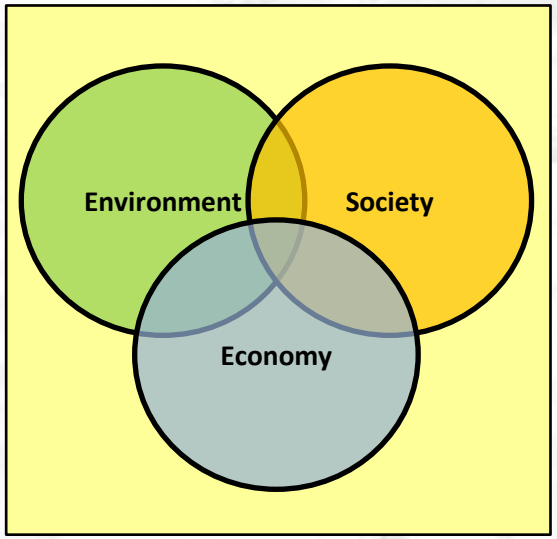



…. a normative concept

…. an anthropocentric concept


Sustainability Strategies
Environmental Column
Ecologically viable
Social Column
Socially desirable
Economic Column
Economically feasible
Interdisciplinay trade-offs

# Nature in culture or culture in nature?



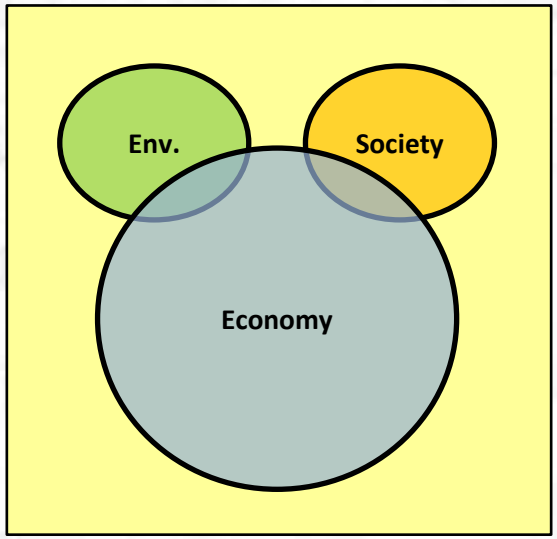

„Venn“

↓

3 equal pillars

↓

„weak“ sustainability



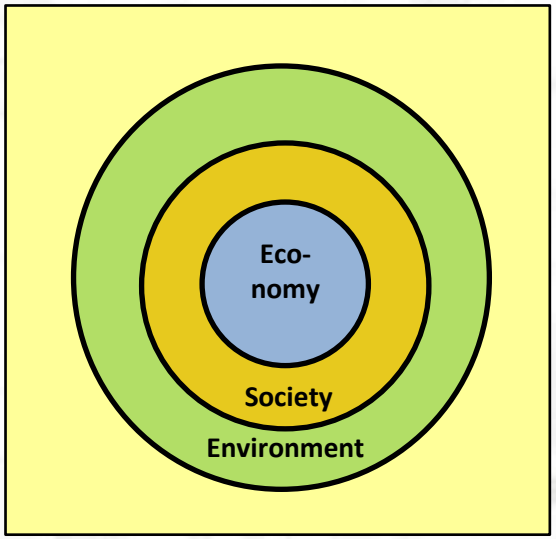

„Mickey Mouse“

↓

Economic dominance

↓

„very weak“ sustainability




„Bull‘s eye“

↓

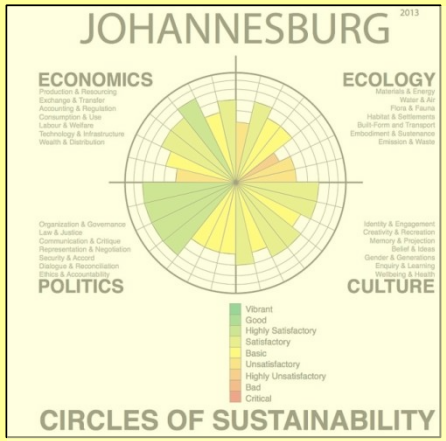
Environmental constraints

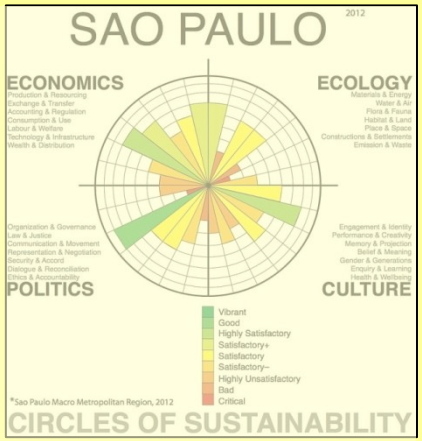
↓

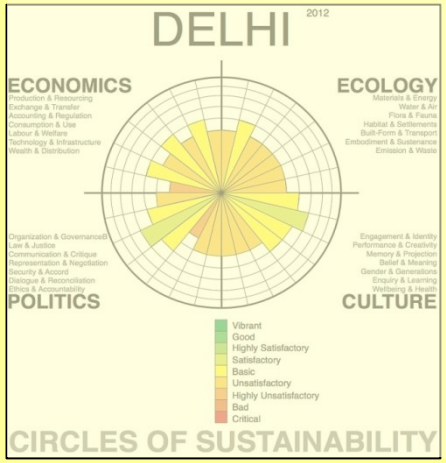
„strong“ sustainability

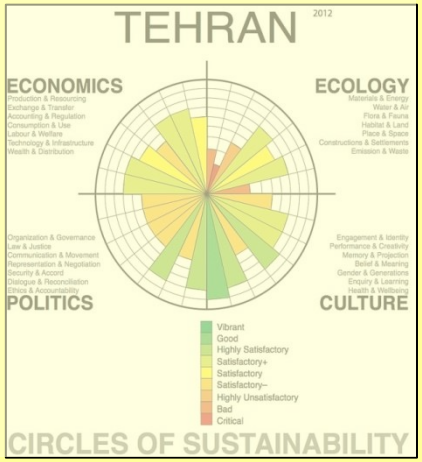
# How to indicate sustainability?

- **Requirements**
- **Reality**
- **Demands**

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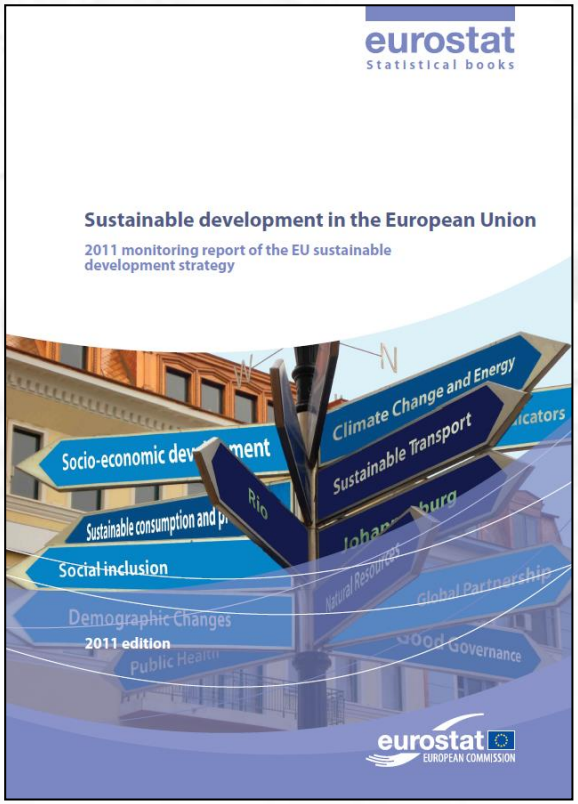
Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Johannesburg_Profile,_Level_2,_2013.jpg#mediaviewer/File:Johannesburg_Profile,_Level_2,_2013.jpg

# The ambitious demands of sustainability

- **long-term strategies** ..... think in generations
- **multi-scale strategies** ..... human vs. ecological time scales
- **interdisciplinary strategies** ..... ecology is only a part
- **functional strategies** …. integrate interrelations
- **fair strategies** …. same significance of columns
- **holistic strategies** ..... structures *and* functions
- **realistic strategies** ..... include uncertainties
- **nature oriented strategies** ..... take nature as a model
- **theory-based strategies** ..... make sure correctness
- **hierarchical strategies** ..... realise constraints and scales
- **goal oriented strategies** ..... joint definition of the targets

# Sustainability indicators in reality

## Environmental issues in EU sustainability indicator set



# Environmental issues in EU sustainability indicator set

## EU Sustainable Development Indicators

**Socio-economic development** — E
- GDP growth rate

**Sustainable Consumption and Production** — E
- Resource productivity

**Social Inclusion** — S
- Risk-of-poverty or exclusion

**Demographic Changes** — S
- Employment of older workers

**Public Health** — S
- Healthy life years and life expectancy

**Climate Change and Energy** — State — P
- Greenhouse gas emissions
- Renewable energy

**Sustainable Transport** — E
- Energy consumption of transport relative to GDP

**Natural Resources** — State — S
- Common bird index
- Fish catches outside safe biological limits

**Global Partnership** — E
- Official development assistance

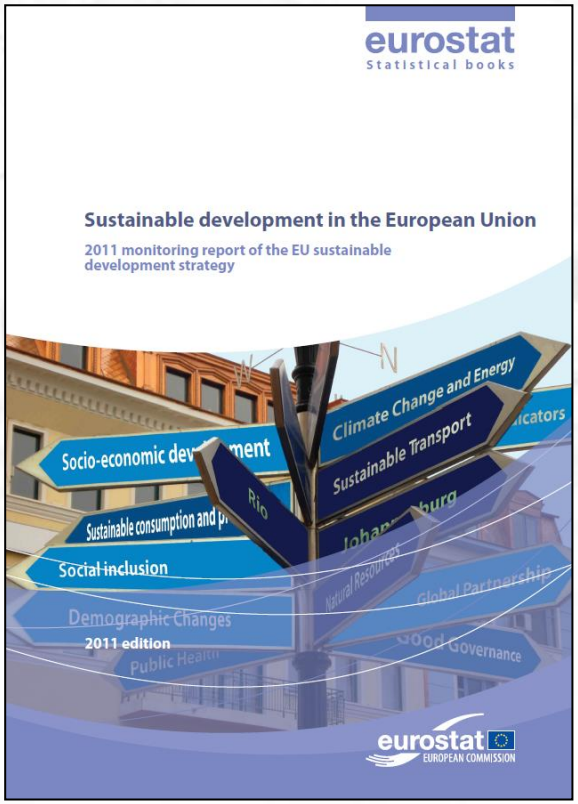
**Good Governance** — S

More than 130 economic, social, environmental, d institutional dicators are used to onitor the EU's progress in sustainable evelopment.

e indicators are grouped into ten themes and are organized in four dicator levels reflecting e objectives and ucture of the EU Sustainable Development Strategy.

- Headline Indicator
- Operational Indicator
- Explanatory Indicator
- Contextual Indicator

eurostat



DESTATIS
wissen. nutzen.

# SUSTAINABLE DEVELOPMENT IN GERMANY

## Indicator Report 2012

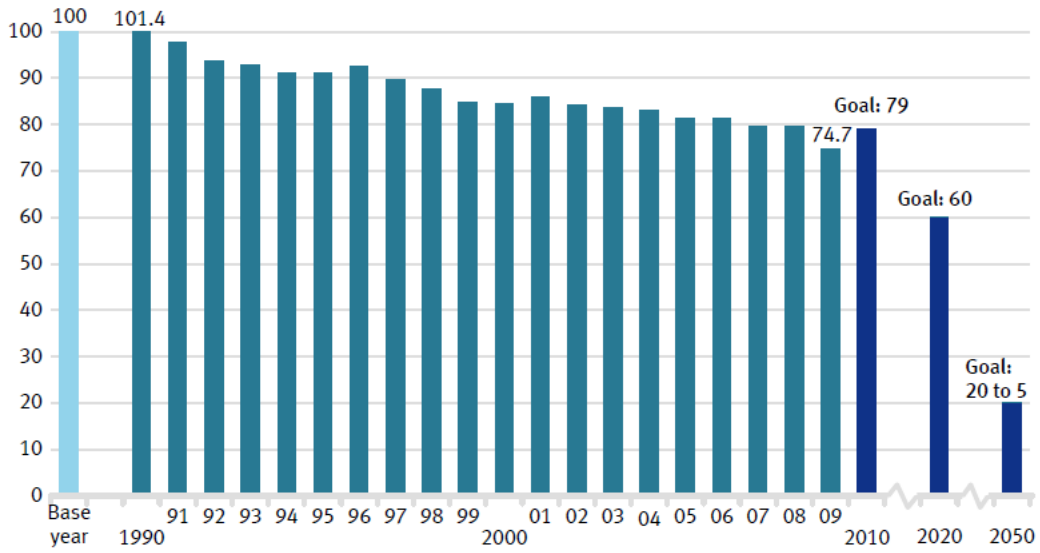
Federal Statistical Office of Germany

Nachhaltigkeits-
strategie
für Deutschland

## Climate protection

*Reducing greenhouse gases*

**Greenhouse gas emissions (six Kyoto gases) in $CO_2$ equivalents**
Base year = 100




Source: Federal Environment Agency

### 2 Greenhouse gas emissions

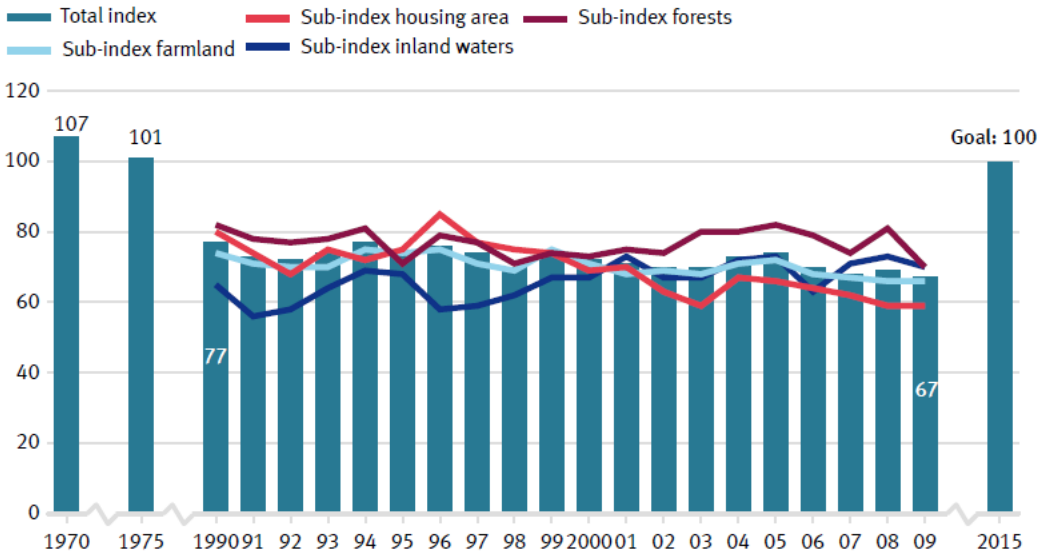
Climate change is an enormous challenge for mankind. Germany has thus committed itself to an average reduction of 21 % in its emissions of the six greenhouse gases and greenhouse gas groups referred to under the Kyoto Protocol between 2008 and 2012 compared with 1990. Beyond this, the Federal Government has set itself the goal of cutting emissions by 40 % from 1990 levels by the year 2020. Looking to the long term, the Federal Government wants to see greenhouse gases slashed by 80 to 95 % compared to 1990 by 2050 as part of the Energy Concept.

According to the Kyoto Protocol, greenhouse gases include the following substances: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide = laughing gas ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$). In terms of quantity, these gases are emitted chiefly during the burning of fossil energy sources, such as coal, oil and natural gas. But they are also produced during other, non-energy related activities, for example in the production of iron and steel, during the application of solvents, in the

## Species diversity

*Conserving species – protecting habitats*

**Species diversity and landscape quality**
Index 2015 = 100




Source: Federal Agency for Nature Conservation, 2011

### 5 Species diversity and landscape quality

Having a wide diversity of animal and plant species is a fundamental prerequisite for a healthy natural environment and an essential basis for our human livelihood. Nature and landscapes in Germany bear the marks of centuries of use. Small-scale protection of species and habitats alone will not be sufficient to preserve the diversity which has been created by such use and through wholly natural processes. What is required instead are sustainable forms of land use throughout the entire landscape, restrictions on emissions and a more gentle hand in dealing with nature. In this way species diversity can be preserved and at the same time the quality of human life can be secured.

The indicator supplies information on species diversity, on the quality of the landscape and on the sustainability of the various land uses. The calculation of the indicator is based upon changes in the populations of 59 bird species, which together represent the most important types of landscape and habitat in Germany (farmlands, forests, settlements, inland waters, coasts

| | No. | Indicator areas Sustainability axiom | Indicators | Goals | Status | 5 year trend[1] |
|---|---|---|---|---|---|---|
| | | **I. Intergenerational equity** | | | | |
| | 1a | **Resource conservation** *Using resources economically and efficiently* | Energy productivity | To be doubled between 1990 and 2020 | | t |
| P | 1b new | | Primary energy consumption | To be reduced by 20 % by 2020 and 50 % by 2050 compared to 2008 | | t |
| | 1c | | Raw material productivity | To be doubled between 1994 and 2020 | | t |
| P | 2 | **Climate protection** *Reducing greenhouse gases* | Greenhouse gas emissions | To be reduced by 21 % by 2008/2012, 40 % by 2020 and 80 to 95 % by 2050, in each case compared to 1990 | | t |
| P | 3a amen-ded | **Renewable energy sources** *Strengthening a sustainable energy supply* | Share of renewable energy sources in final energy con-sumption | To be increased to 18 % by 2020 and 60 % by 2050 | | t |
| | 3b | | Share of renewable energy sources in electricity consump-tion | To be increased to 12.5 % by 2010, to at least 35 % by 2020 and to at least 80 % by 2050 | | t |
| P | 4 | **Land use** *Sustainable land use* | Built-up area and transport infrastructure expansion | Increase to be reduced to 30 hectares a day by 2020 | | t |
| S | 5 | **Species diversity** *Conserving species – protecting habitats* | Species diversity and landscape quality | Increase to the index value of 100 by 2015 | | t[2] |

1 t = Trend, nt = no trend. – 2 10 year trend.

| No. | Indicator areas Sustainability axiom | Indicators | Goals | Status | 5 year trend[1] | |
|---|---|---|---|---|---|---|
| 6a | **Government debt** *Consolidating the budgets – creating intergenerational equity* | General government deficit | Ratio of government deficit to GDP less than 3 % | | t | E |
| 6b new | | Structural deficit | Structurally balanced public spending, total national structural deficit of no more than 0.5 % of GDP | | t | E |
| 6c new | | Government debt | Ratio of government debt to GDP no more than 60 % | | t | E |
| 7 | **Provision for future economic stability** *Creating favourable investment conditions – securing long-term prosperity* | Gross fixed capital formation in relation to GDP | Increase in gross fixed capital formation share in GDP | | nt | E |
| 8 | **Innovation** *Shaping the future with new solutions* | Private and public spending on research and development | To be increased to 3 % of GDP by 2020 | * | t | E |
| 9a | **Education and training** *Continuously improving education and vocational training* | 18- to 24-year-olds without a school leaving certificate | To be reduced to less than 10 % by 2020 | * | t | E |
| 9b amen-ded | | 30- to 34-year-olds with a tertiary or post-secondary non-tertiary level of education | To be increased to 42 % by 2020 | | t | E |
| 9c | | Share of students starting a degree course | To be increased to 40 % by 2010, followed by further increase and stabilisation at a high level | | t | E |

1 t = trend, nt = no trend, * New goal / new evaluation; cannot be compared to previous period; see indicator description for explanation.





| No. | Indicator areas Sustainability axiom | Indicators | Goals | Status | 5 year trend[1] | |
|---|---|---|---|---|---|---|
| 14a | **Health and nutrition** *Living healthy longer* | Premature mortality (cases of death per 100,000 residents under 65): Men | To be reduced to 190 cases per 100,000 by 2015 | | t | SO |
| 14b | | Premature mortality (cases of death per 100,000 residents under 65): Women | To be reduced to 115 cases per 100,000 by 2015 | | t | SO |
| 14c | | Smoking rate amongst young people (12- to 17-year-olds) | To be decreased to under 12 % by 2015 | | nt | SO |
| 14d | | Smoking rate amongst adults (15 years and older) | To be decreased to under 22 % by 2015 | | nt | SO |
| 14e | | Proportion of adults suffering from obesity (18 years and older) | To be reduced by 2020 | | nt | SO |
| 15 amen-ded | **Crime** *Further increasing personal security* | Criminal offences | To be reduced in number of recorded cases per 100,000 inhabitants to under 7,000 by the year 2020 | | t | SO |
| | **III. Social cohesion** | | | | | SO |
| 16a | **Employment** *Boosting employment levels* | Employment rate (total) (15- to 64-year-olds) | To be increased to 73 % by 2010 and 75 % by 2020 | | t | SO |
| 16b | | Employment rate (older people) (55- to 64-year-olds)) | To be increased to 55 % by 2010 and 60 % by 2020 | | t | SO |

1 t = trend, nt = no trend.





| No. | Indicator areas Sustainability axiom | Indicators | Goals | Status | 5 year trend[1] | |
|---|---|---|---|---|---|---|
| | **II. Quality of life** | | | | | |
| 10 | **Economic output** *Combining greater economic output with environmental and social responsibility* | Gross domestic product per capita | Economic growth | | nt | E |
| 11a | **Mobility** *Guaranteeing mobility – protecting the environment* | Intensity of goods transport | To be reduced to 98 % by 2010 and to 95 % by 2020, compared to 1999 levels | | nt | E |
| 11b | | Intensity of passenger transport | To be reduced to 90 % by 2010 and to 80 %by 2020, compared to 1999 levels | | nt | E |
| 11c | | Share of rail transport in goods transport performance | To be increased to 25 % by 2015 | | nt | E |
| 11d | | Share of inland freight water transport in goods transport performance | To be increased to 14% by 2015. | | t | E |
| 12a | **Farming** *Environmentally sound production in our cultivated landscapes* | Nitrogen surplus | To be reduced to 80 kg/hectare of agricultural area by 2010, further reduction by 2020 | | t | P |
| 12b | | Organic farming | Share of organic farming on land used for agriculture to be increased to 20 % in coming years | | t | D |
| 13 | **Air quality** *Keeping the environment healthy* | Air pollution | To be reduced to 30 % by 2010, compared to 1990 levels | | t | P |

1 t = trend, nt = no trend.



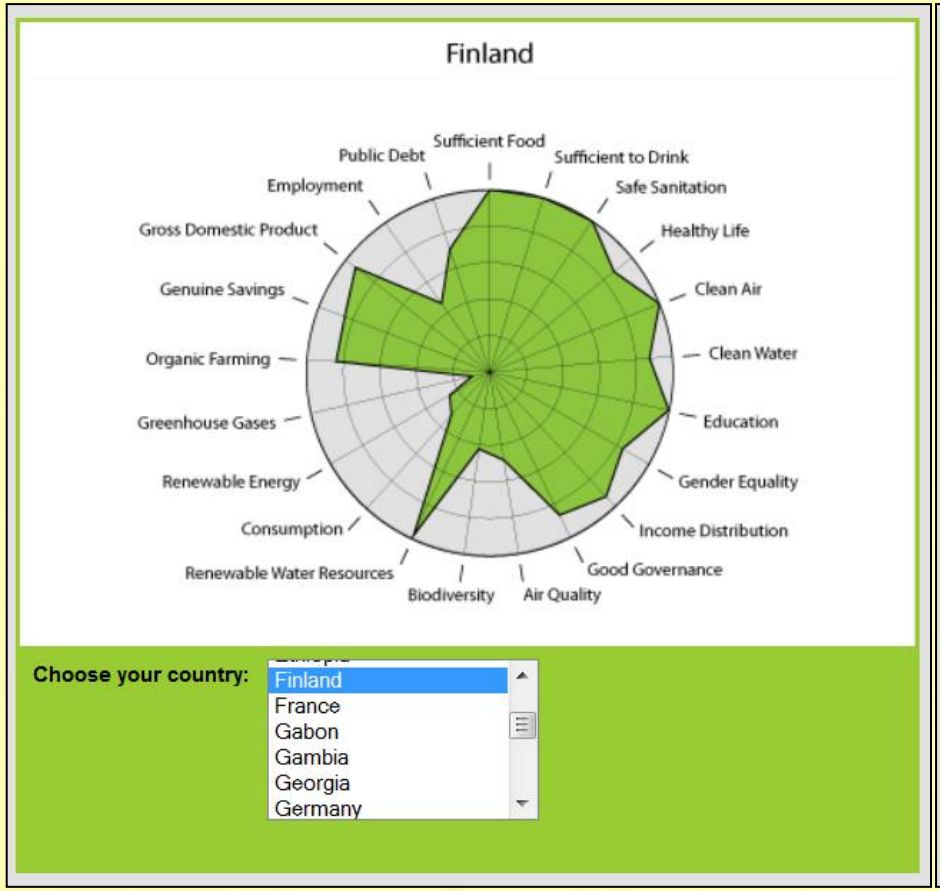


| No. | Indicator areas Sustainability axiom | Indicators | Goals | Status | 5 year trend[1] | |
|---|---|---|---|---|---|---|
| 17a | **Prospects for families** *Improving the compatibility of work and family life* | All-day care provision for children (0- to 2-year-olds) | To be increased to 30 % by 2010 and 35 % by 2020 | | nt | SO |
| 17b | | All-day care provision for children (3- to 5-year-olds) | To be increased to 30 % by 2010 and 60 % by 2020 | | nt | SO |
| 18 | **Equal opportunities** *Promoting equal opportunities in society* | Gender pay gap | To be reduced to 15 % by 2010 and to 10 % by 2020 | | t | SO |
| 19 | **Integration** *Integration instead of exclusion* | Foreign school leavers with a school leaving certificate | Proportion of foreign school leavers with at least a *Hauptschule* certificate (lower secondary schooling) is to be increased, with their diploma rate to be raised to that of German school leavers by 2020 | | t | SO |
| | **IV. International responsibility** | | | | | |
| 20 | **Development cooperation** *Supporting sustainable development* | Share of expenditure for official development assistance in gross national income | To be increased to 0.51 % by 2010 and 0.7 % by 2015 | | nt | E |
| 21 | **Opening markets** *Improving trade opportunities for developing countries* | German imports from developing countries | Further increase | | t | E |

1 t = trend, nt = no trend.

http://www.sustainablesocietyindex.com/

http://www.sustainablesocietyindex.com/



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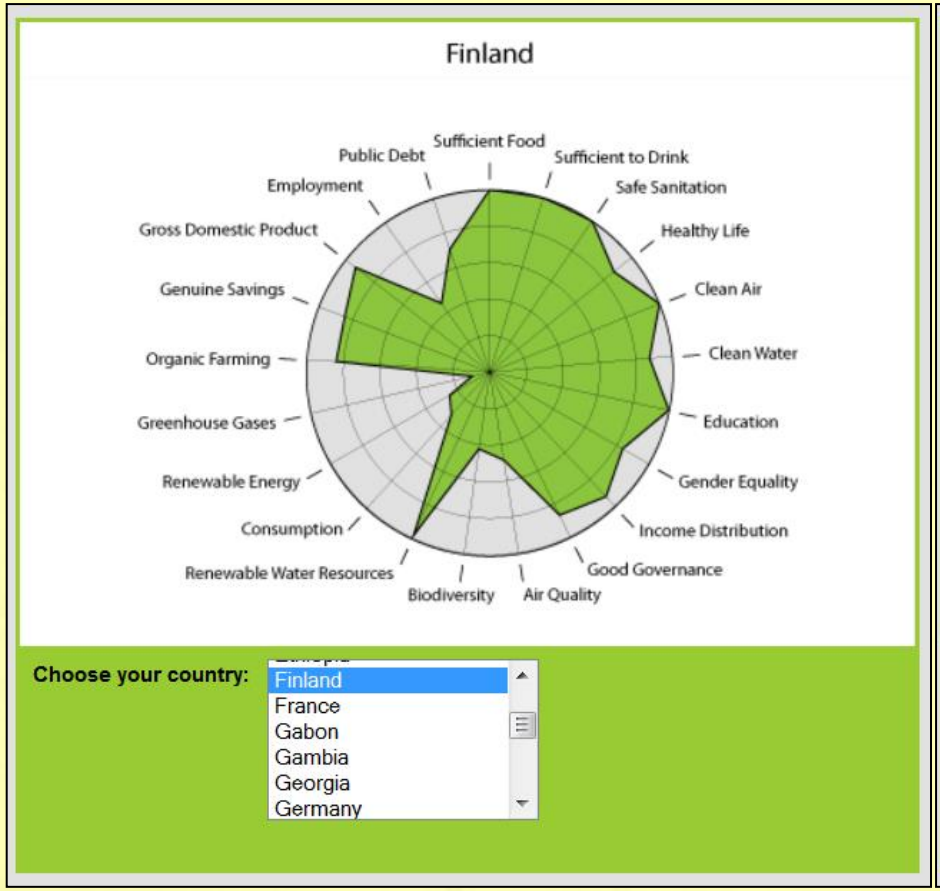

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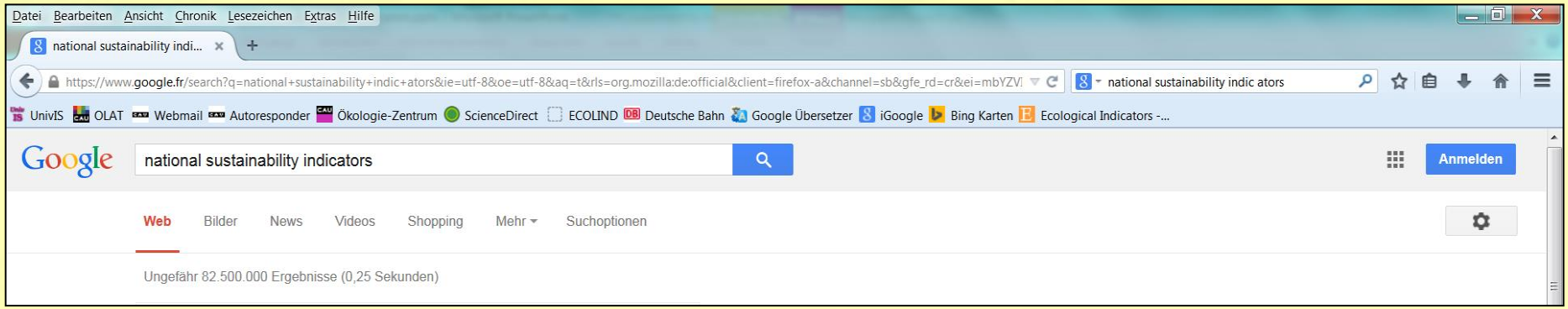

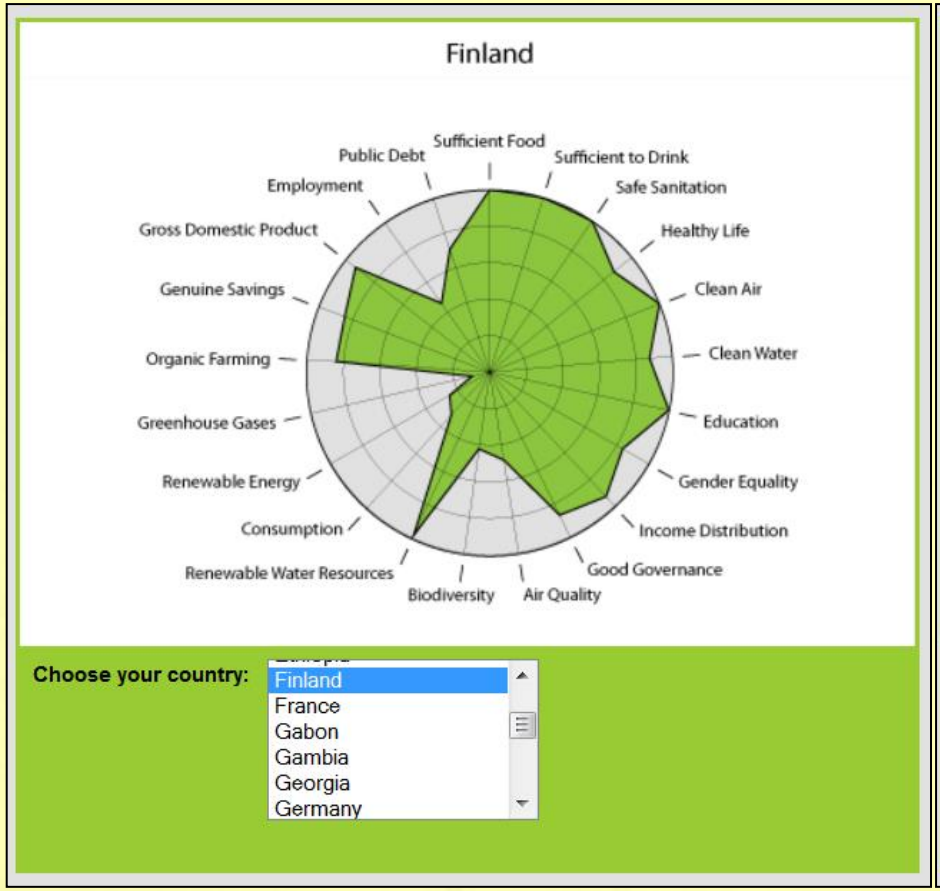

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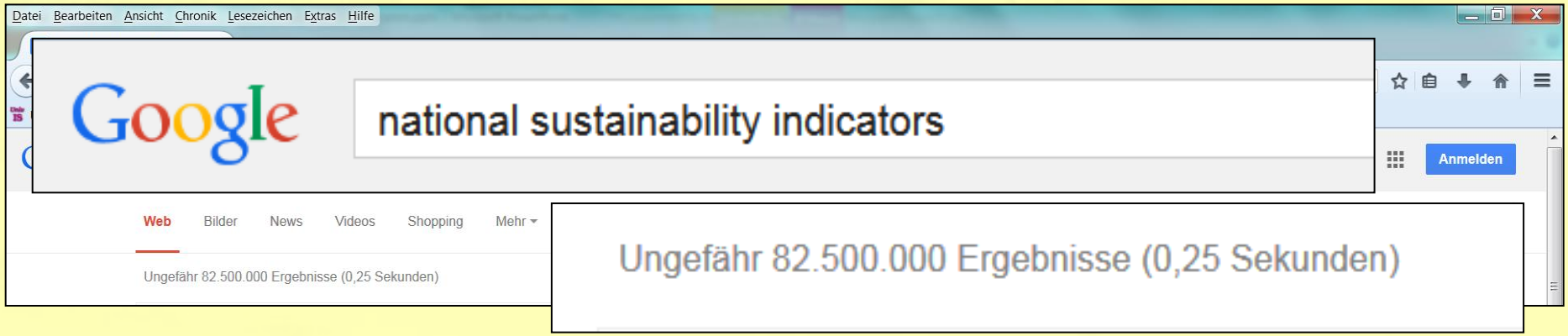


# Are the requirements for indicators fulfilled?

**Political arguments**

↓

**Socio-economic focus: <u>growth</u>**

↓

**Green growth**
**Green economy**

# Are the requirements for indicators fulfilled?

| | |
|---|---|
| **Political arguments** | **Accounting arguments** |
| ↓ | ↓ |
| **Socio-economic focus: <u>growth</u>** | **GDP criticism** |
| ↓ | ↓ |
| **Green growth<br>Green economy** | **Beyond GDP** |

# A problem of traditional key indicators
# → Beyond GDP

- **GDP - Gross Domestic Product - measures the monetary value of all goods and services that are produced** within a nation during a given period and sold to consumers, government, investors or are exported.
- Being a monetary value measure, GDP therefore represents **the part of the population's well-being that comes from consumption of goods and services sold on established markets** - i.e. selling apples to a neighbour is in most cases not a part of GDP.
- **Environmental damages, health problems, death,….. count positively to GDP**
- **No integration** of measures for
  - **Social situation**
  - **Environmental situation**
  - **Well-being situation**

**→ No sustainaility of welfare indicator**

# „New“ Approaches to indicate sustainable development

- Genuin process index
- Sustainable national income
- Index of well-being
- Happy Life years
- Happy planet index
- Dashboard of sustainability
- National accounts of well-being
- Natural capital index
- Environmental performance index

- System of environmental-economic accounting
- How‘s life indicators
- Gross national happiness index
- Sustainable society index
- FEEM sustainability index
- Living planet index
- ……

# Are the requirements for indicators fulfilled?

| Political arguments | Accounting arguments | Systems based arguments |
|---|---|---|
| ↓ | ↓ | ↓ |
| Socio-economic focus: <u>growth</u> | GDP criticism | Interrelation criticism |
| ↓ | ↓ | ↓ |
| Green growth<br>Green economy | Beyond GDP | Ecosystem approach |

# Are the system-based requirements fulfilled?

- **long-term strategies** ..... think in generations
- **multi-scale strategies** ..... human vs. ecological time scales
- **interdisciplinary strategies** ..... ecology is only a part
- **functional strategies** …. integrate interrelations
- **fair strategies** …. same significance of columns
- **holistic strategies** ..... structures *and* functions
- **realistic strategies** ..... include uncertainties
- **nature oriented strategies** ..... take nature as a model
- **theory-based strategies** ..... make sure correctness
- **hierarchical strategies** ..... realise constraints and scales
- **goal oriented strategies** ..... joint definition of the targets

# Are the requirements fulfilled?

- long-term strategies
- multi-scale strategies
- interdisciplinary strategies
- functional strategies
- fair strategies
- holistic strategies
- realistic strategies
- nature oriented strategies
- theory-based strategies
- hierarchical strategies
- goal oriented strategies

**Can systems approaches help to improve the indication strategies?**

# Are the requirements fulfilled?

- long-term strategies
- multi-scale strategies
- interdisciplinary strategies
- functional strategies
- fair strategies
- holistic strategies
- realistic strategies
- nature oriented strategies
- theory-based strategies
- hierarchical strategies
- goal oriented strategies

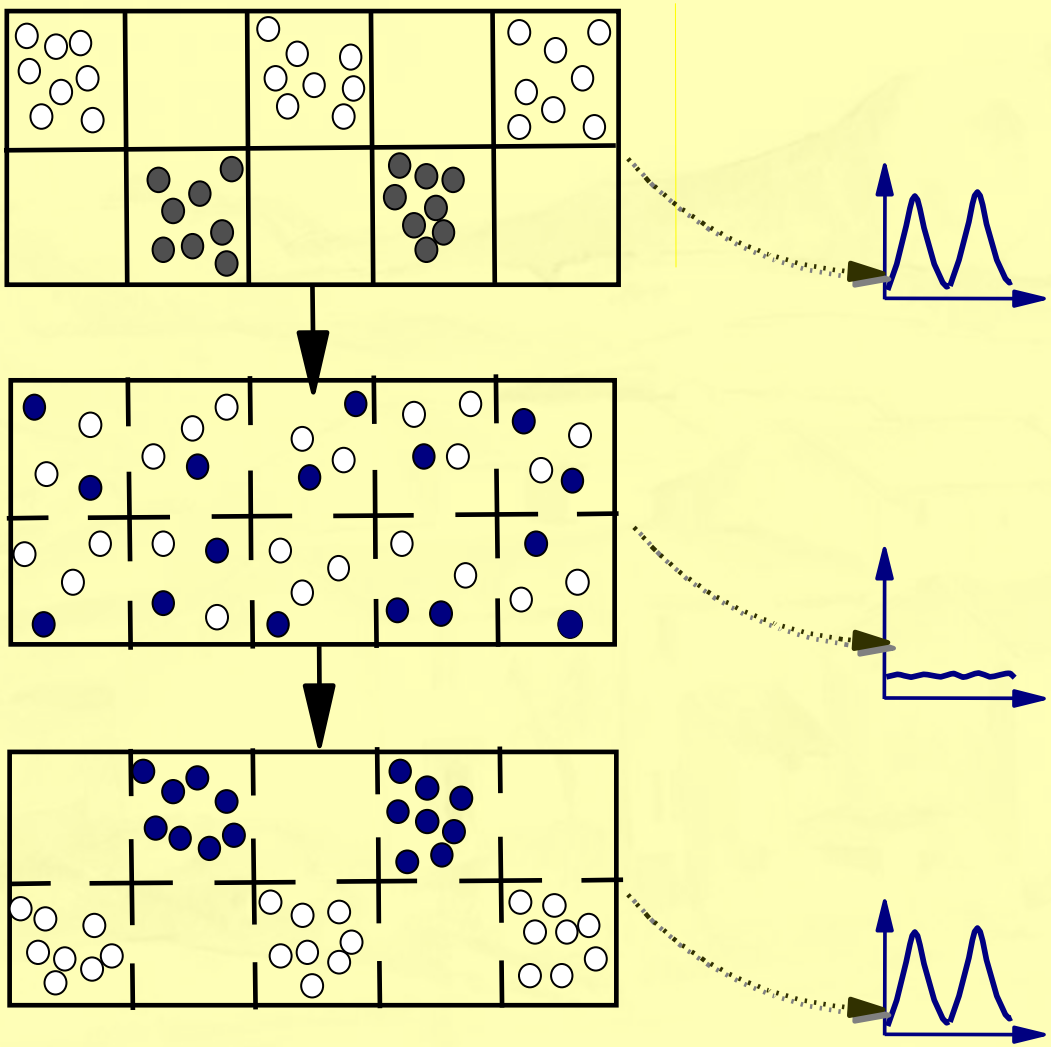
**Can systems approaches help to improve the indication strategies?**

**Self-organization?**
**Ecological integrity?**
**Resilience?**

# Presentation Structure

- What are indicators and why do we need them?
- What are socio-ecological systems?
- What is sustainability?
- How to indicate sustainability?
- **Which is the role of systems approaches?**
- **How to apply ecosystem theoretical concepts for sustainability indication?**
- How to indicate the contributions of ecosystems for „human“ sustainability?

# Self - Organization:

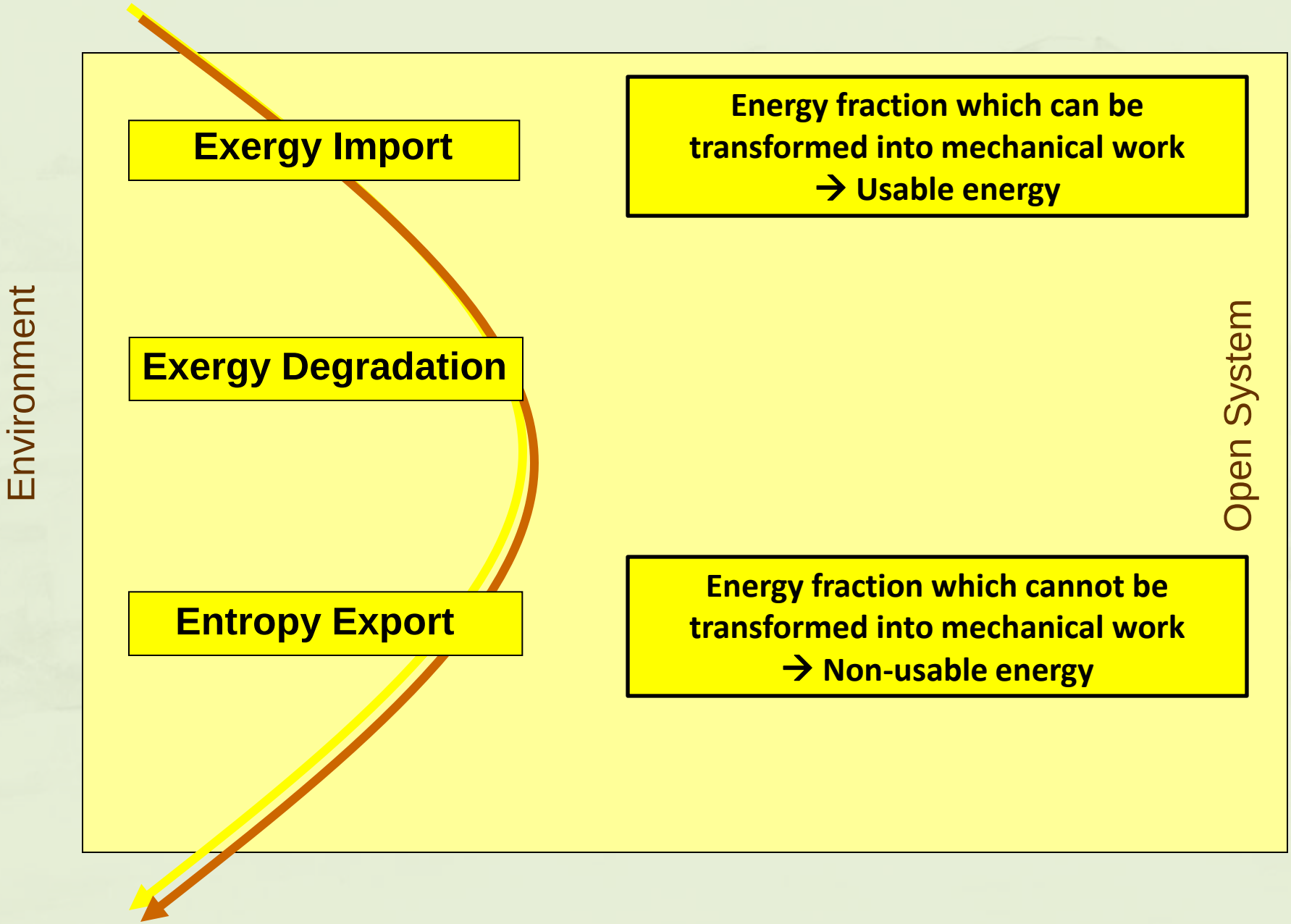


***Spontaneous Creation of Macroskopic Structures from Microskopic Disorder***

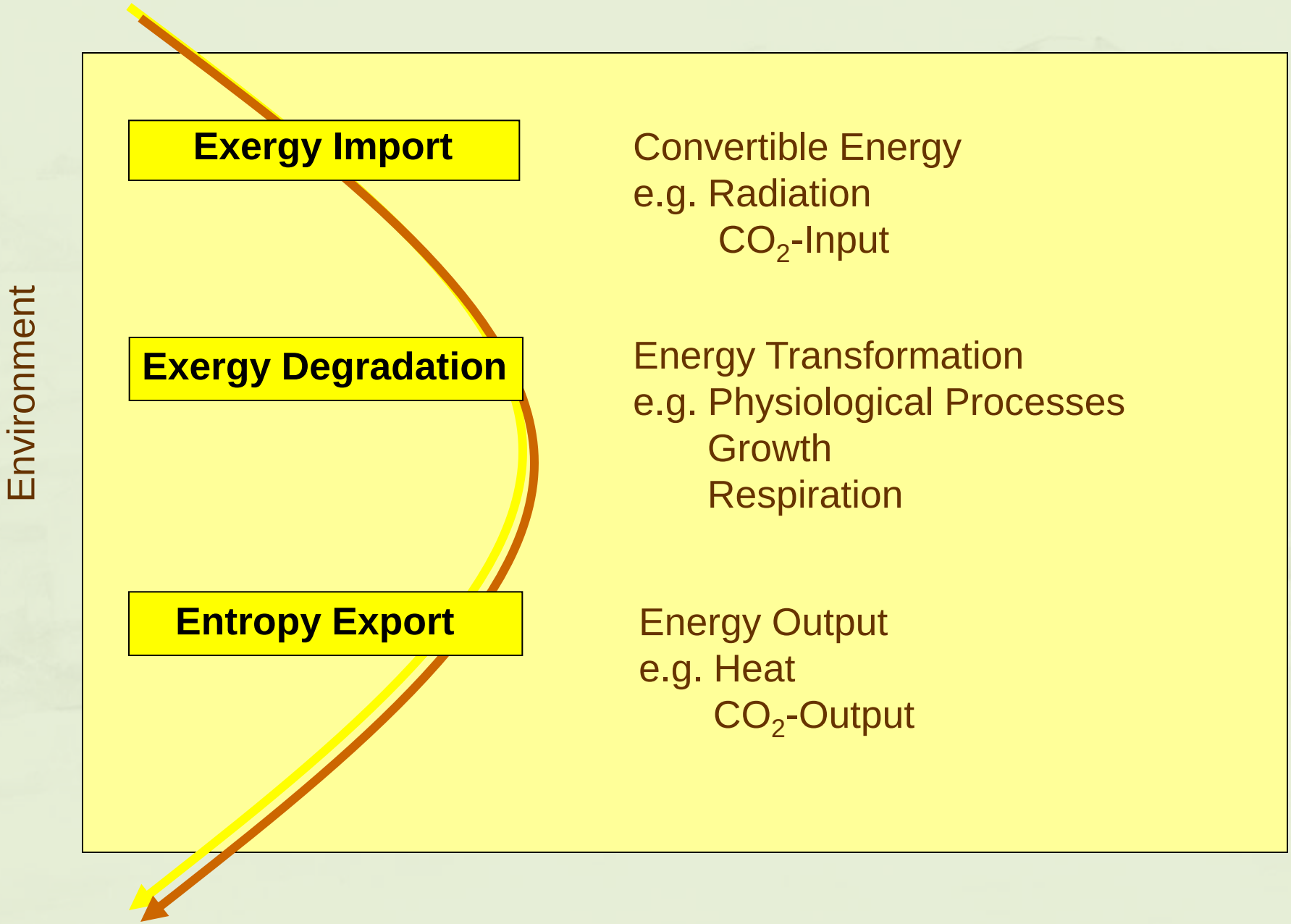
**<u>Gradient Formation</u>**

# Principles of Self - Organization:

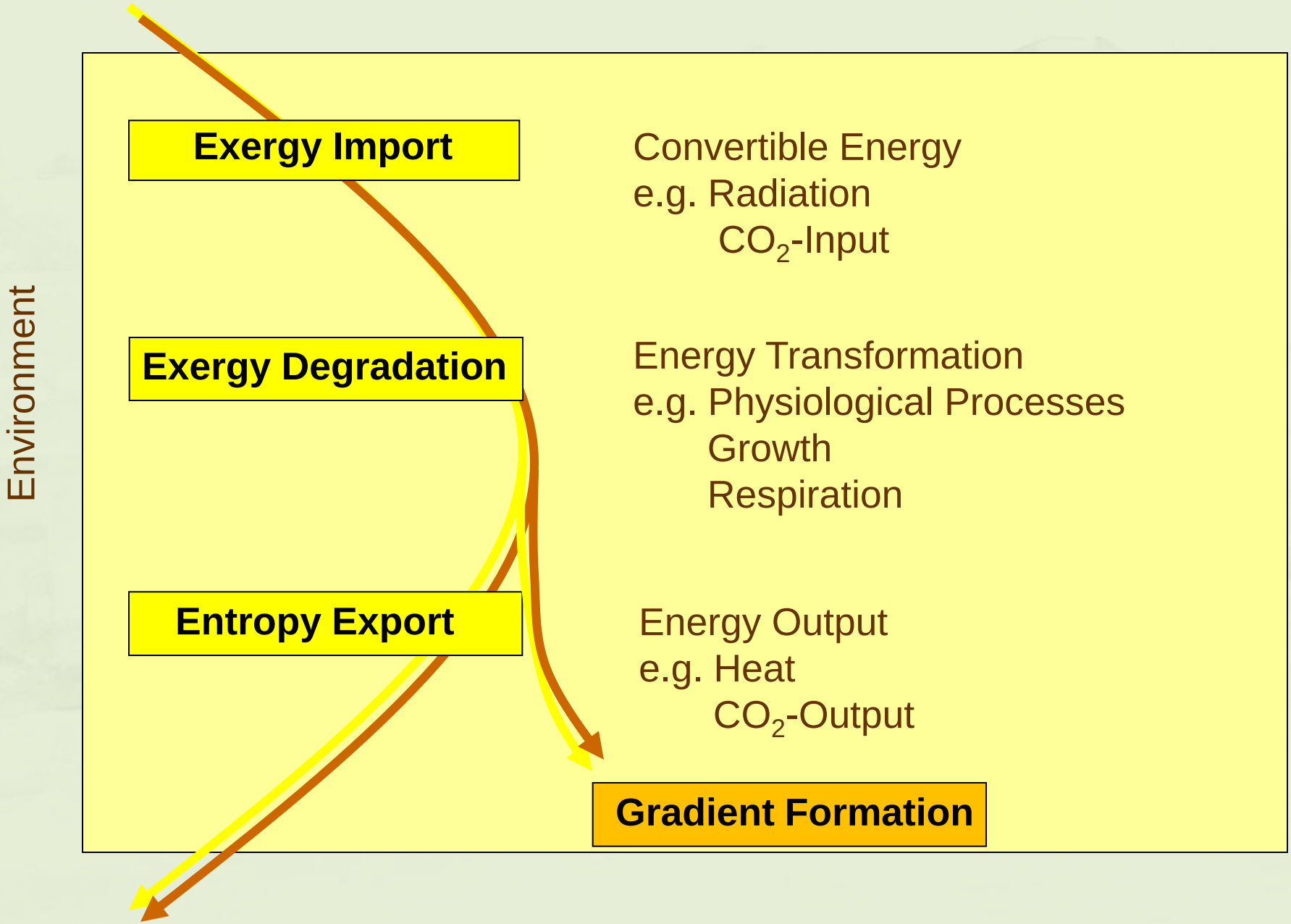
# Principles of Self - Organization:



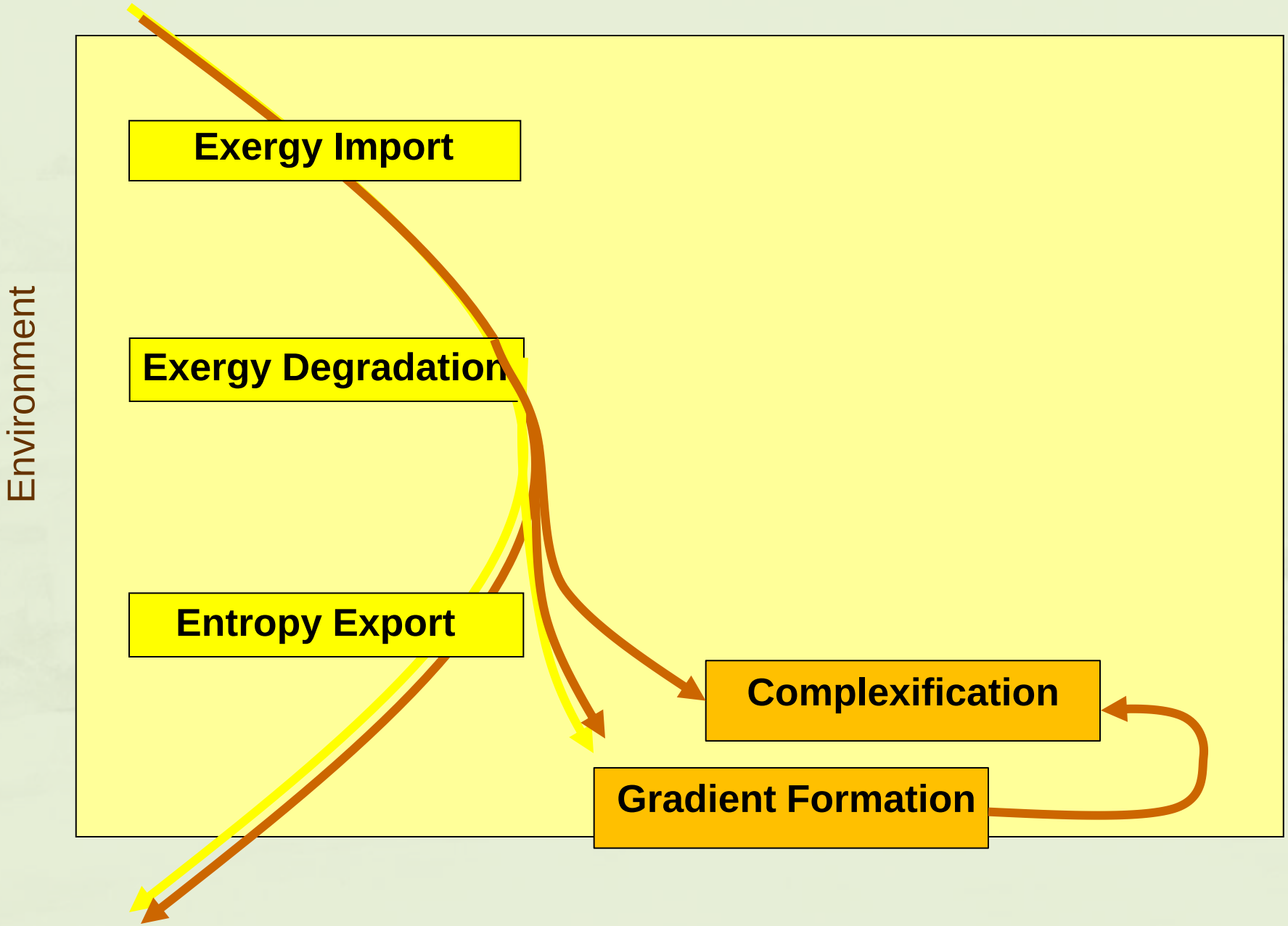
# Principles of Self - Organization:



# Principles of Self - Organization:



# Principles of Self - Organization:



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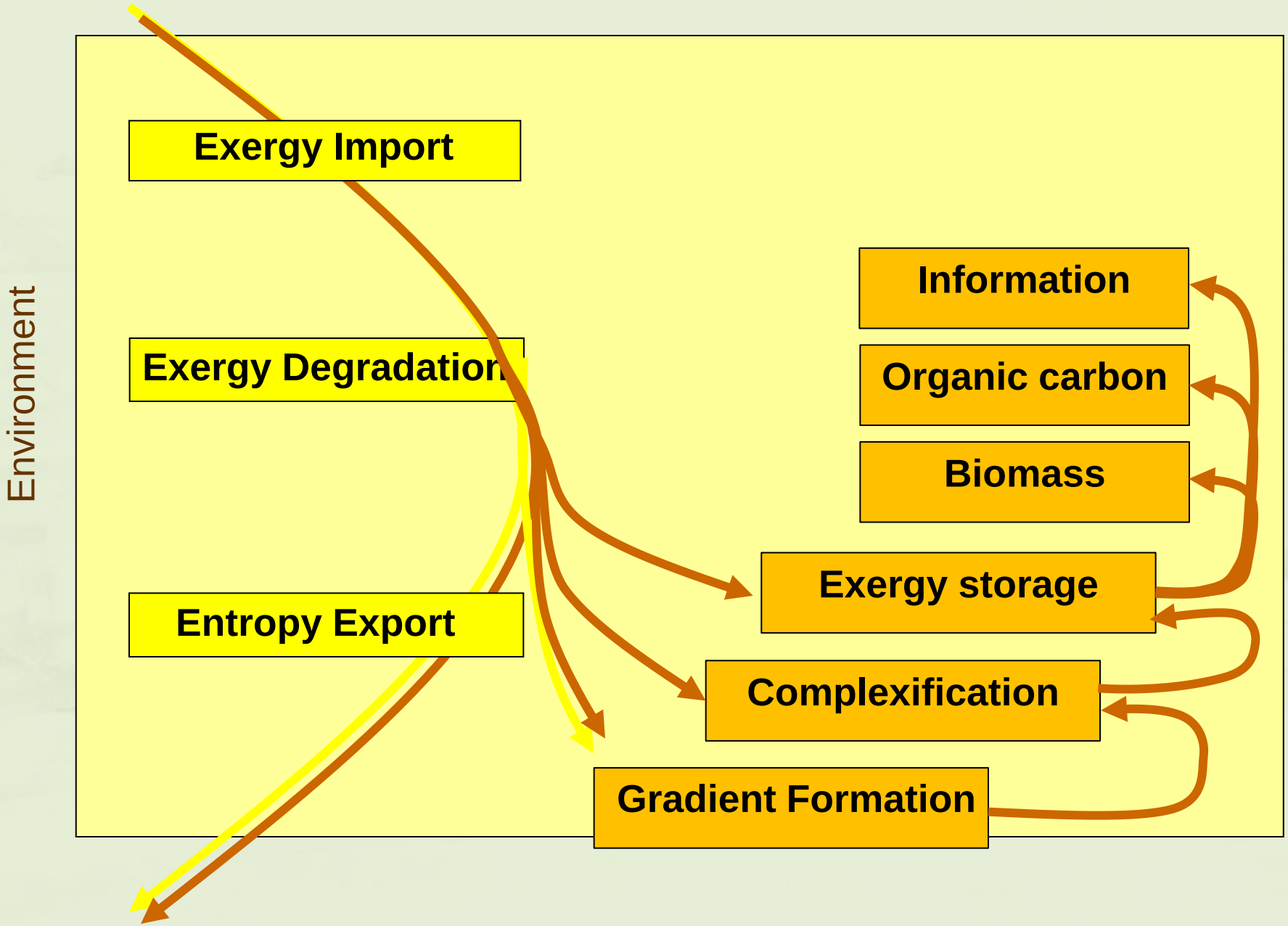
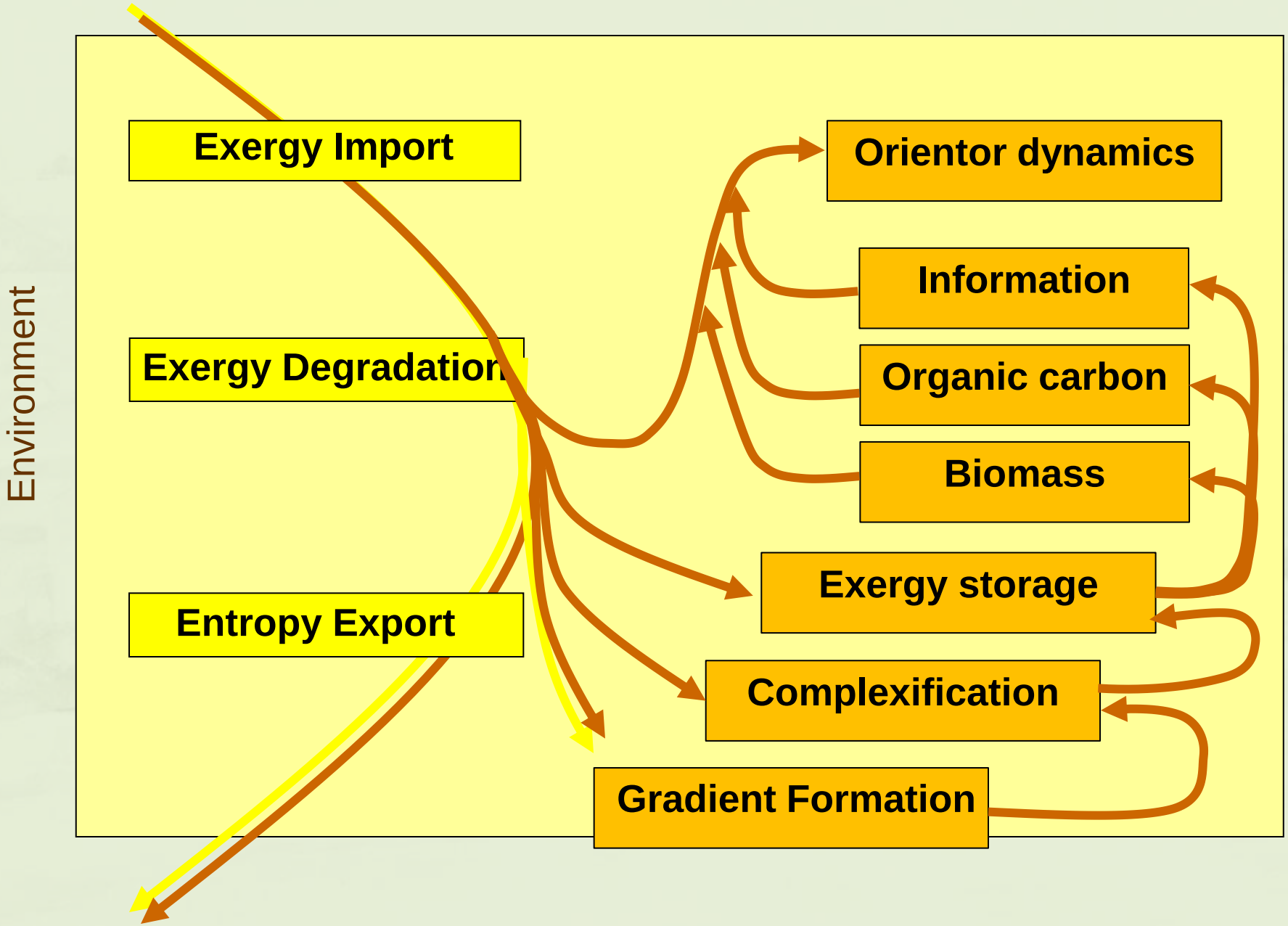
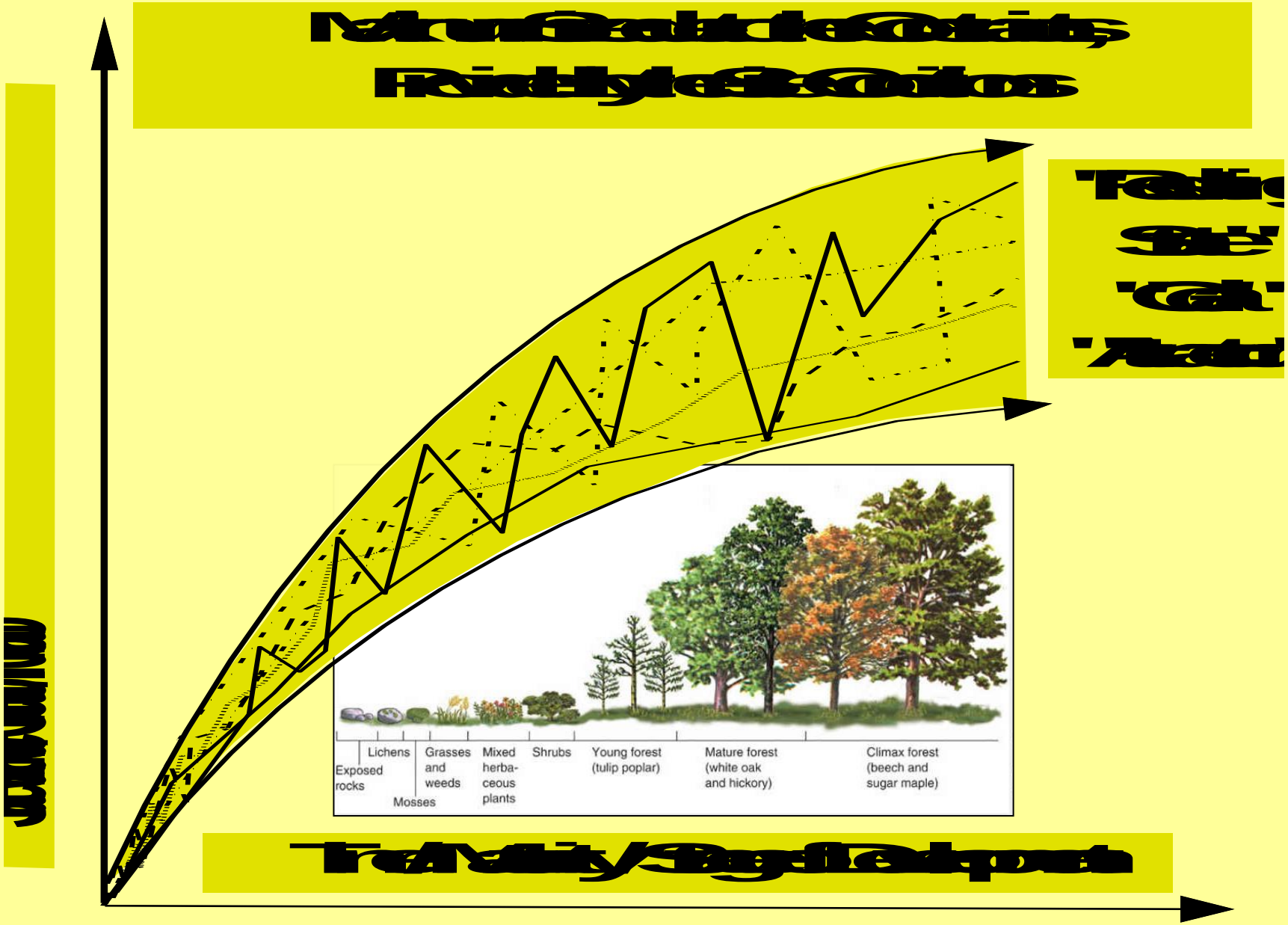


# Principles of Self - Organization:




Lichens
Exposed rocks
Mosses
Grasses and weeds
Mixed herba-ceous plants
Shrubs
Young forest (tulip poplar)
Mature forest (white oak and hickory)
Climax forest (beech and sugar maple)

**Thermodynamic orientors:**

- exergy capture
- exergy flows
- exergy storage

- total entropy production

- emergy
- power

**Ecophysiological orientors:**

- loss reduction
- storage capacity
- flux density
- internal flows
- cycling
- respiration
- total throughput
- metabolic efficiencies

**Community orientors:**

- niche diversity
- symbiosis
- r vs. k selection
- life span
- body mass

**Thermodynamic orientors:**

gradients

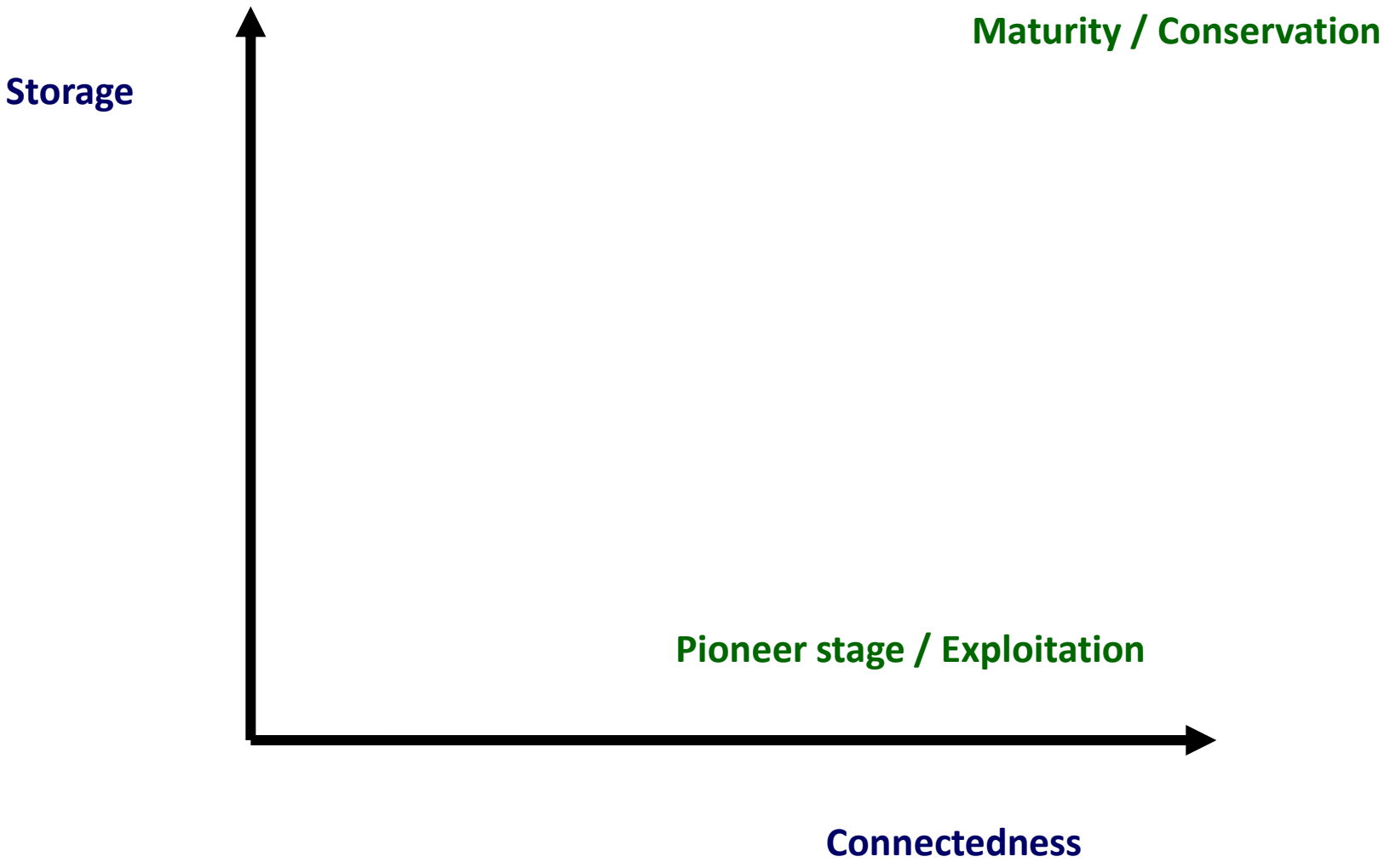
- gradient emergence
- gradient degradation

**Structural orientors:**

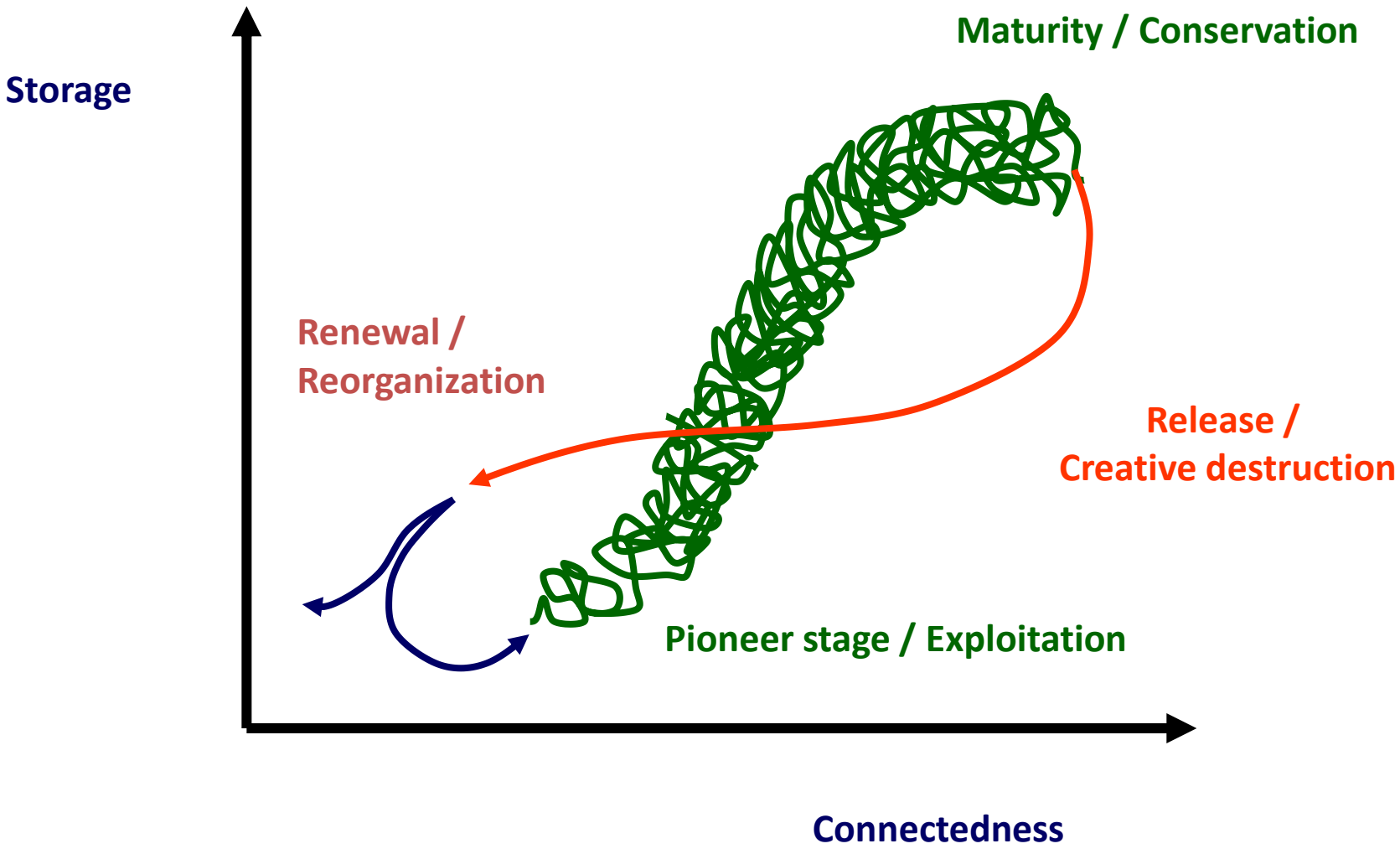
distance from equilibrium

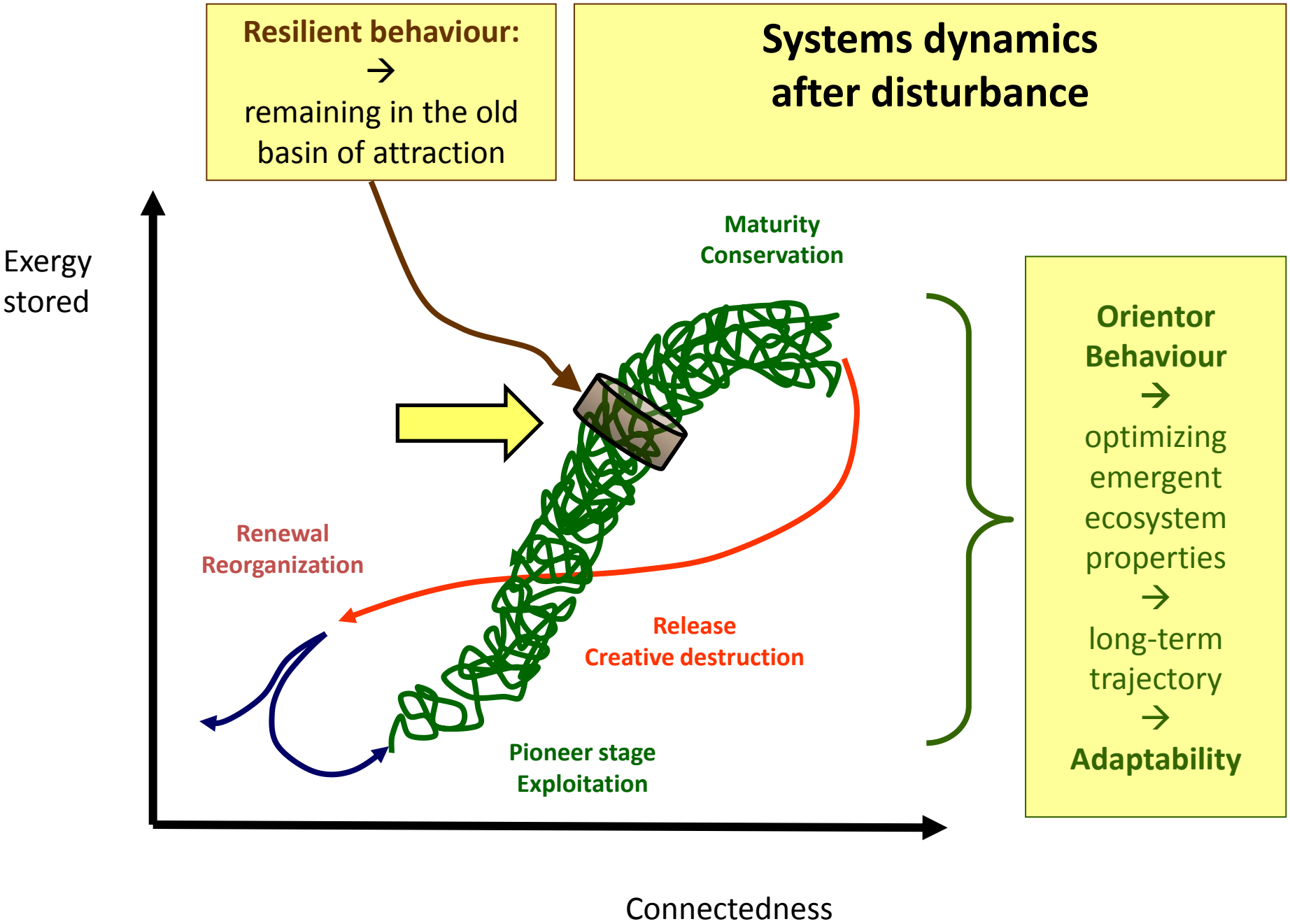
- structure
- information
- heterogeneity
- complexity
- connectedness

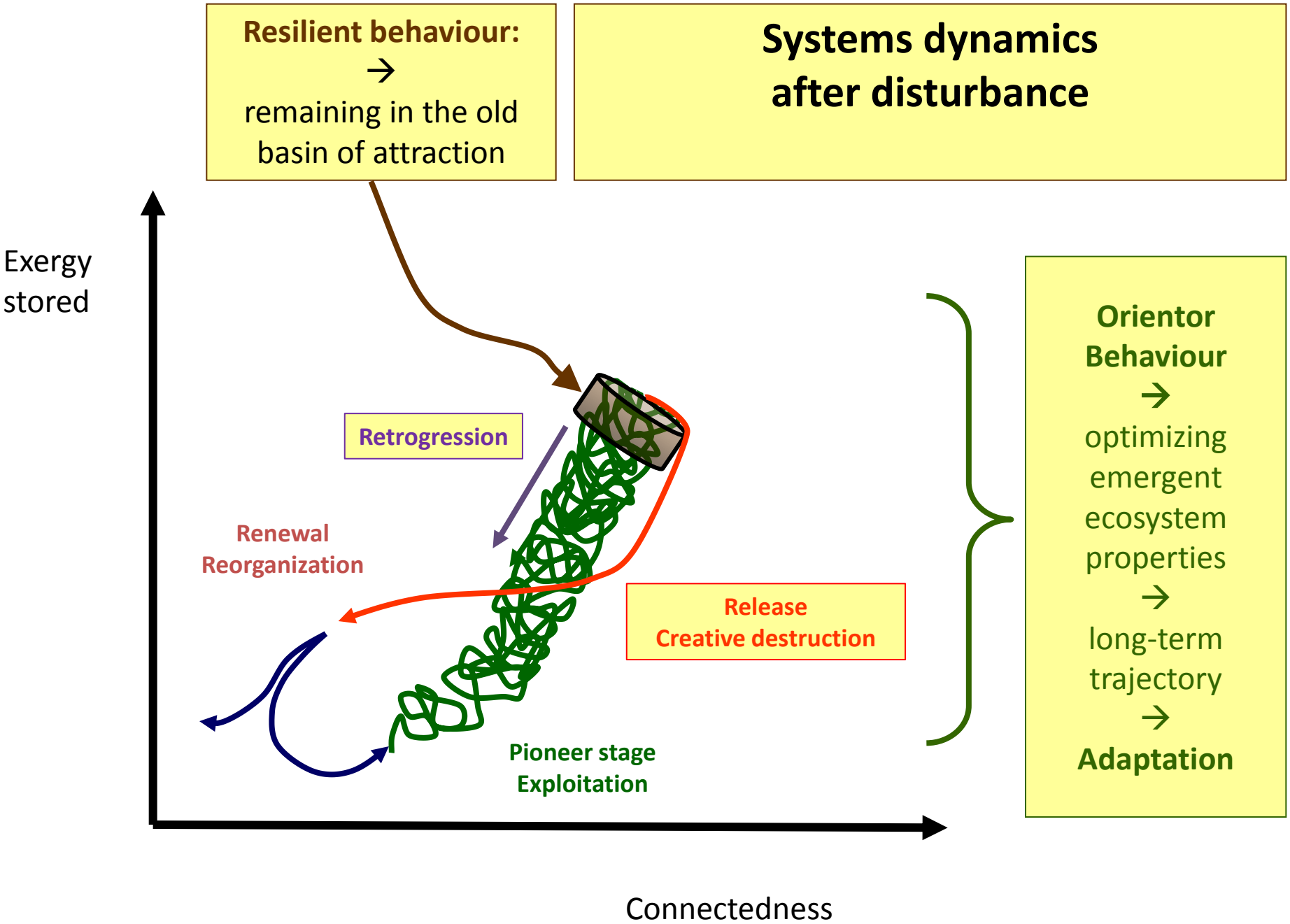
# Hypothetical dynamics of ecosystem features



# Hypothetical dynamics of ecosystem features

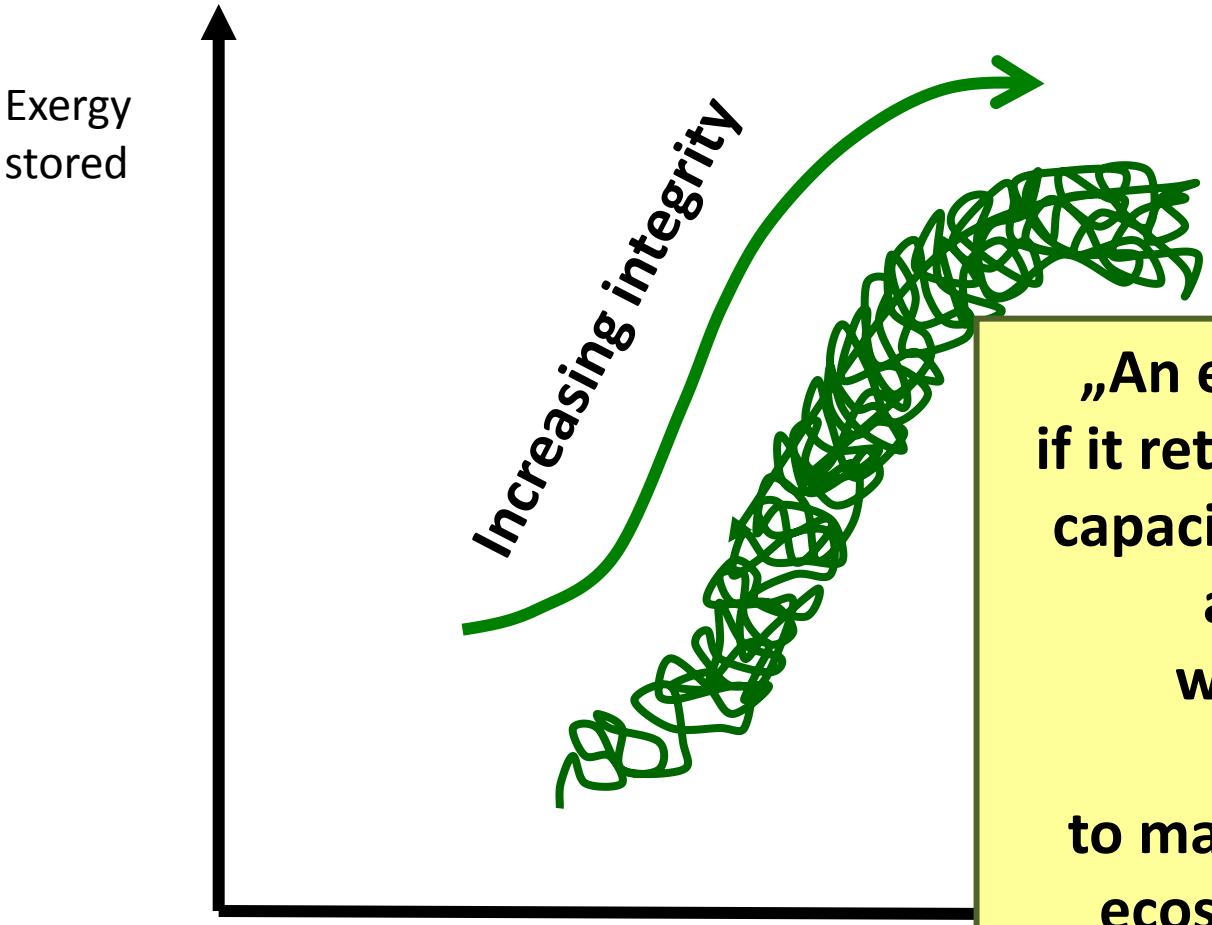



Resilient behaviour:
→
remaining in the old basin of attraction
Systems dynamics after disturbance
Exergy stored
Maturity
Conservation
Renewal
Reorganization
Release
Creative destruction
Pioneer stage
Exploitation
Orientor Behaviour
→
optimizing emergent ecosystem properties
→
long-term trajectory
→
Adaptability
Connectedness


Resilient behaviour:
→
remaining in the old basin of attraction
Systems dynamics after disturbance
Exergy stored
Retrogression
Renewal
Reorganization
Release
Creative destruction
Pioneer stage
Exploitation
Orientor Behaviour
→
optimizing emergent ecosystem properties
→
long-term trajectory
→
Adaptation
Connectedness

# Ecosystem functions and integrity

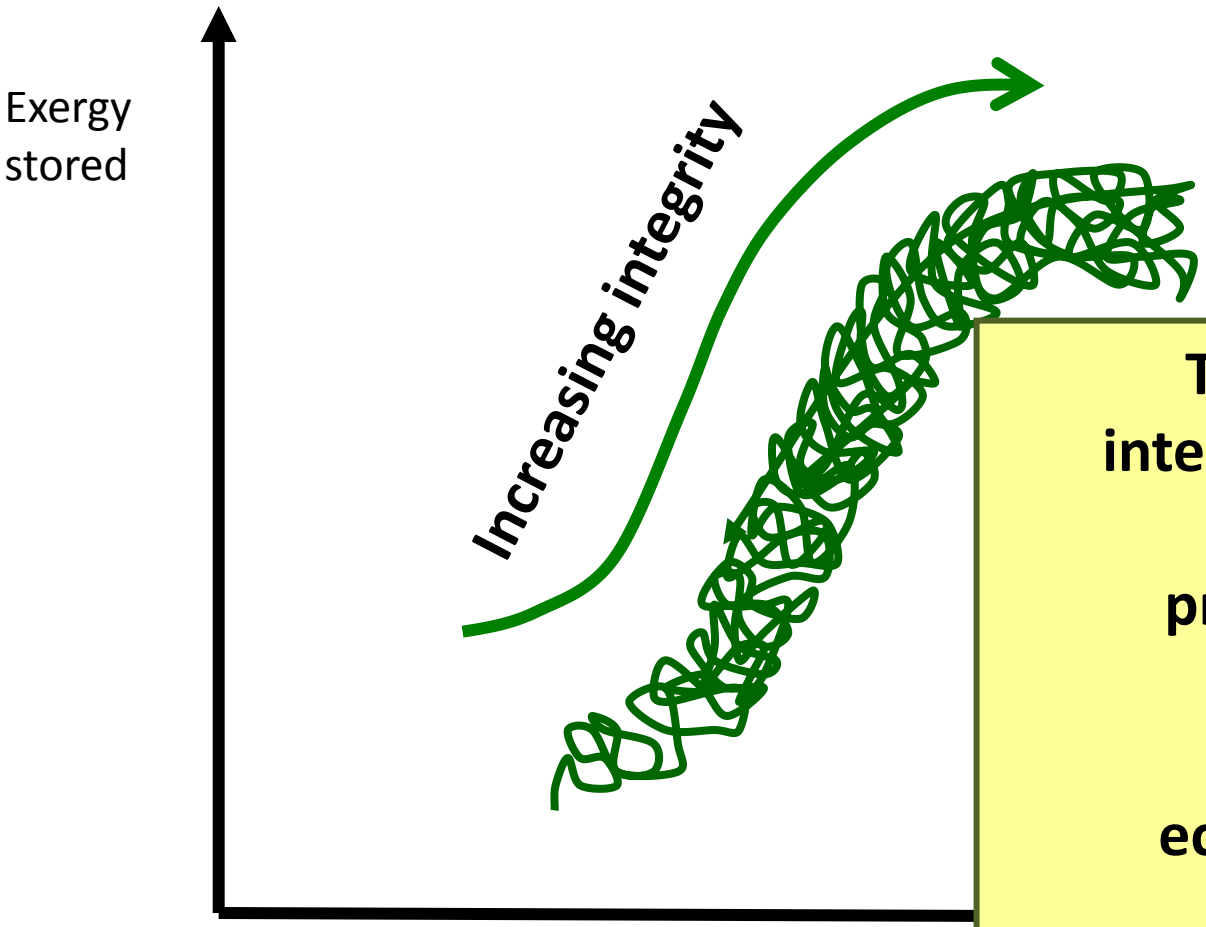
# Ecosystem functions and integrity




**„An ecosystem has integrity if it retains its complexity and capacity for self-organization and sufficient diversity, within its structures and functions, to maintain and develop the ecosystem's self-organizing complexity through time.“**

***(James Kay, 1993)***

# Integrity as a guideline



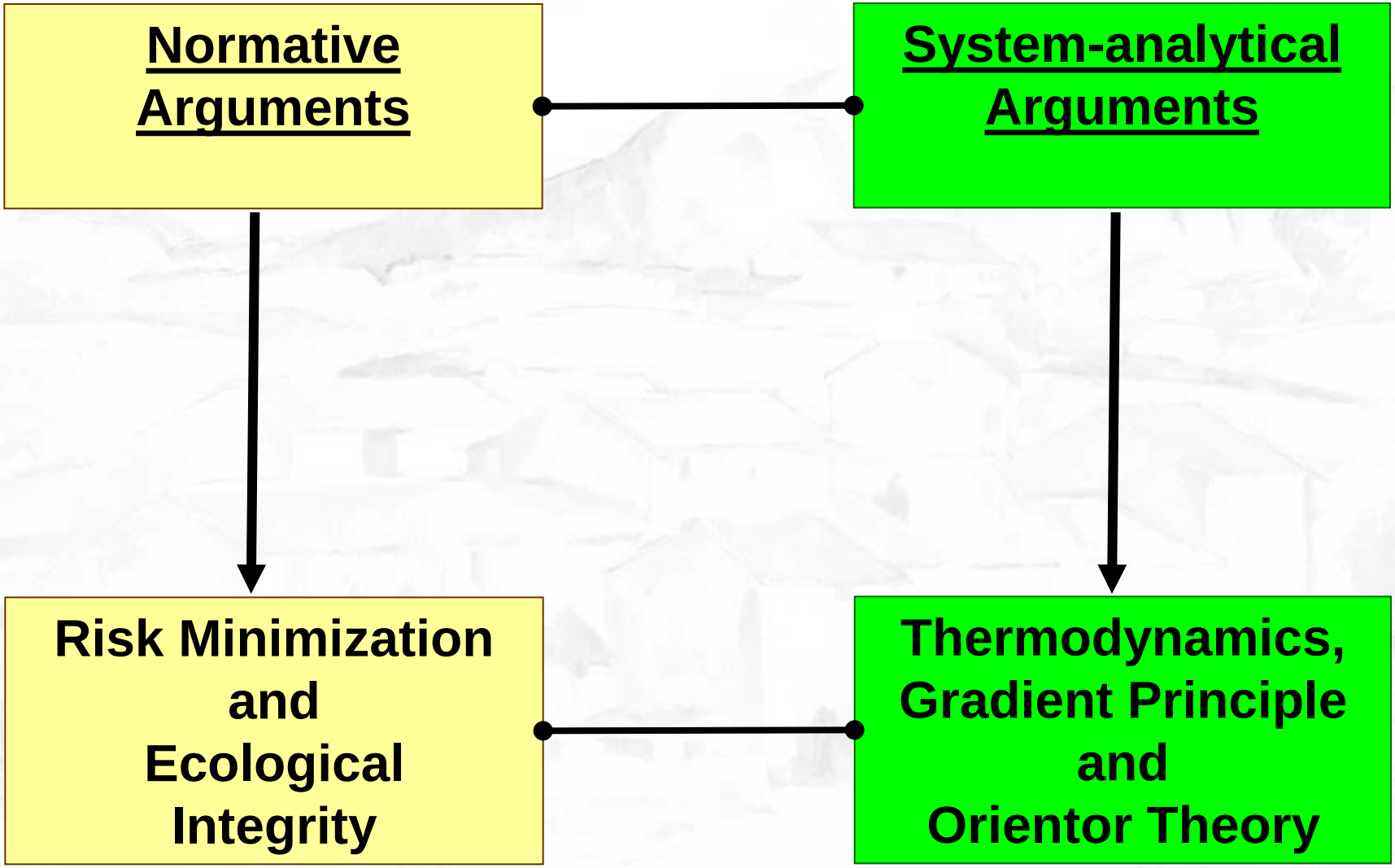

**The target of ecosystem integrity management is to preserve those processes and structures which are essential prerequisites of the ecological ability for self-organization.**

***Barkmann et al. 2001***

**….. One small example considering integrity indication….**

**Normative Arguments**

**System-analytical Arguments**




Fundamentals of Ecosystem Indicator Derivation

## Structural Gradients

## Functional Gradients

Barkmann, J./Baumann, R./Meyer, U./Müller, F./Windhorst, W. (2001): Ökologische Integrität: Risikovorsorge im Nachhaltigen Landschaftsmanagement. In: Gaia (10)2, 97-108

## Structural Gradients

- Abiotic Gradients
- Biotic Gradients

## Functional Gradients

- Hydrological Gradients
- Energetic Gradients
- Nutrient Gradients

## Structural Gradients

- Abiotic Gradients
- Biotic Gradients

## Functional Gradients

- Hydrological Gradients
- Energetic Gradients
- Nutrient Gradients

→

- Inputs
- Outputs
- Efficiencies
- Storages

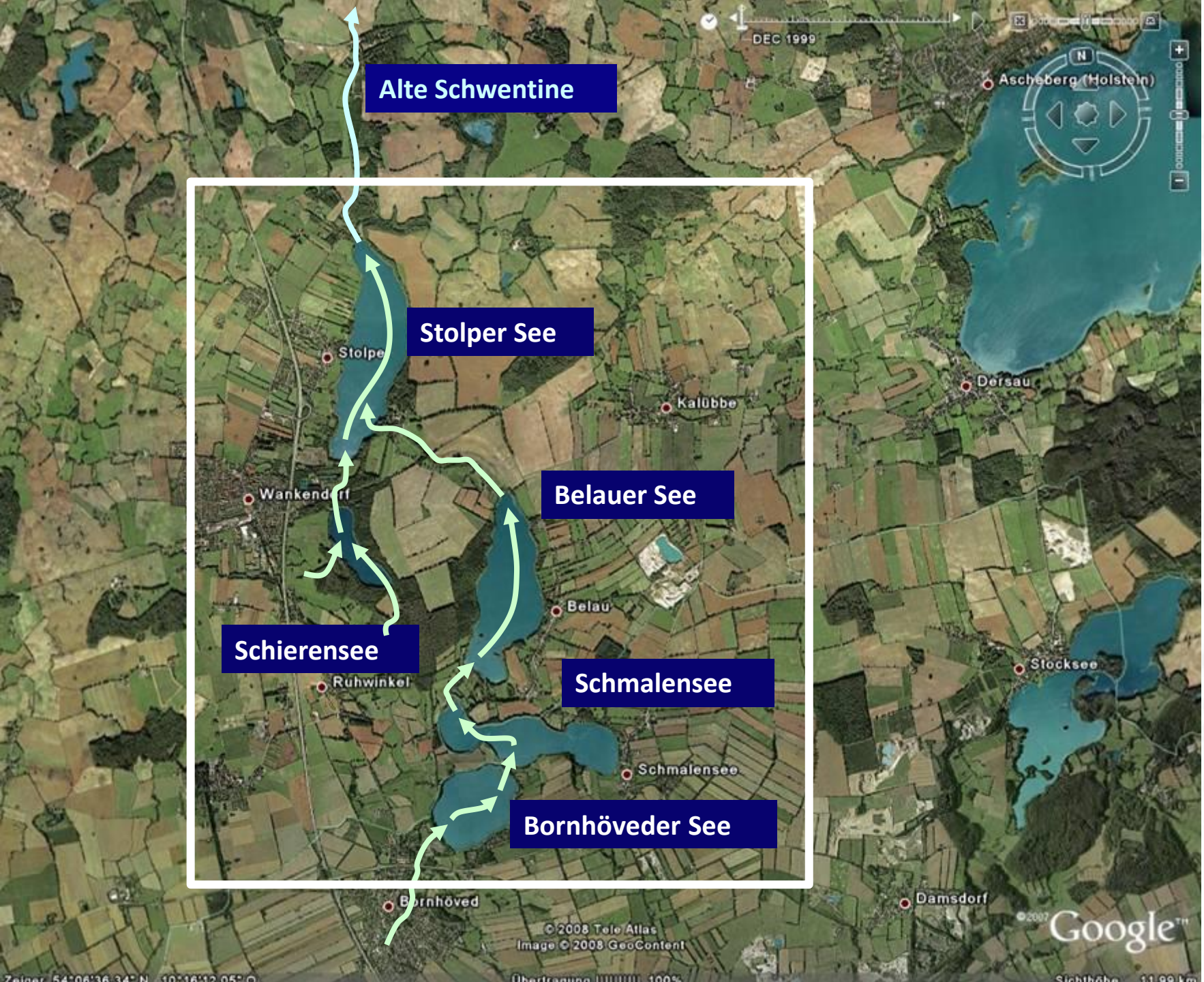
| | |
|---|---|
| **Structural Gradients**<br>• Abiotic Gradients<br>• Biotic Gradients | **Proposed Indicators:**<br>• Biotop Heterogeneity<br>• Species Abundances |
| **Functional Gradients**<br>• Hydrological Gradients<br>• Energetic Gradients<br>• Nutrient Gradients | • Biotic Water Flows<br>• Exergy Capture<br>• Entropy Export<br>• Metabolic Efficiency<br>• Nutrient Loss<br>• Storage Capacity |

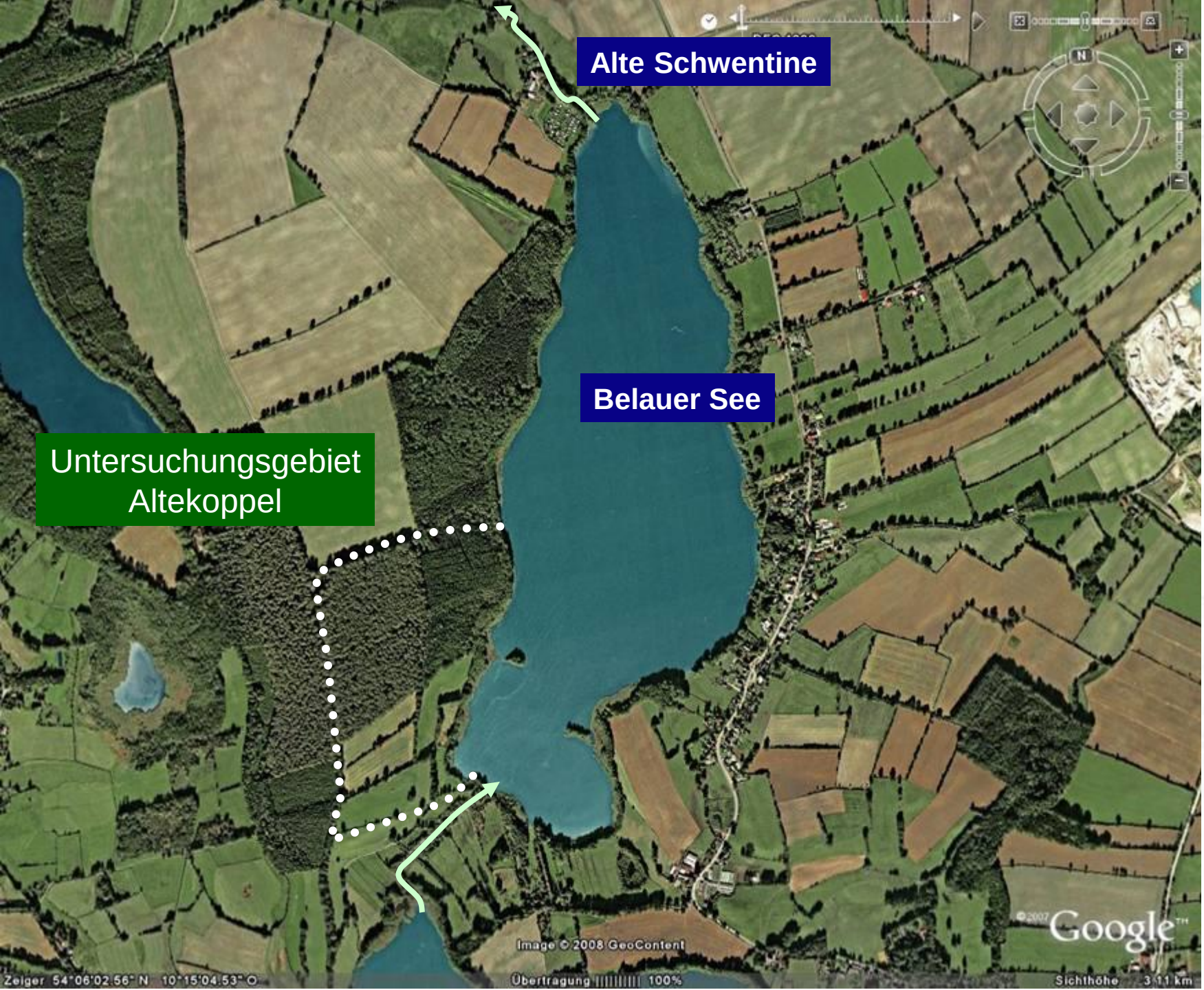
Müller, F. (2004): Ecosystem indicators fort he integrated management of landscape health and integrity,
In: Joergensen, S.E./Costanza, R./Fu-Liu, X. (eds): Ecological indicators for assessment of ecosystem health. Boca Raton. 277-303.

# Bornhöved Lakes District

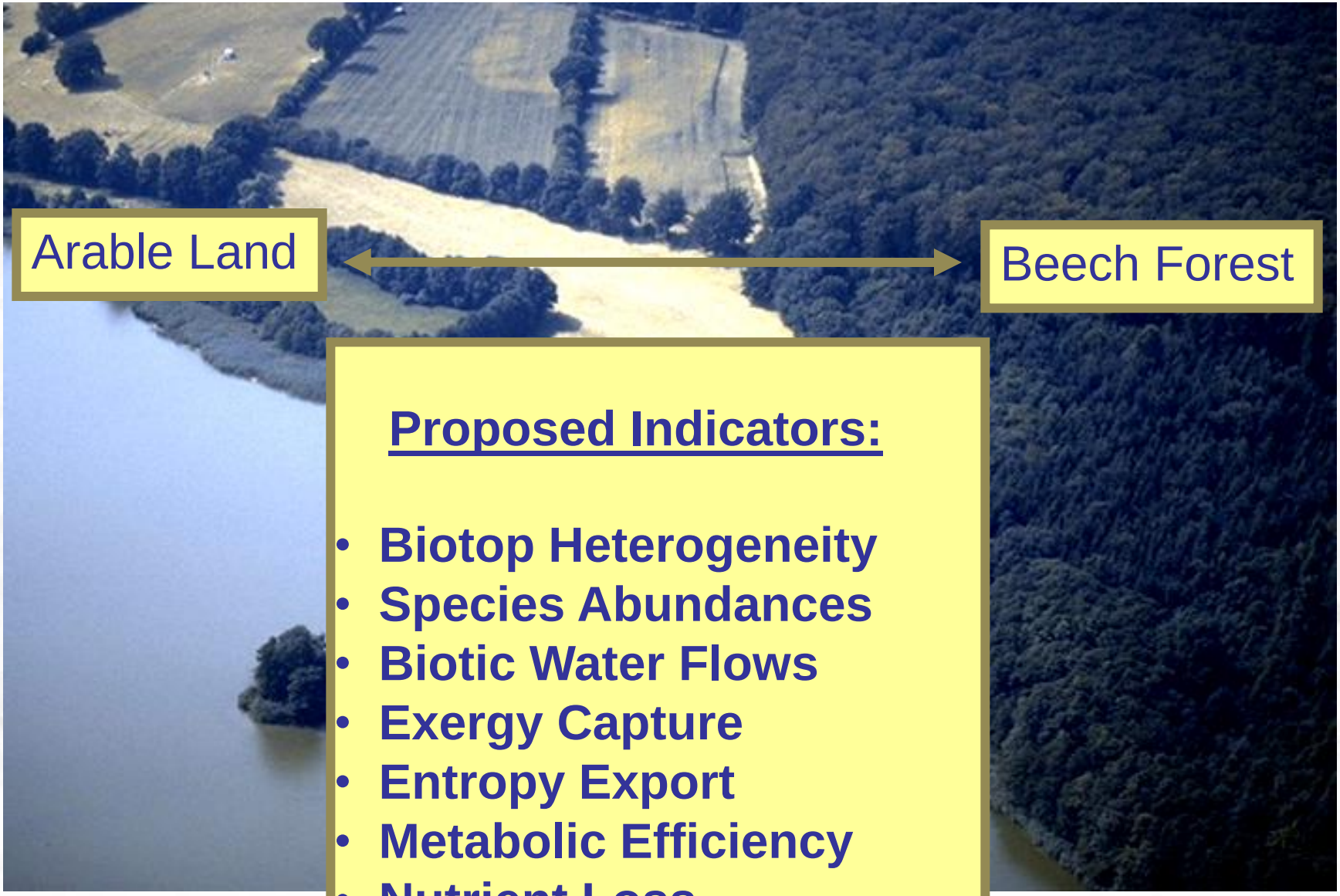
# Bornhöveder Seenkette

# Bornhöveder Seenkette





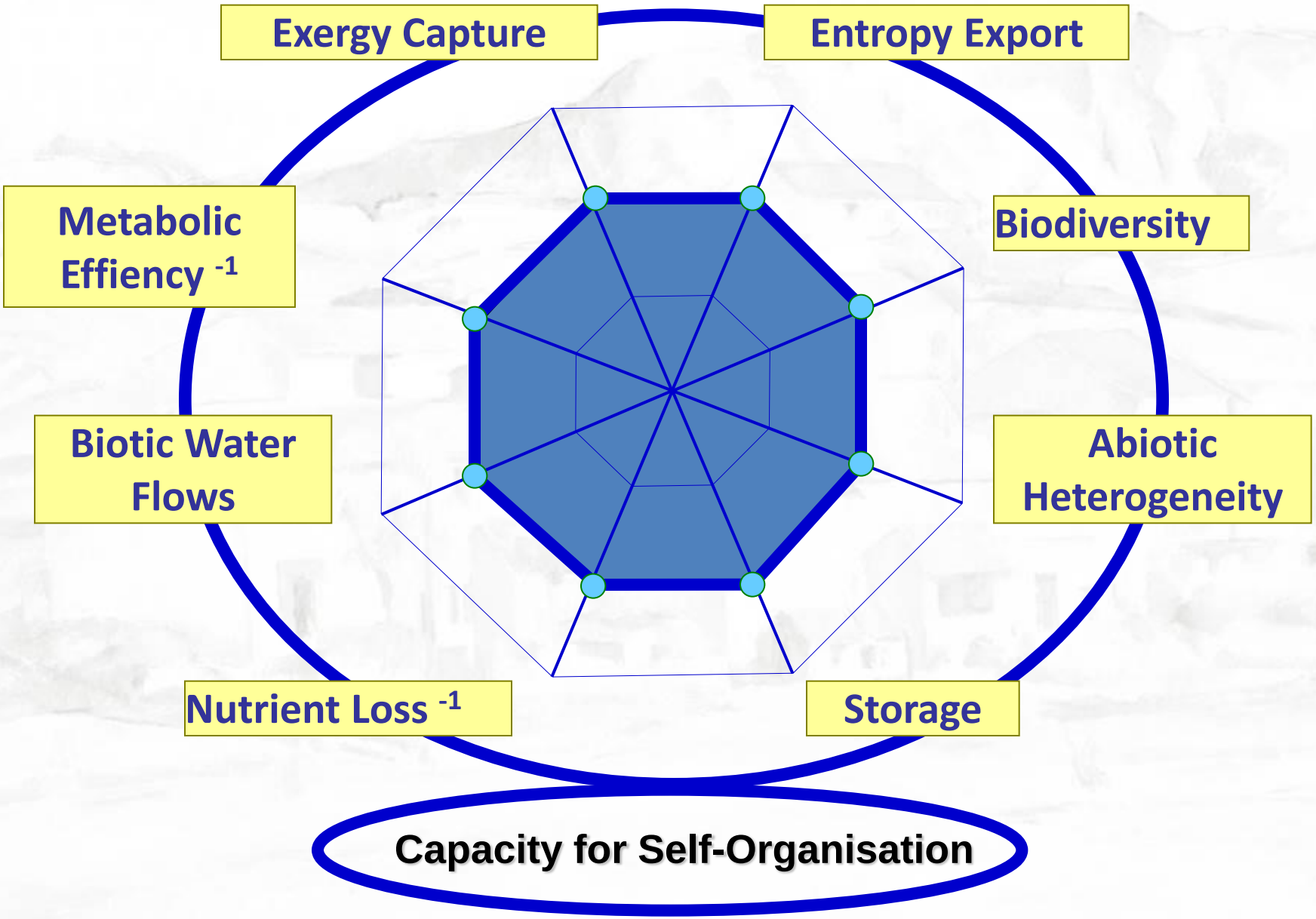

Bornhöveder Seenkette

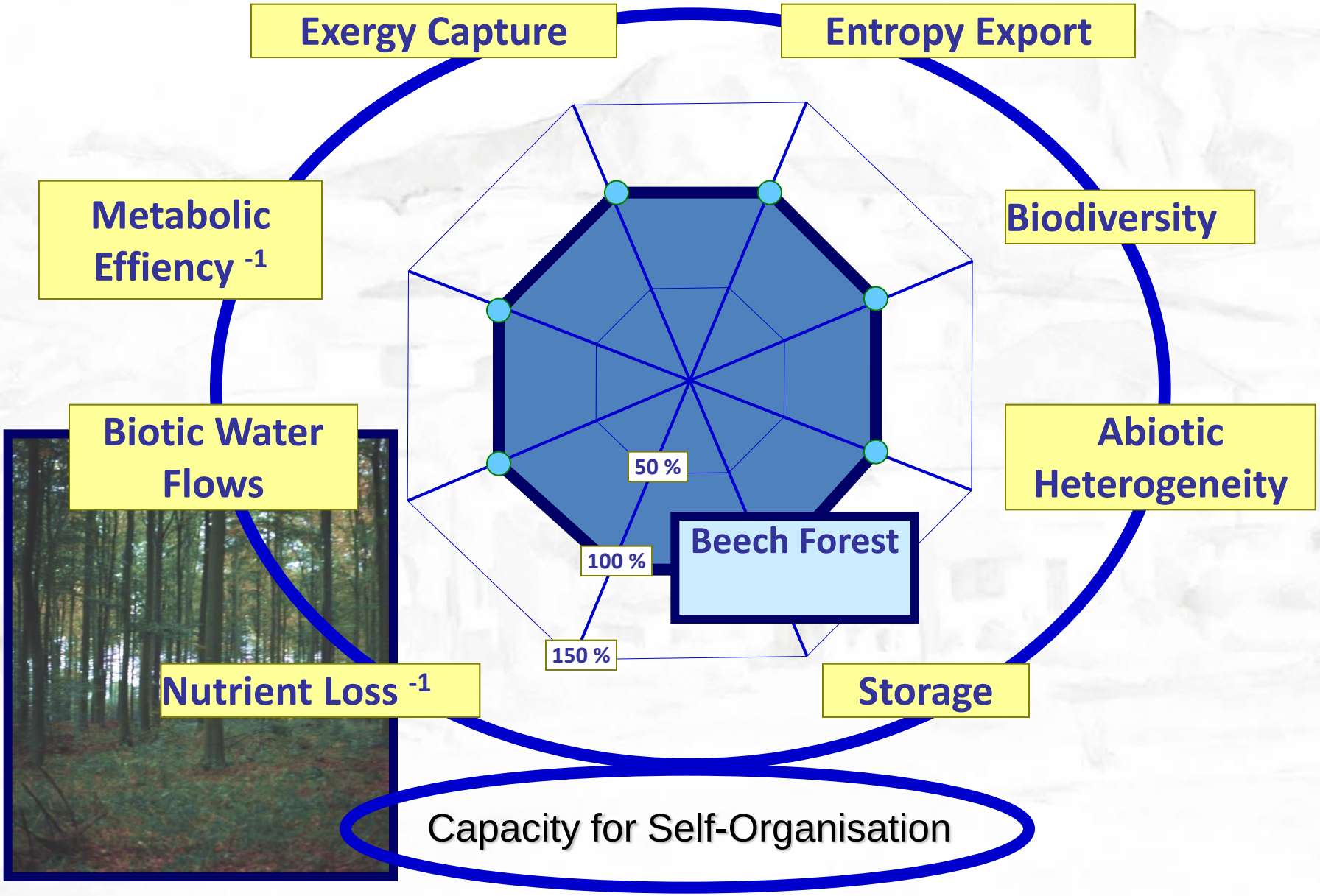


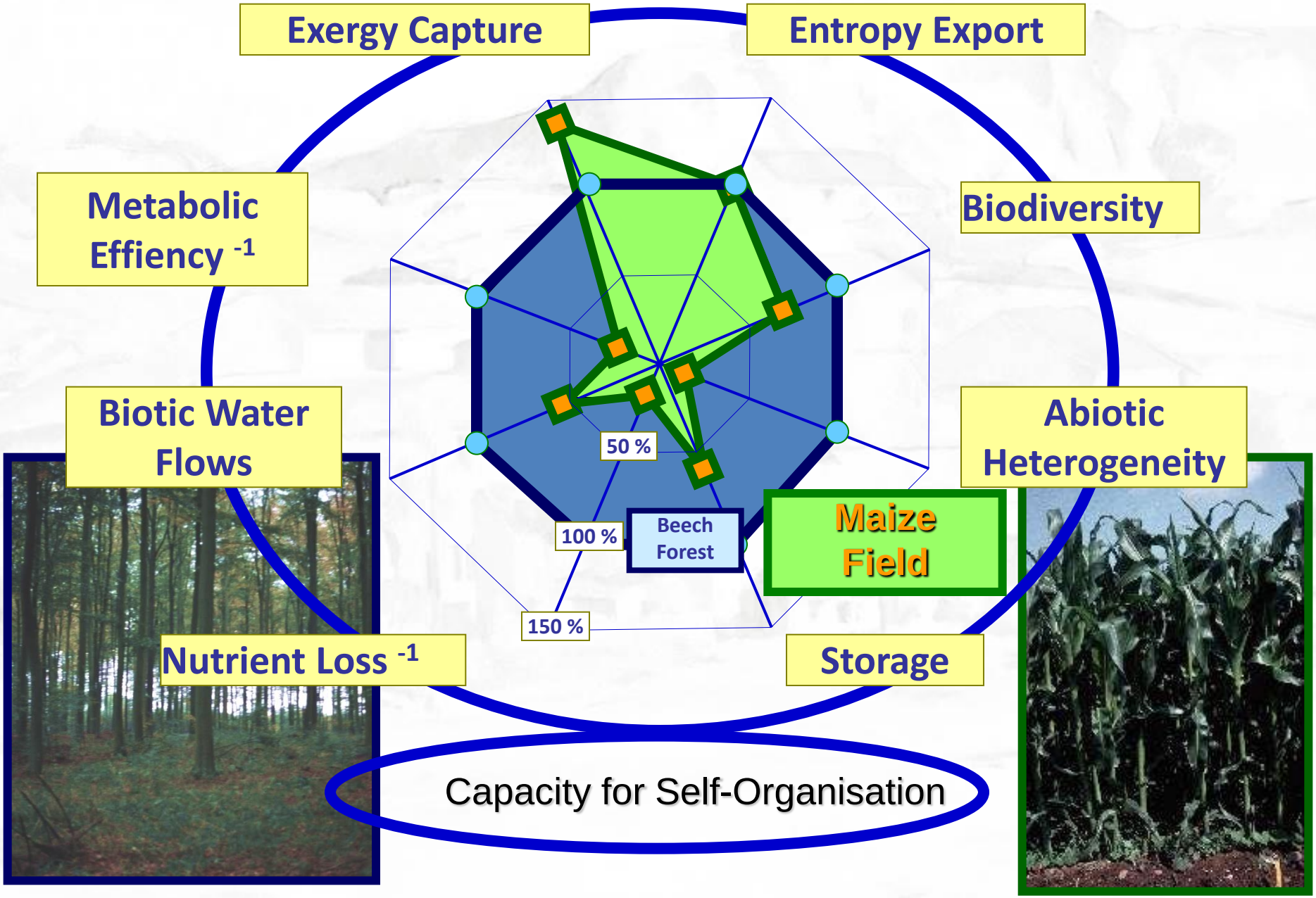

**Proposed Indicators:**

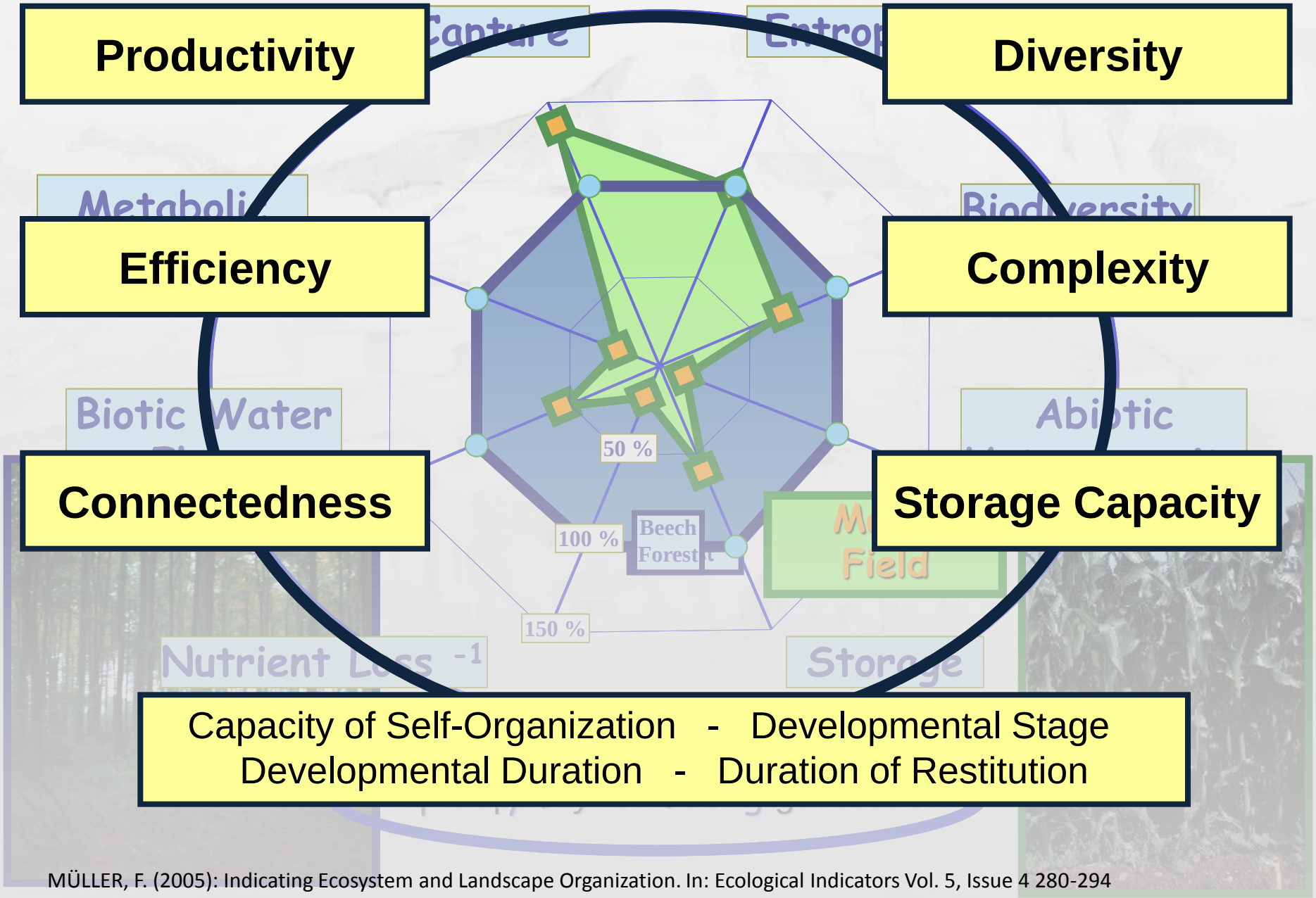
- **Biotop Heterogeneity**
- **Species Abundances**
- **Biotic Water Flows**
- **Exergy Capture**
- **Entropy Export**
- **Metabolic Efficiency**
- **Nutrient Loss**
- **Storage Capacity**

Baumann (2001), Barkmann et al. (2001)


Exergy Capture
Entropy Export
Metabolic Effiency -1
Biodiversity
Biotic Water Flows
Abiotic Heterogeneity
Nutrient Loss -1
Storage
Capacity for Self-Organisation


Exergy Capture
Entropy Export
Metabolic Effiency -1
Biodiversity
Biotic Water Flows
Abiotic Heterogeneity
50 %
100 %
150 %
Beech Forest
Nutrient Loss -1
Storage
Capacity for Self-Organisation


Exergy Capture
Entropy Export
Metabolic Effiency -1
Biodiversity
Biotic Water Flows
Abiotic Heterogeneity
50 %
100 %
150 %
Beech Forest
Maize Field
Nutrient Loss -1
Storage
Capacity for Self-Organisation




Capacity of Self-Organization - Developmental Stage
Developmental Duration - Duration of Restitution

MÜLLER, F. (2005): Indicating Ecosystem and Landscape Organization. In: Ecological Indicators Vol. 5, Issue 4 280-294

# Presentation Structure

- What are indicators and why do we need them?
- What are socio-ecological systems?
- What is sustainability?
- How to indicate sustainability?
- Which is the role of systems approaches?
- How to apply ecosystem theoretical concepts for sustainability indication?
- **How to indicate the contributions of ecosystems for „human“ sustainability?**

# How to indicate the contributions of ecosystems for „human sustainability“

**Human welfare** refers to the **general well being of someone**. It covers aspect ranging from good fortune, health, happiness, prosperity, among others. It is a term commonly associated with the principle of common good.

**Factors of quality of life** (http://www.learnalberta.ca/content/ssoc9/html/):

- nutritious food to eat
- freedom to act on one's beliefs
- access to education
- family life
- sense of hope
- emotional security
- freedom to practice one's chosen religion/spirituality
- strong connections to one's community (may include culture, place, language)
- opportunities for recreation and leisure activities
- healthy environment
- participation in a democracy
- respect for individual and collective identity.

# What is human welfare?

## Determinants and Constituents of Well-being

**Security**
- Ability to live in an environmentally clean and safe shelter
- Ability to reduce vulnerability to ecological shocks and stress

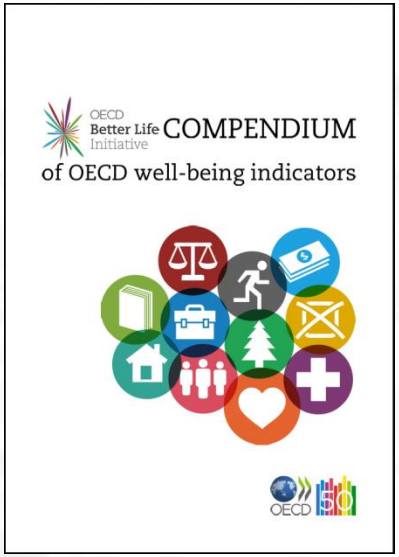
**Basic Material for a Good Life**
- Ability to access resources to earn income and gain a livelihood

**Health**
- Ability to be adequately nourished
- Ability to be free from avoidable disease
- Ability to have adequate and clean drinking water
- Ability to have clean air
- Ability to have energy to keep warm and cool

**Good Social Relations**
- Opportunity to express aesthetic and recreational values associated with ecosystems
- Opportunity to express cultural and spiritual values associated with ecosystems
- Opportunity to observe, study, and learn about ecosystems

**FREEDOMS AND CHOICE**

# How is nature correlated with human well-being?




| Your Better Life Index | Compendium of OECD Well-being Indicators |
|---|---|
| Housing | Housing |
| Income | Income and Wealth |
| Jobs | Jobs and Earnings |
| Community | Social Connections |
| Education | Education and Skills |
| Environment | Environmental Quality |
| Governance | Civic engagement and Governance |
| Health | Health Status |
| Life satisfaction | Subjective Well-being |
| Safety | Personal Security |
| Work-Life balance | Work and Life |

# How is nature correlated with human well-being?

Provision of **environmental goods**

Provision of **supporting environmental processes**

Provision of **non-matrerial benefits**

**Your Better Life Index**

- Housing
- Income
- Jobs
- Community
- Education
- Environment
- Governance
- Health
- Life satisfaction
- Safety
- Work-Life balance

**Compendium of OECD Well-being Indicators**

- Housing
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- Social Connections
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- Work and Life

# How is nature correlated with human well-being?

Provision of **ecosystem services**

**Your Better Life Index**

- Housing
- Income
- Jobs
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- Education
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- Civic engagement and Governance
- Health Status
- Subjective Well-being
- Personal Security
- Work and Life

## What are Ecosystem Services?

**"Ecosystem services are
the conditions and processes
through which natural ecosystems,
and the species that make them up,
sustain and fulfill human life."**

**(Daily, 1997)**

| | |
|---|---|
| **Daily (1997)** | Ecosystem services are the **conditions and processes** through which natural ecosystems, and the species that make them up, sustain and fulfill human life. |
| **Costanza et al. (1997)** | Ecosystem **goods** (such as food) and **services** (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions. |
| **Boyd and Banzhaf (2007)** | **(Final) Ecosystem services** are components of nature, directly enjoyed, consumed, or used to yield human well-being. |
| **Fisher and Turner (2008)** | Ecosystem services are the aspects of ecosystems **utilized (actively or passively**) to produce human well-being. |
| **Millenium Ecosystem Assesment** | - Ecosystem services are the benefits people derive from ecosystems.<br>- Ecosystem services are the benefits people obtain from ecosystems and **also the processes that produce** or support the production of ecosystem goods. |
| **TEEB (2010)** | Ecosystem Services are **the direct and indirect contributions** of ecosystems to human well-being. The concept "ecosystem goods and services" is synonymous with ecosystem services. |
| **Haines-Young and Potschin (2009)** | Ecosystem services are the contribution which the biotic and abotic components of ecosystems jointly and directly make to human well-being; **an 'end-product' of nature.** |
| **Burkhard et al. (2012)** | Ecosystem services are the contributions of ecosystem structure and function **– in combination with other inputs –** to human well-being. |
| **UK National Ecosystem Assessment** | Ecosystem services are the benefits provided by ecosystems that contribute to making **human life both possible and worth living.** |

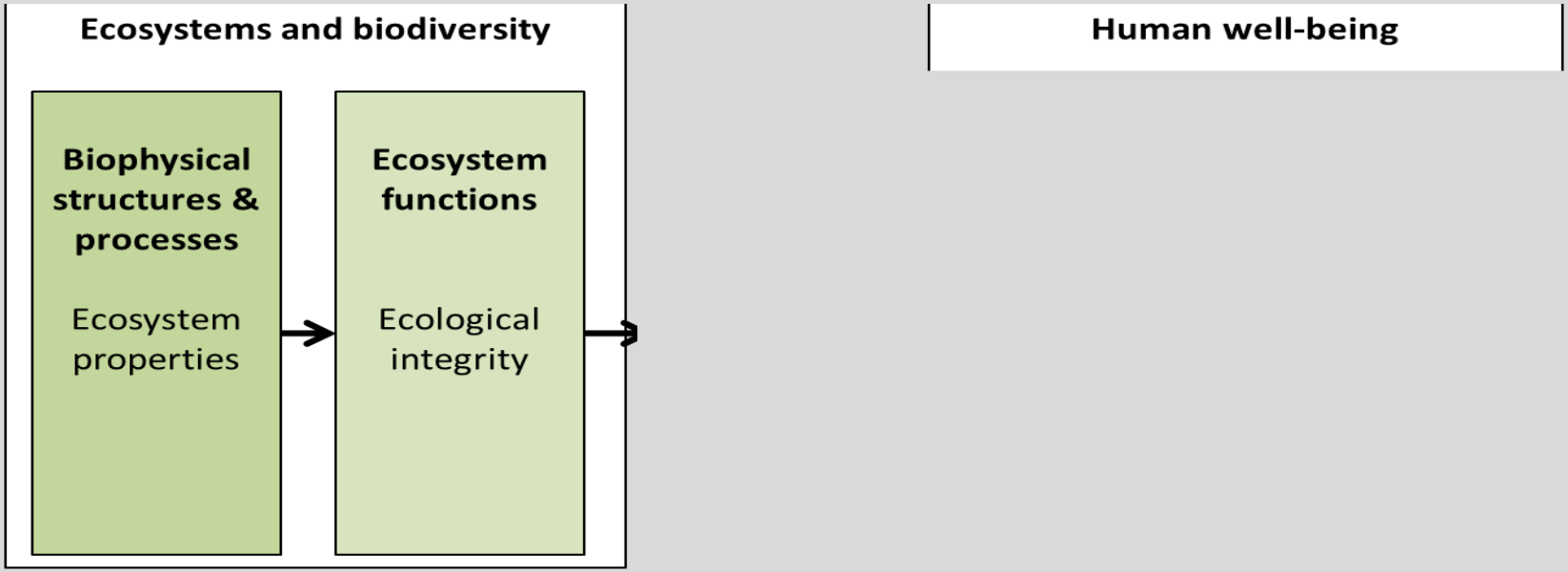
# The ecosystem service cascade
after Haines-Young and Potschin (2010)

## How are ecosystem services produced?

| Ecosystems and biodiversity | Human well-being |
| --- | --- |

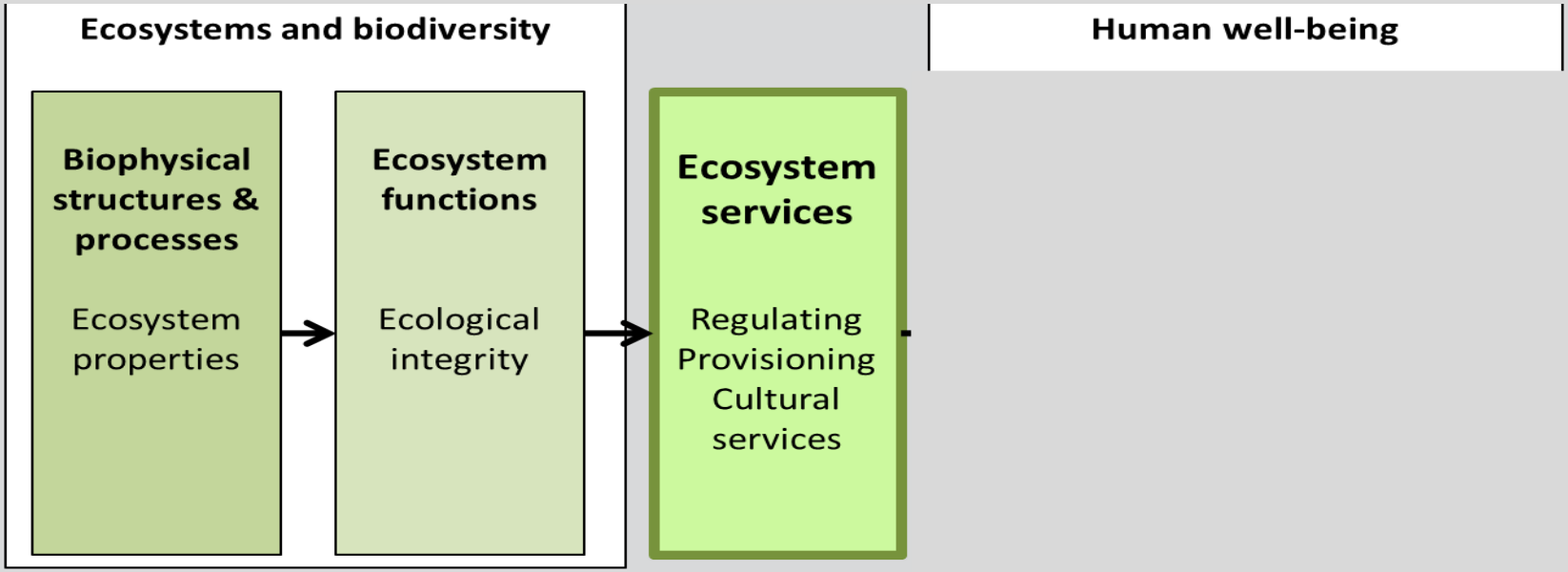
# The ecosystem service cascade
after Haines-Young and Potschin (2010)

## How are ecosystem services produced?



# The ecosystem service cascade
after Haines-Young and Potschin (2010)

## How are ecosystem services produced?



# The ecosystem service cascade
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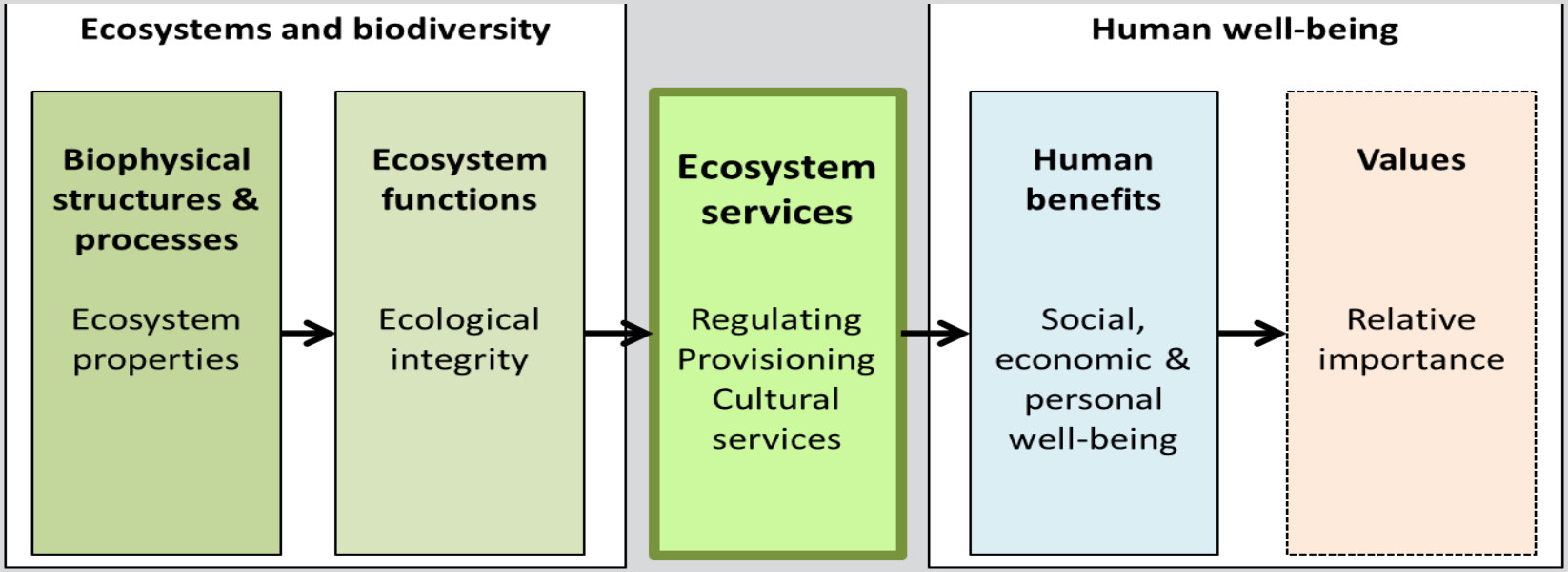
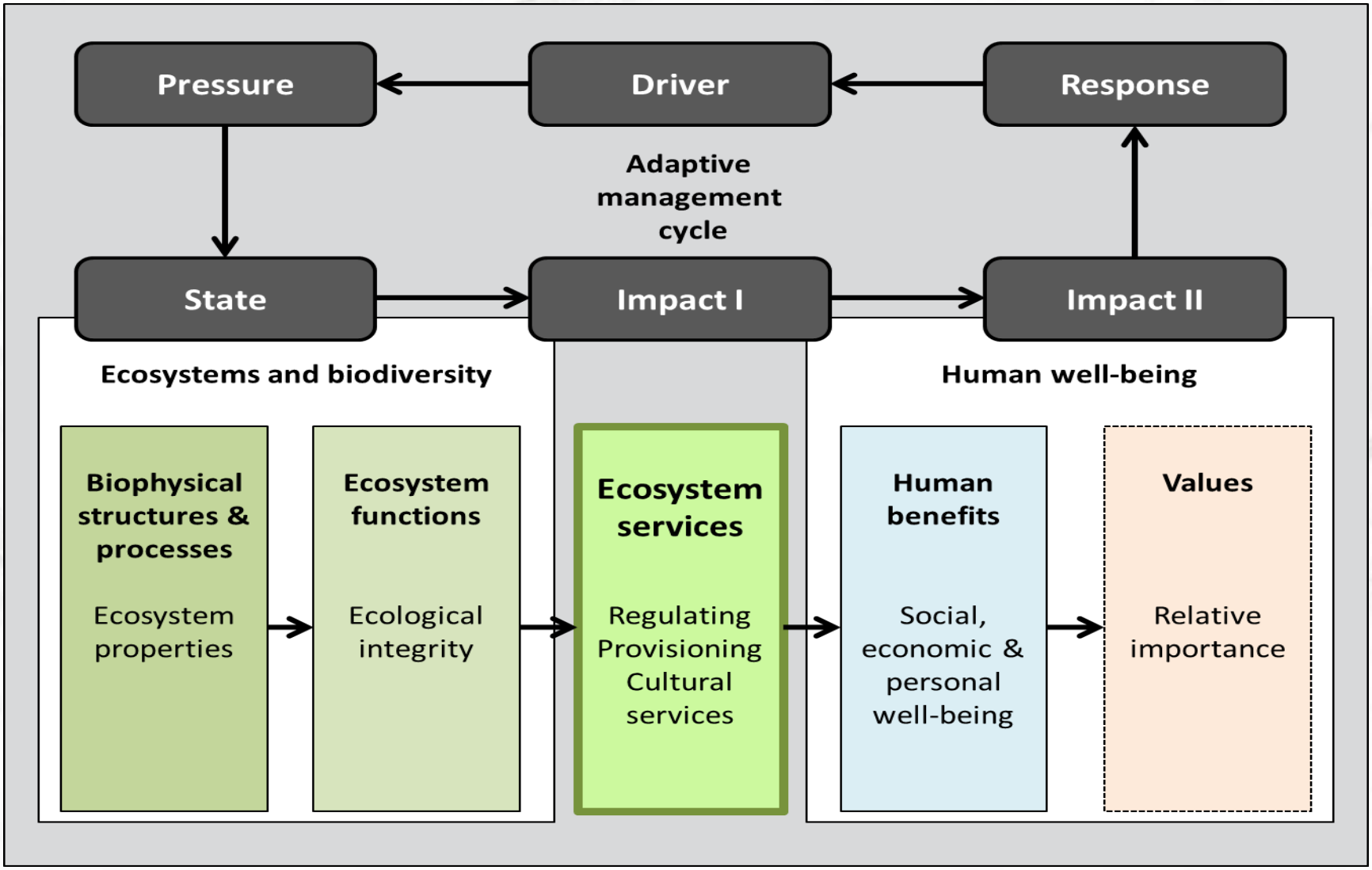
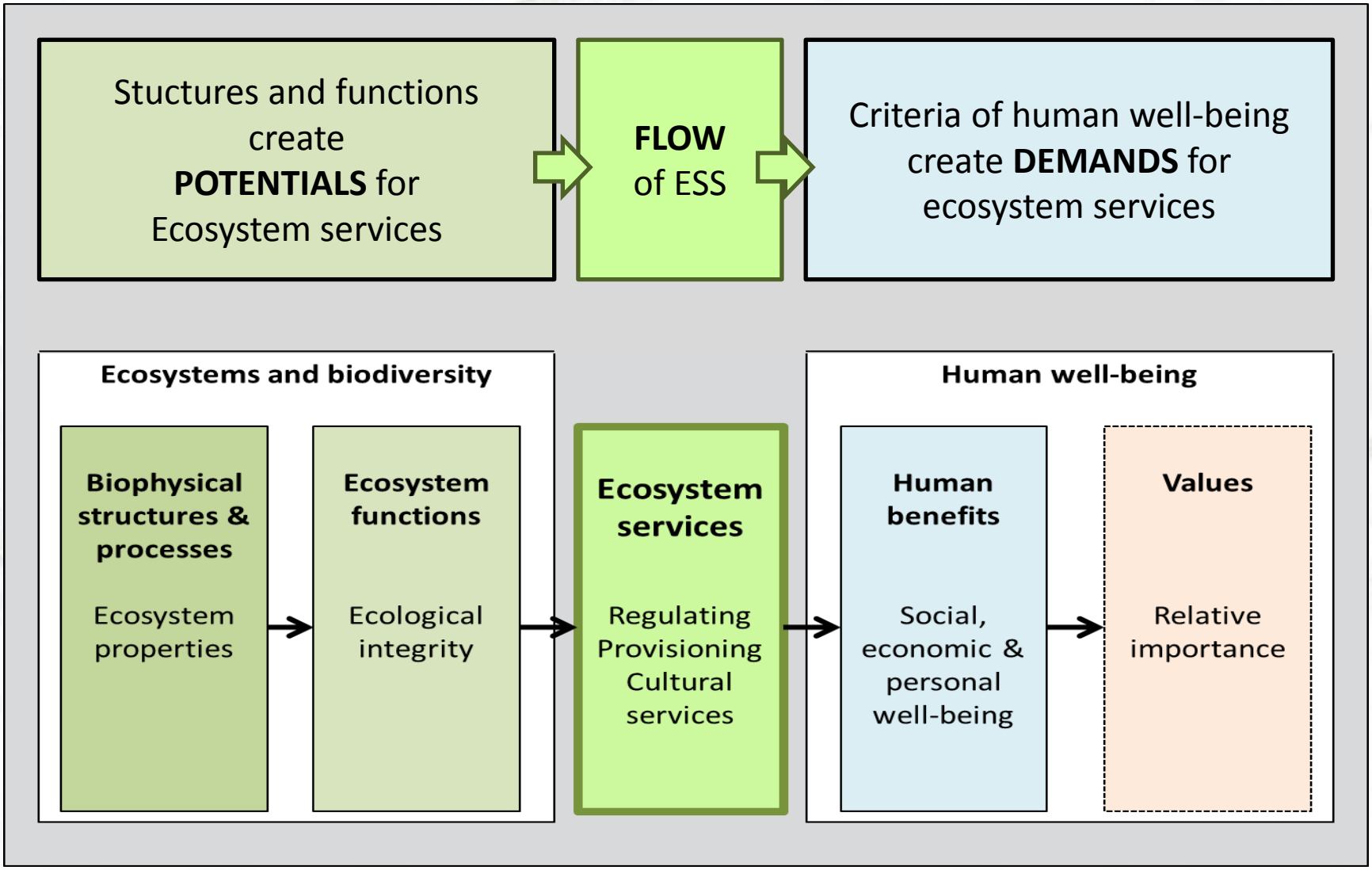
## How are ecosystem services produced?



# The ecosystem service cascade
after Haines-Young and Potschin (2010)



# The ecosystem service cascade
after Haines-Young and Potschin (2010)



# Types of ecosystem services

Millenium Assessment (2005)

- **Provisioning**

Goods produced or provided by ecosystems

**Production Functions**

- **Regulating**

Benefits obtained from regulation of ecosystem processes

**Regulation Functions**

- **Cultural**

Non- material benefits from ecosystems

**Information Functions**

Photo credits (left to right, top to bottom): Purdue University, WomenAid.org, LSUP, NASA, unknown, CEH Wallingford, unknown, W. Reid, Staffan Widstrand

# Provisioning services

## Goods produced or provided by ecosystems

- **Food**
  - Crops
  - Livestock
  - Capture Fisheries
  - Aquaculture
  - Wild Foods
- **Fiber**
  - Timber
  - Cotton, Hemp, Silk
  - Wood Fuel
- **Energy**
- **Genetic Resources**
- **Biochemicals**
- **Freshwater**

Millenium Assessment (2005)

# Regulating services

## Benefits obtained from regulation of ecosystem processes

- **Air Quality Regulation**
- **Climate Regulation**
  - Global ($CO_2$ sequestration)
  - Regional and local
- **Erosion Regulation**
- **Nutrient Regulation**
- **Water Purification**
- **Disease Regulation**
- **Pest Regulation**
- **Pollination**
- **Natural Hazard Regulation**

Millenium Assessment (2005)

# Cultural services

## Non-material benefits obtained from ecosystems

Millenium Assessment (2005)

- Spiritual and Religious Values
- Knowledge Systems
- Educational values
- Inspiration
- Aesthetic Values
- Social Relations
- Sense of Place
- Recreation and Ecotourism

# Different service classifications (examples)

| | TEEB | CICES | Kiel |
|---|---|---|---|
| **Ecosystem service categories** | • Provisioning<br>• Regulating<br>• Habitat<br>• Cultural | • Provisioning<br>• Regulation & Maintenance<br>• Cultural<br>• Abiotic outputs from natural systems | • Regulating Provisioning<br>• Cultural |
| **Amount of ecosystem services considered** | 17 | 53 classes in 22 groups | 28 |
| **Indicator quantification units suggested** | Yes | No | Yes |
| **Indicator peculiarities** | Indicators should be convertible into economic values | Focusing on outputs directly contributing to human well-being | Distinction between ecosystem potentials, flows an demands |

# Sustainability of ecosystem services

*… "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

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# Sustainability of ecosystem services

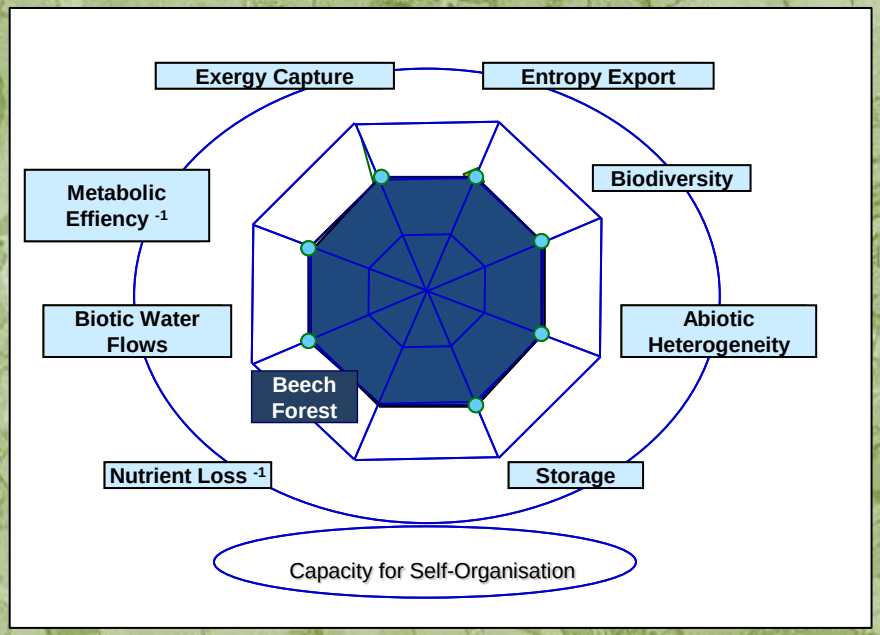
*… "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

- **a development that obtains the potentials of ecosystems to provide basic goods and services on a long-term and interregional scale.**

- **a development that supports ecological integrity (which determines the conditions of ecosystem service potentials).**

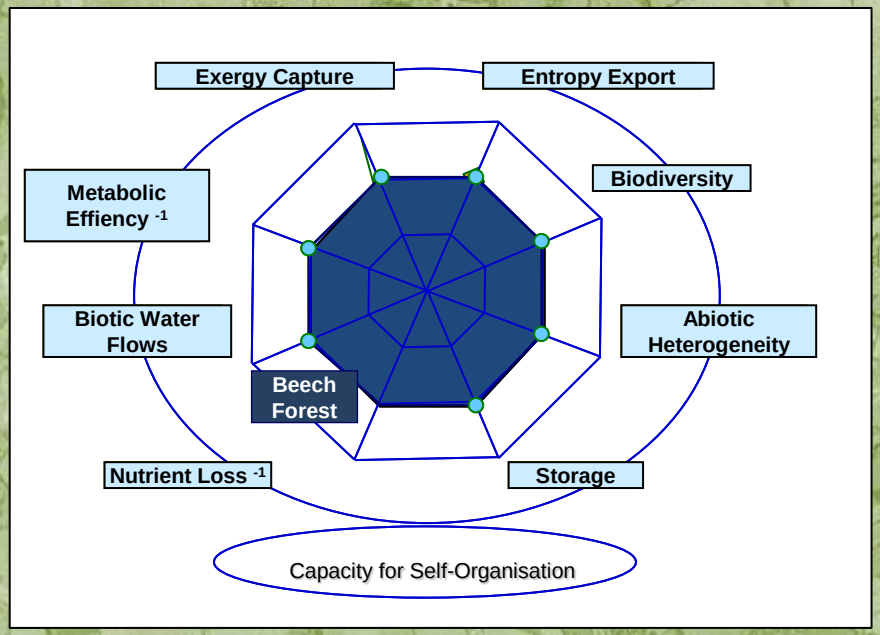
# Case studies

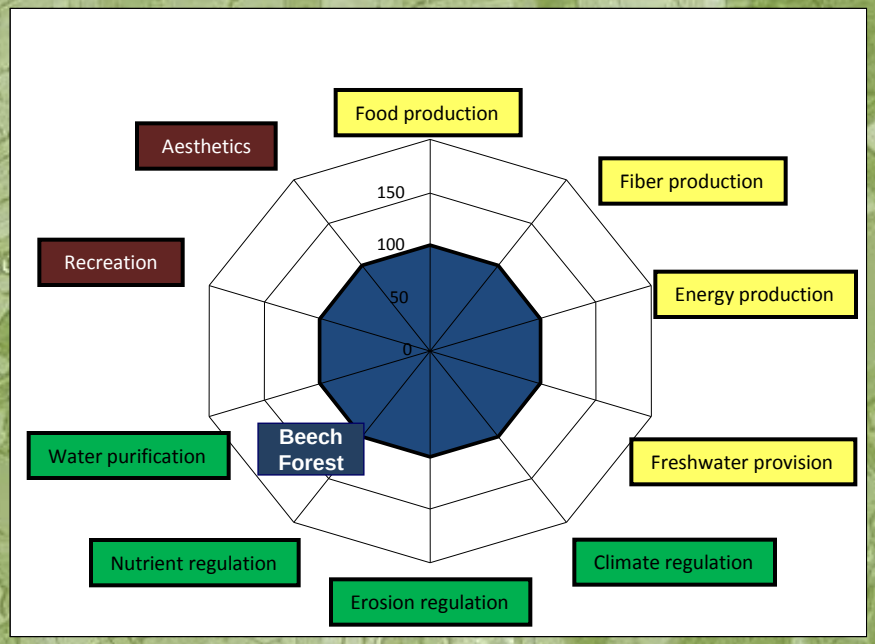
# Ecosystem integrity
(Supporting services)



**Ecosystem integrity**
(Supporting services)

**Ecosystem services**



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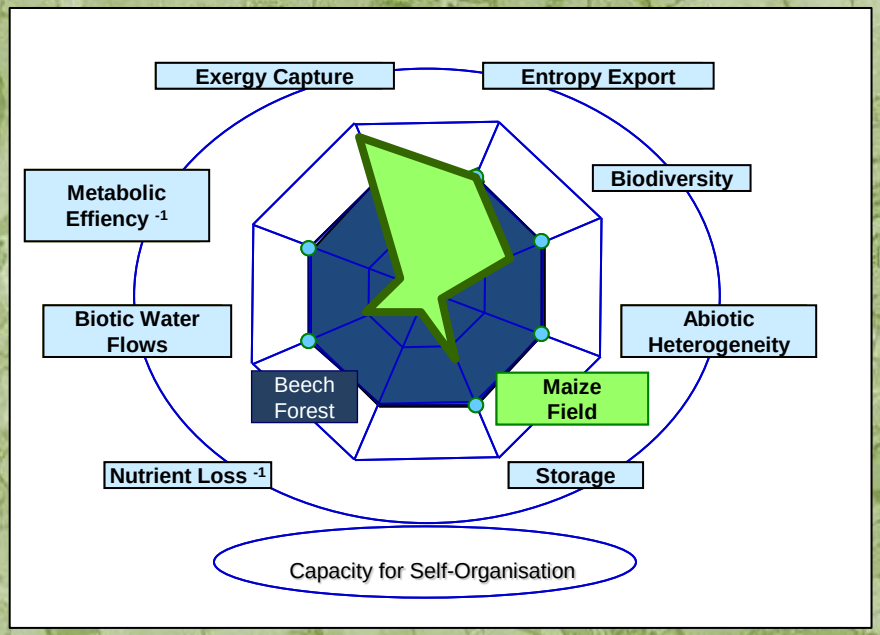


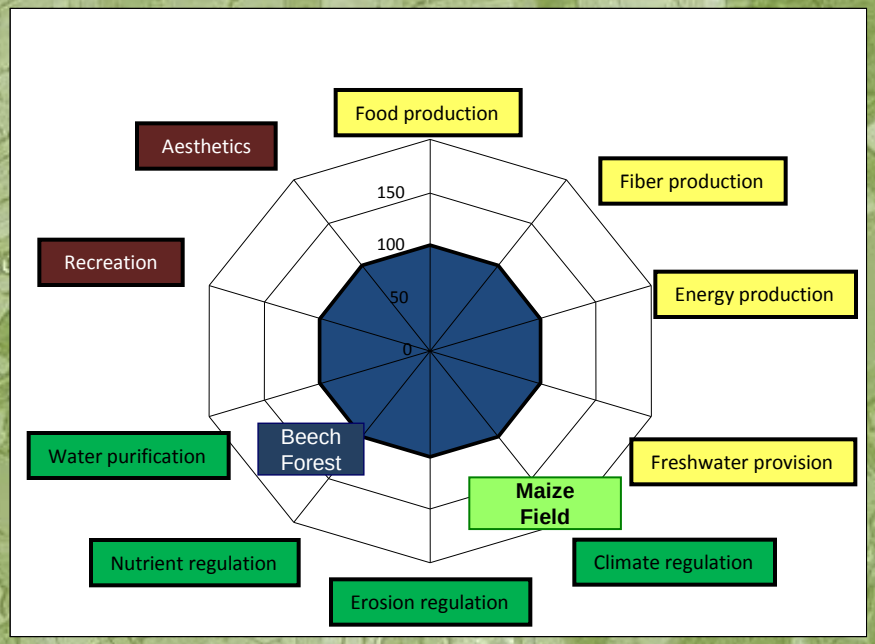

## Ecosystem integrity
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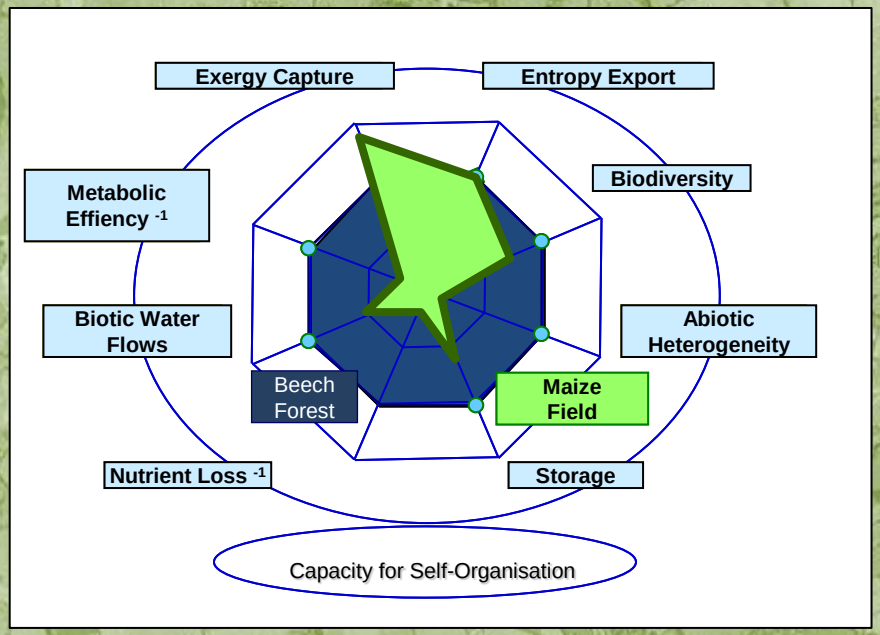
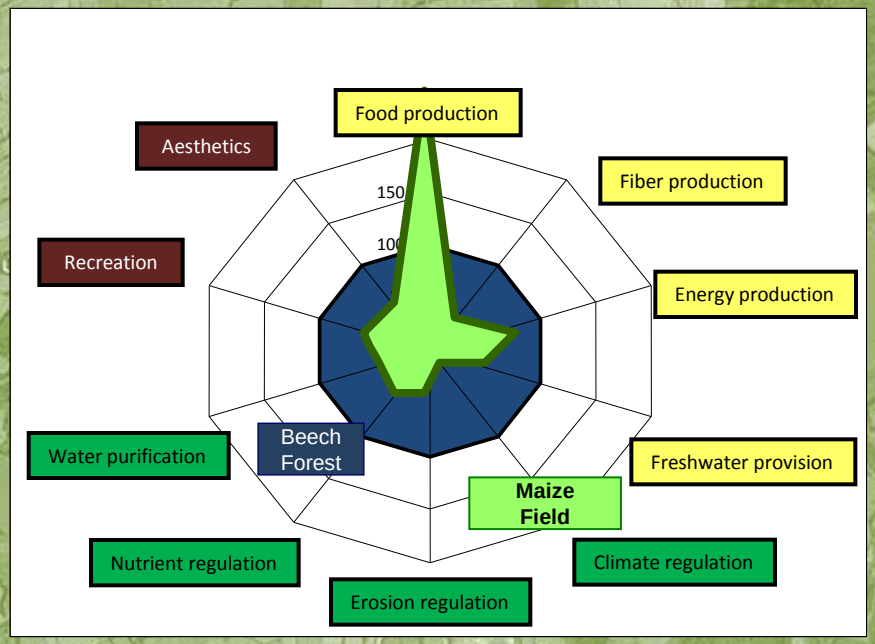
## Ecosystem services

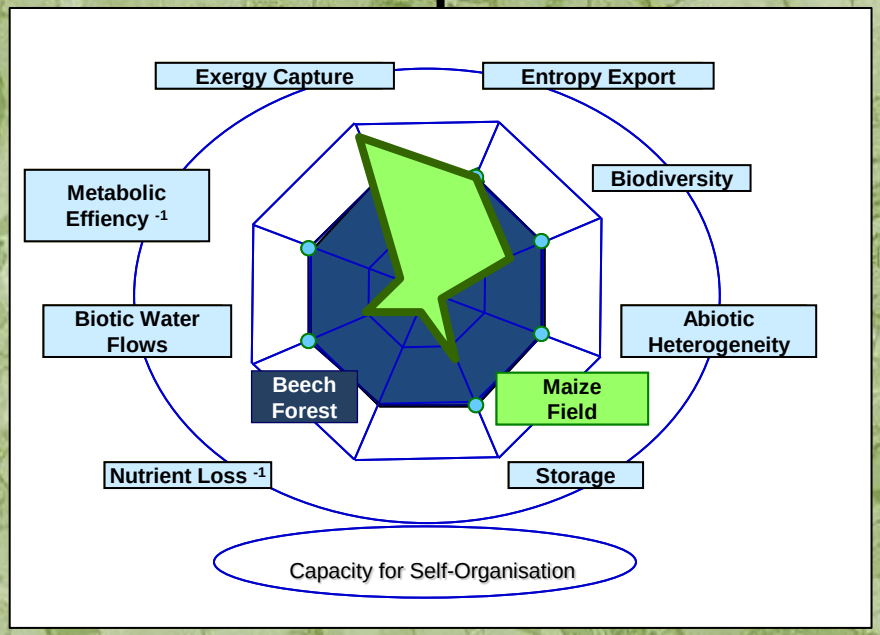


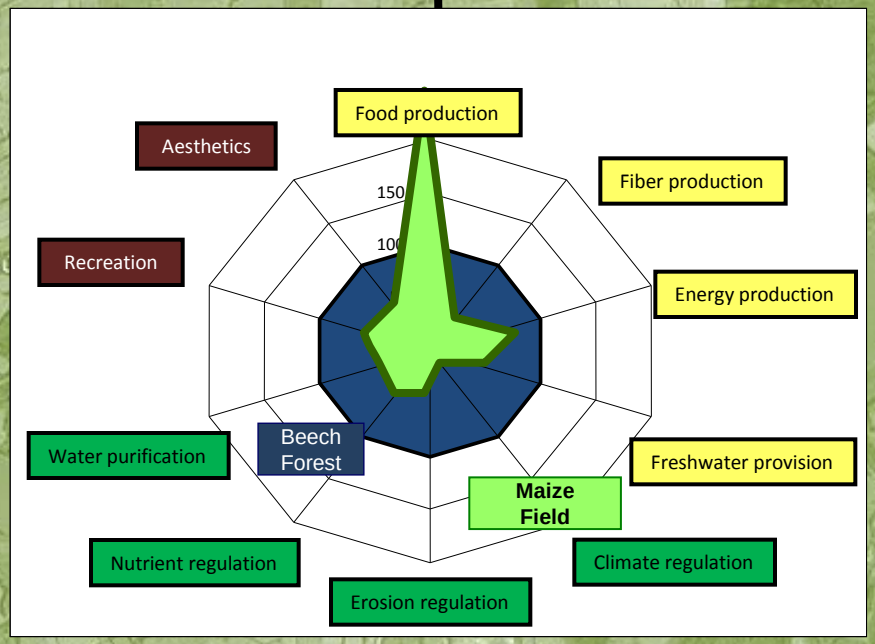



# Distinct information

## Ecosystem integrity
(Supporting services)

## Ecosystem services



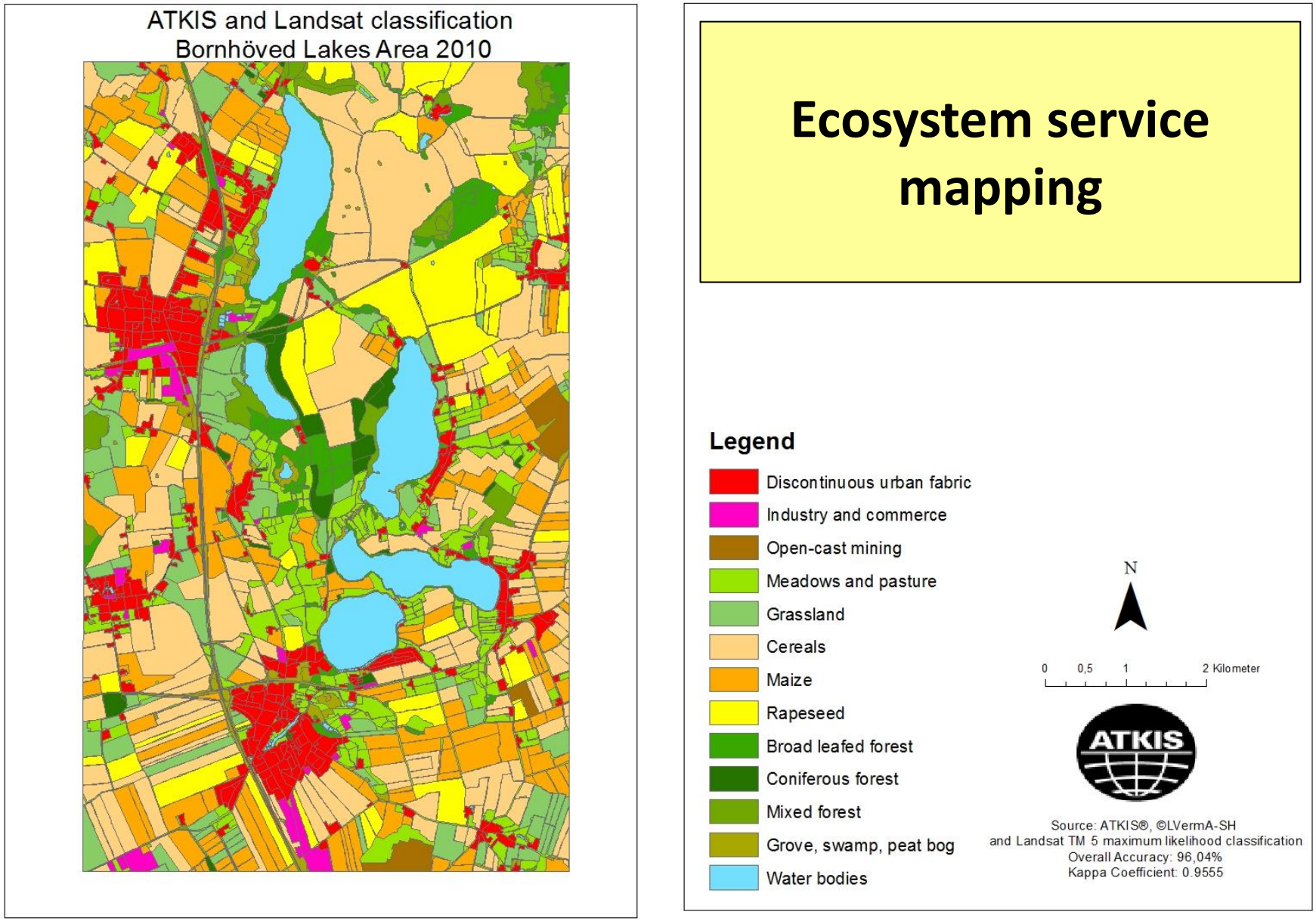
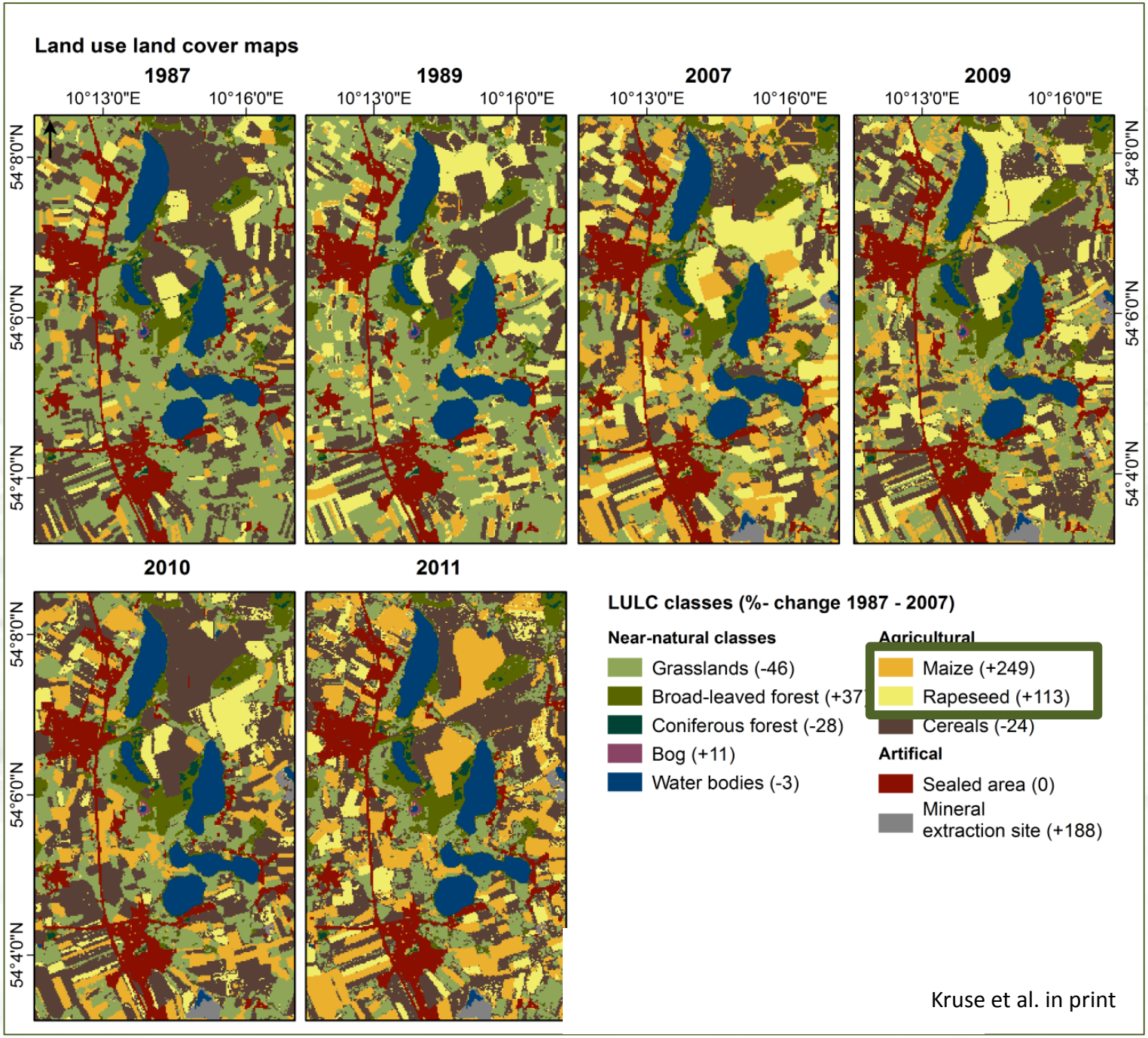


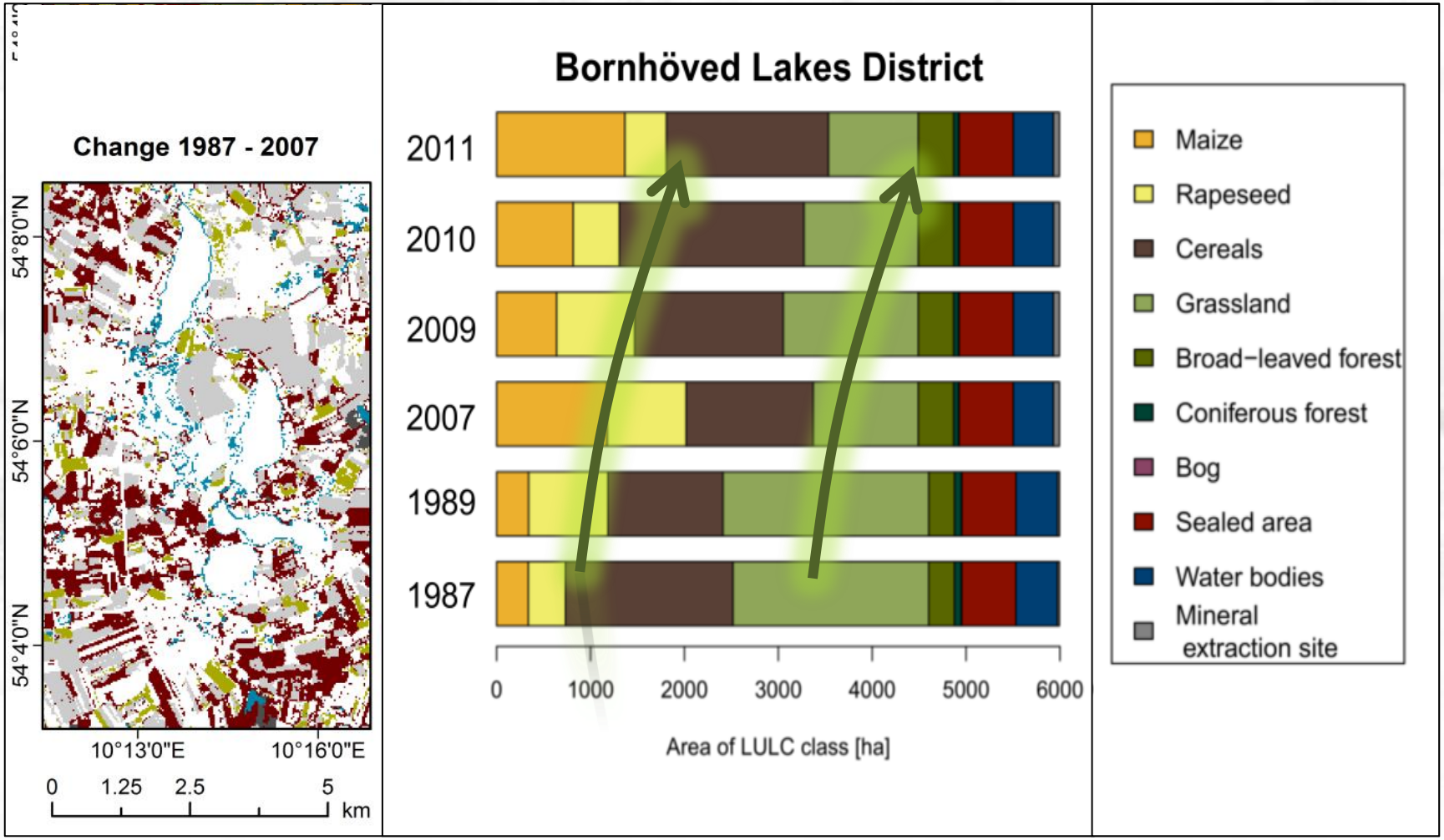

Figure 4: Land us/ land cover map for the Bornhöved Lakes District in the year 2010 based on ATKIS, InVeKoS agricultural data and the multiseasonal LANDSAT TM 5 maximum likelihood classification

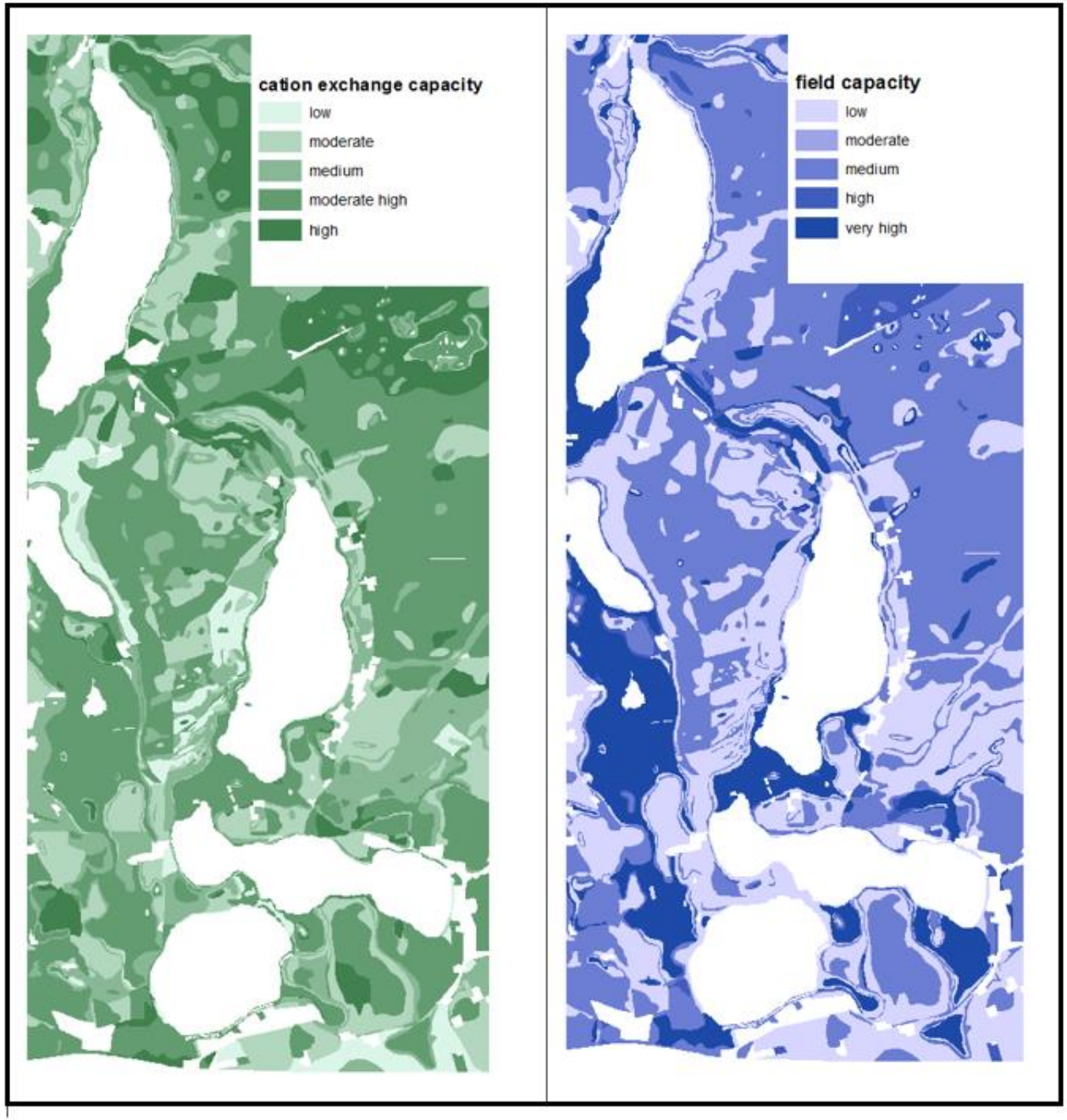
# Land cover change




Kruse et al. in print

# Land use dynamics

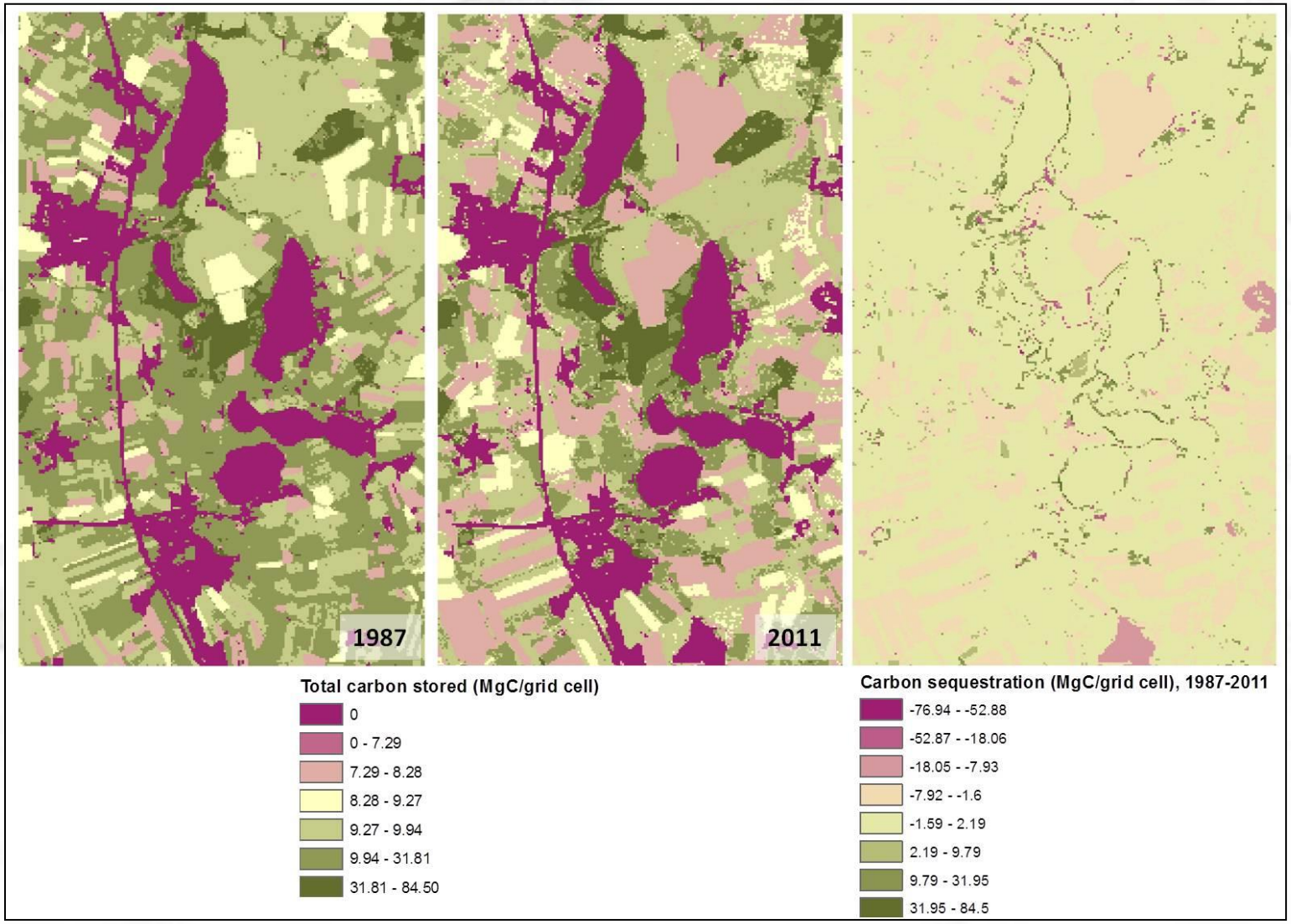




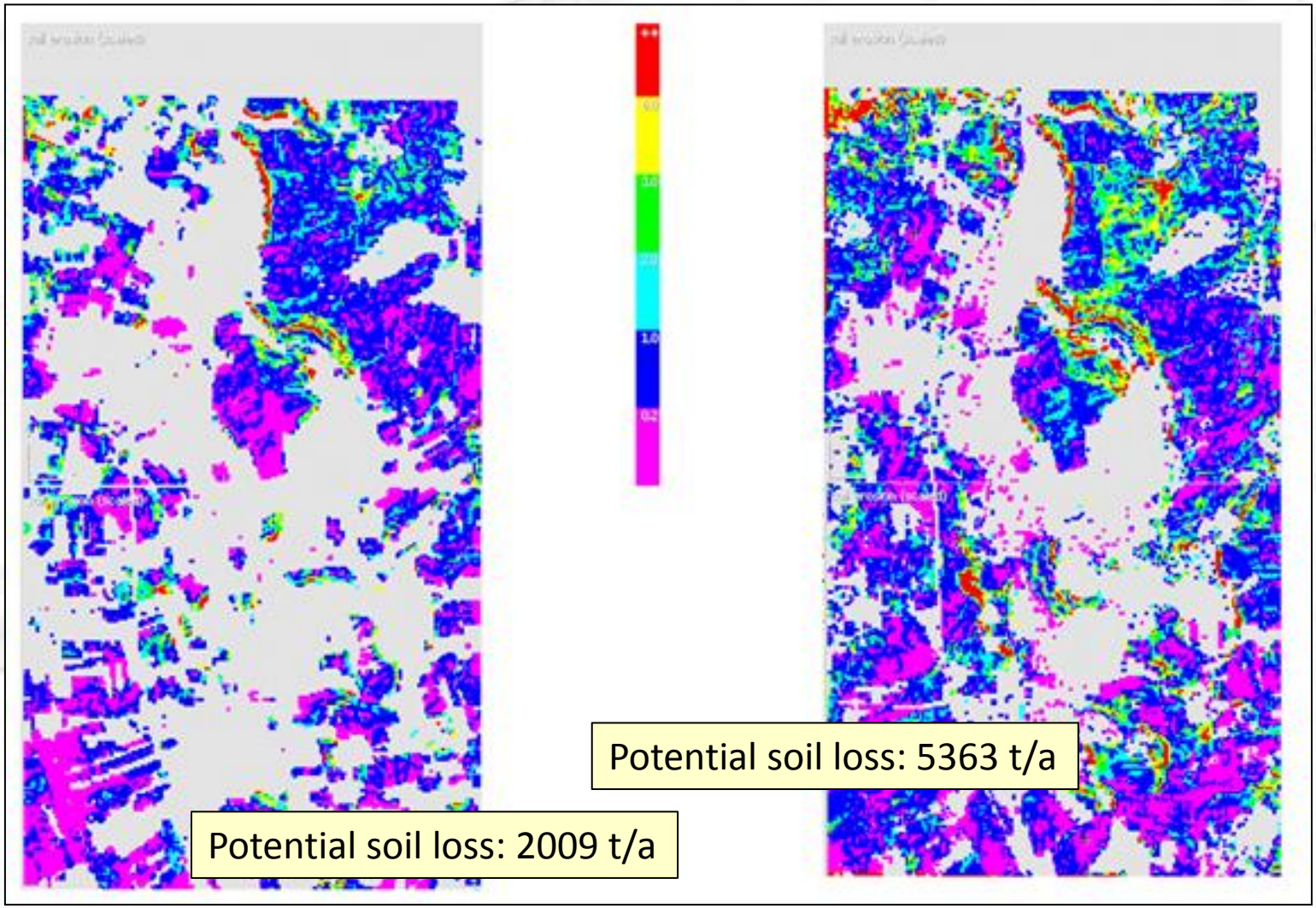

**Distribution of potential <u>nutrient regulation</u> (left) and <u>water flow regulation</u> (right) of the Bornhöved Lakes District (data from Schleuß 1992),**

**from Kruse et al. in print**

# InVEST results for total carbon stored in 1987 (left) and 2011 (middle) and carbon sequestration from 1987-2011 (in Mg C / grid cell) from Kruse et al. in print



**GIS CAME application: Soil erosion on agricultural areas in 1987 (left) and 2011 (right) in the Bornhöved Lakes District (scale: pink <0.2 to red >6 (t / (ha*a)) from Kruse et al. in print**

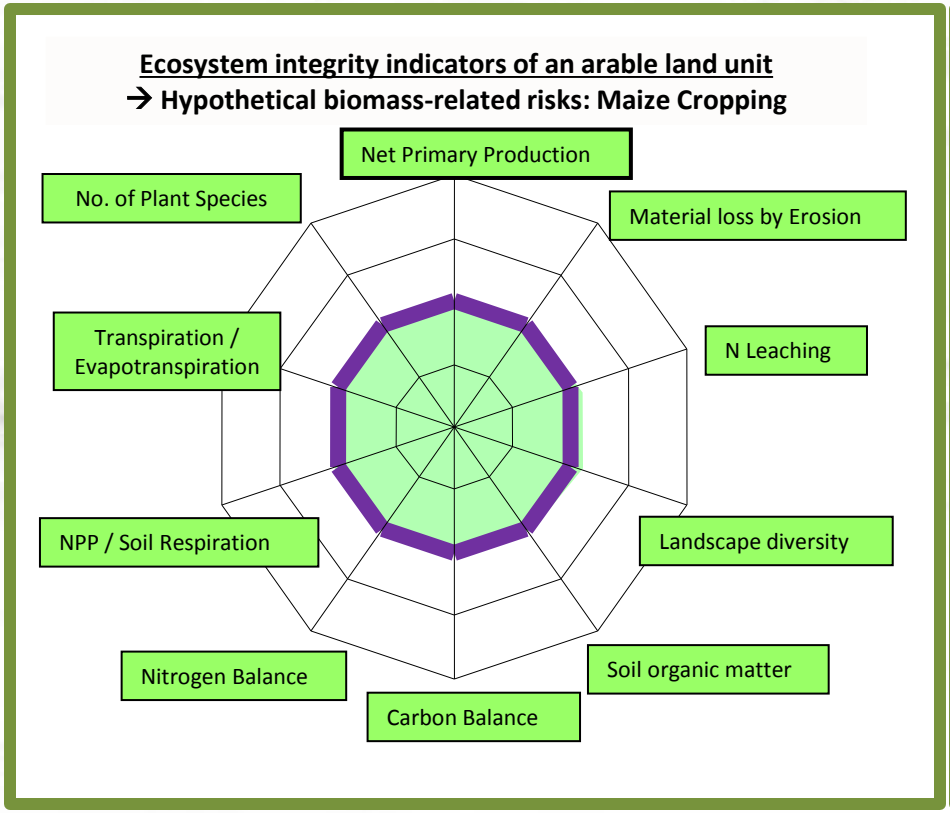


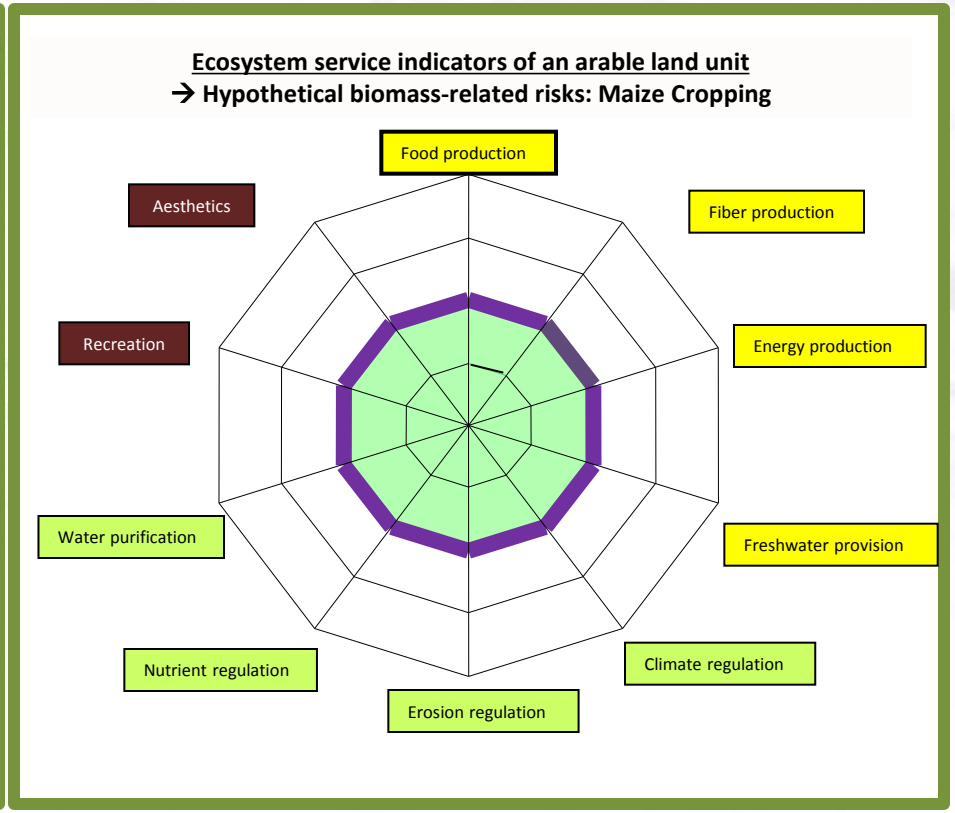
# Consequences of biomass cropping

## A. Average arable ecosystems

**Ecosystem integrity**
(Supporting services)

**Ecosystem services**



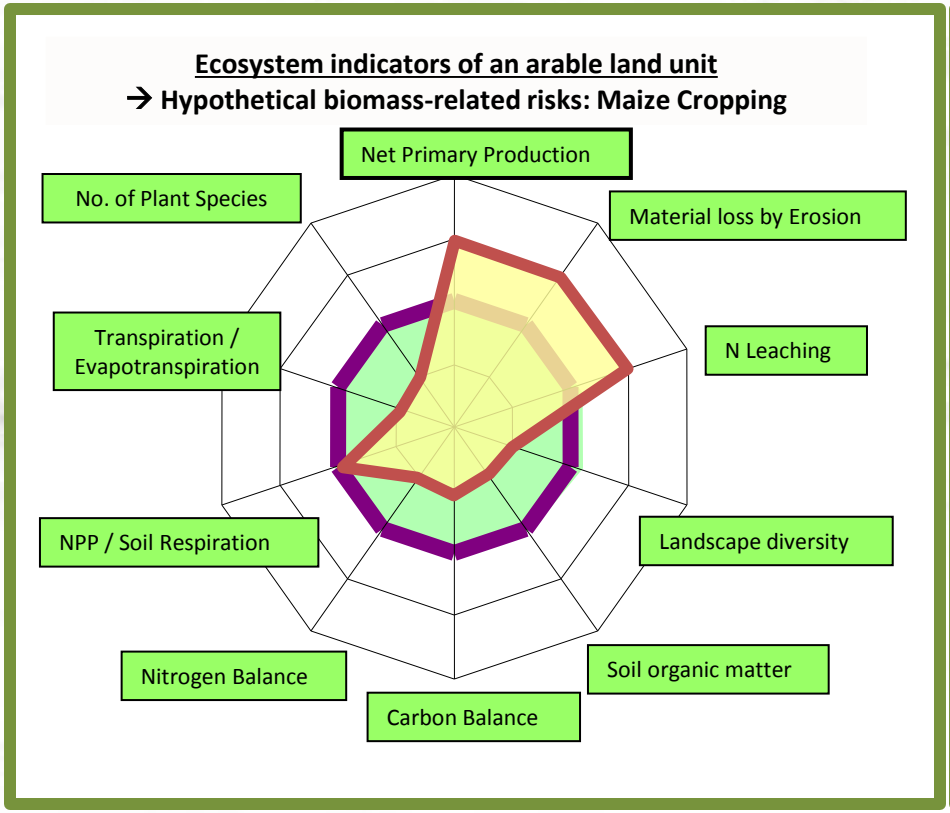



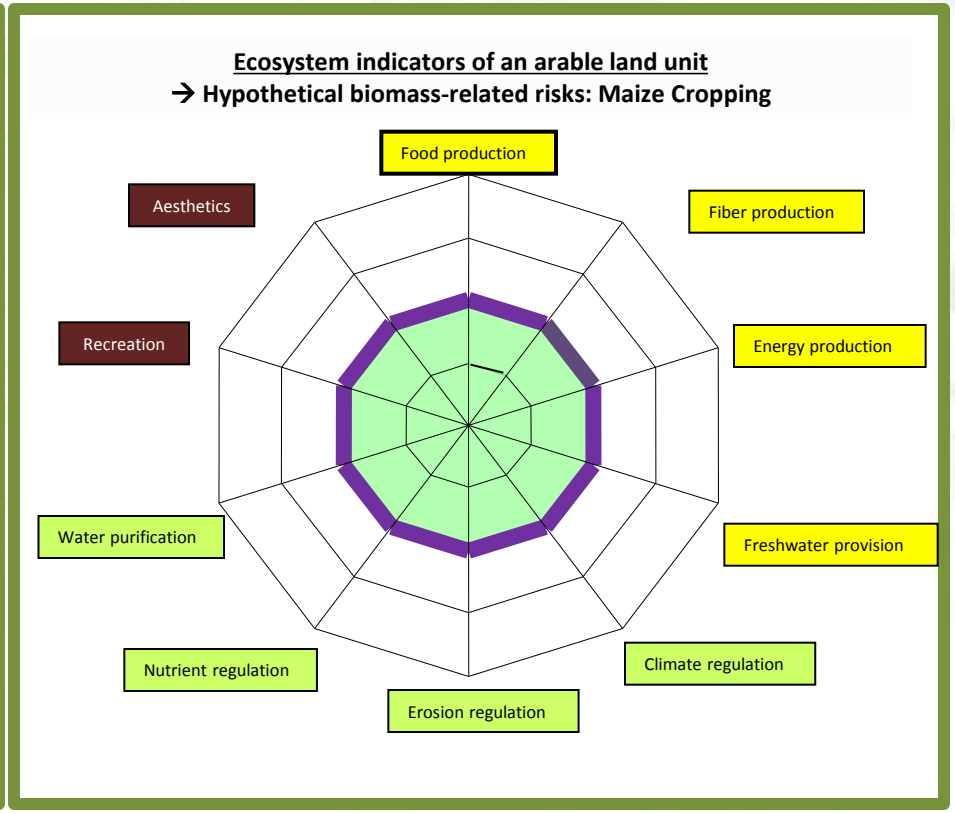
# Consequences of biomass cropping

## B. Biomass for energy (maize)

**Ecosystem integrity**
(Supporting services)

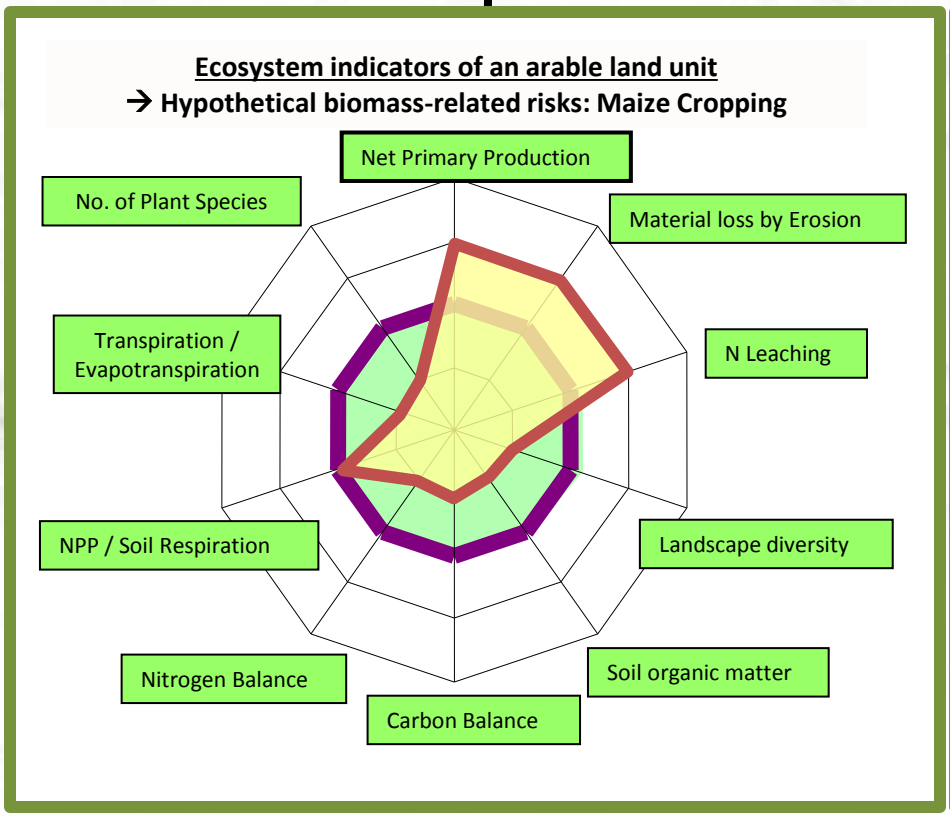
**Ecosystem services**



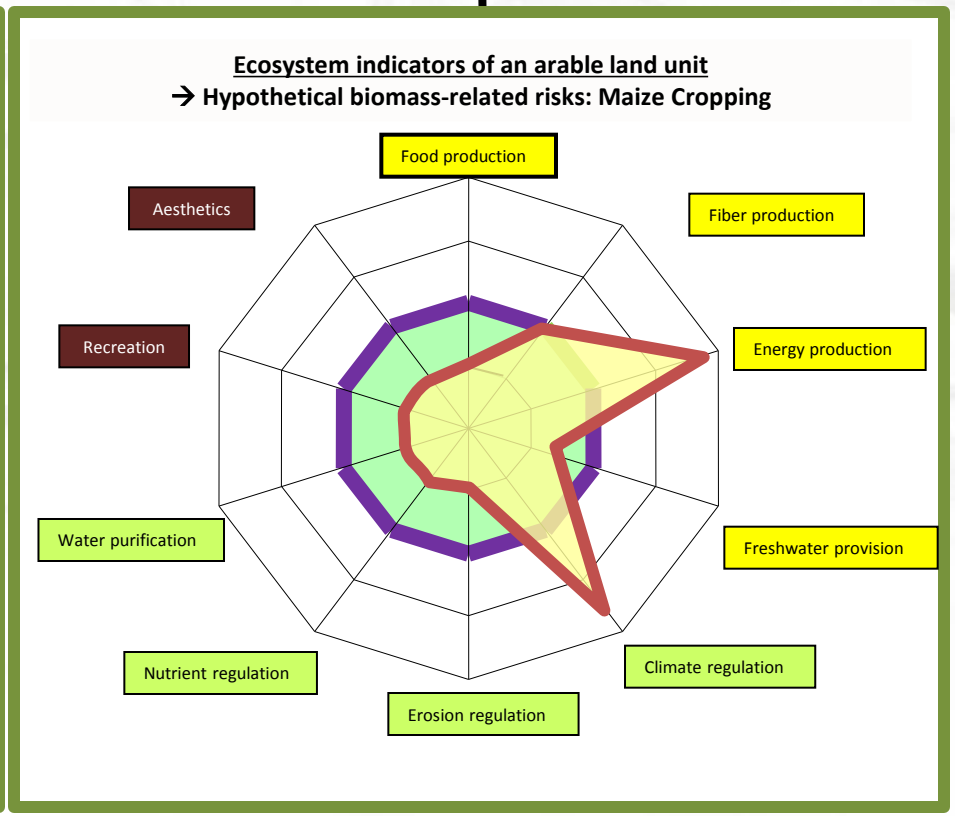



# Distinct information

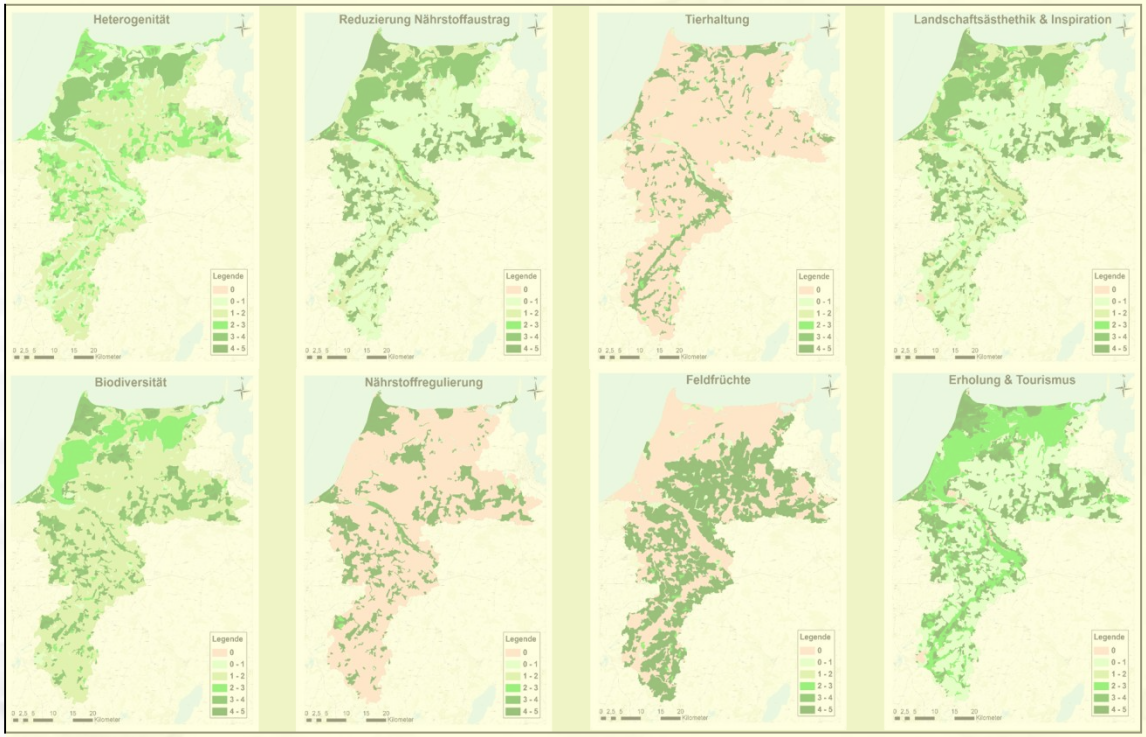
## Ecosystem integrity
(Supporting services)

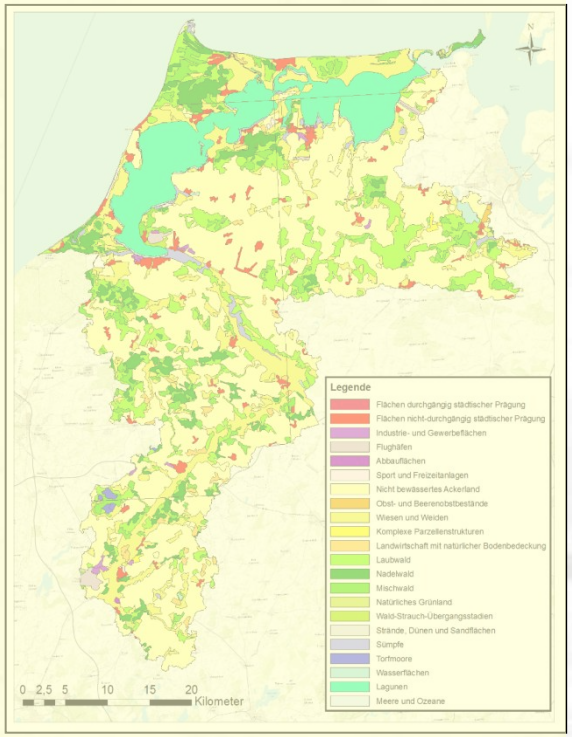



## Ecosystem services



# Translating land cover information into ecosystem service potentials




**Attempts to make ecosystem service approaches more suitable for environmental planning**

# Support of ecological integrity & ecosystem service supply in different land covers

*- basic assumptions -*

| Corine Land Cover classes | Ecological integrity | | | | | | | | Regulating services | | | | | | | | | | | | Provisioning services | | | | | | | | | | | | | Cultural services | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 Exergy capture | 2 Entropy production | 3 Storage capacity | 4 Cycling & Nutrient loss reduction | 5 Biotic water flows | 6 Metabolic efficiency | 7 Heterogeneity | 8 Biodiversity | 9 Global climate regulation | 10 Local climate regulation | 11 Air quality Regulation | 12 Water flow regulation | 13 Water purification | 14 Nutrient regulation | 15 Erosion regulation | 16 Natural hazard regulation | 17 Pollination * | 18 Pest and disease control * | 19 Regulation of waste * | 20 Crops | 21 Biomass for energy | 22 Fodder ** | 23 Livestock (domestic) | 24 Fibre | 25 Timber | 26 Wood Fuel | 27 Fish, seafood & edible algae | 28 Aquaculture | 29 Wild foods & resources | 30 Biochemicals & Medicine | 31 Freshwater | 32 Mineral resources *** | 33 Abiotic energy sources *** | 34 Recreation & Tourism | 35 Landscape aesthetics & Inspiration | 36 Knowledge systems | 37 Religious & Spiritual experience | 38 Cultural heritage & Cultural diversi | 39 Natural heritage & Natural diversit |
| 1 Continuous urban fabric | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 | 1 | 5 | 1 | 0 |
| 2 Discontinuous urban fabric | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 2 | 1 | 5 | 1 | 0 |
| 3 Industrial or commercial units | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 4 Road and rail networks | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5 Port areas | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 |
| 6 Airports | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 7 Mineral extraction sites | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 1 | 0 | 0 | 0 |
| 8 Dump sites | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 Construction sites | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 Green urban areas | 4 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 0 | 2 | 0 |
| 11 Sport and leisure facilities | 4 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 1 | 0 |
| 12 Non-irrigated arable land | 5 | 4 | 4 | 1 | 3 | 4 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 5 | 2 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 3 | 0 |
| 13 Permanently irrigated land | 5 | 4 | 3 | 1 | 5 | 2 | 3 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 5 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 3 | 0 |
| 14 Ricefields | 5 | 4 | 3 | 1 | 5 | 1 | 3 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 4 | 0 |
| 15 Vineyards | 3 | 2 | 2 | 0 | 3 | 1 | 3 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 2 | 0 | 5 | 0 |
| 16 Fruit trees and berries | 3 | 2 | 3 | 2 | 4 | 2 | 4 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 5 | 3 | 2 | 5 | 1 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 2 | 0 | 4 | 0 |
| 17 Olive groves | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 3 | 2 | 4 | 1 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 2 | 0 | 4 | 0 |
| 18 Pastures | 5 | 5 | 4 | 2 | 4 | 5 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 4 | 1 | 0 | 2 | 4 | 0 | 1 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 0 | 3 | 0 |
| 19 Annual and permanent crops | 4 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 2 | 5 | 1 | 5 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 2 | 0 |
| 20 Complex cultivation patterns | 4 | 3 | 3 | 1 | 3 | 2 | 4 | 3 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 2 | 4 | 1 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 2 | 0 | 3 | 0 |
| 21 Agriculture & Natural vegetation | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 2 | 1 | 0 | 3 | 1 | 0 | 3 | 2 | 3 | 2 | 2 | 3 | 4 | 3 | 3 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 2 | 3 | 0 | 2 | 3 |
| 22 Agro-forestry areas | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 0 | 3 | 0 |
| 23 Broad-leaved forest | 5 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | 0 | 1 | 1 | 0 | 0 | 5 | 5 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 24 Coniferous forest | 5 | 4 | 5 | 5 | 4 | 4 | 3 | 4 | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | 0 | 1 | 1 | 0 | 0 | 5 | 5 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 25 Mixed forest | 5 | 4 | 5 | 5 | 5 | 4 | 3 | 5 | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 0 | 1 | 1 | 0 | 0 | 5 | 5 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 26 Natural grassland | 4 | 3 | 5 | 5 | 4 | 4 | 3 | 5 | 3 | 2 | 0 | 1 | 5 | 5 | 5 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 27 Moors and heathland | 4 | 3 | 5 | 5 | 4 | 5 | 3 | 4 | 3 | 4 | 0 | 2 | 4 | 3 | 0 | 2 | 2 | 2 | 3 | 0 | 2 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 28 Sclerophyllous vegetation | 3 | 2 | 2 | 4 | 2 | 3 | 3 | 4 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 29 Transitional woodland shrub | 3 | 2 | 2 | 4 | 2 | 3 | 3 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 0 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 30 Beaches, dunes and sand plains | 1 | 0 | 1 | 0 | 1 | 1 | 3 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 31 Bare rock | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 32 Sparsely vegetated areas | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 33 Burnt areas | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 34 Glaciers and perpetual snow | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 35 Inland marshes | 4 | 3 | 5 | 3 | 4 | 4 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 4 | 0 | 4 | 0 | 2 | 3 | 0 | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 36 Peatbogs | 4 | 3 | 5 | 5 | 4 | 4 | 3 | 4 | 5 | 4 | 0 | 3 | 4 | 3 | 0 | 3 | 2 | 3 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 3 | 0 | 2 | 4 |
| 37 Salt marshes | 3 | 2 | 5 | 3 | 4 | 3 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 0 | 2 | 0 |
| 38 Salines | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 0 | 2 | 0 |
| 39 Intertidal flats | 1 | 1 | 1 | 4 | 0 | 2 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 3 | 0 | 2 | 0 |
| 40 Water courses | 3 | 1 | 1 | 3 | 0 | 3 | 4 | 4 | 0 | 1 | 0 | 1 | 3 | 3 | 0 | 2 | 0 | 3 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 5 | 0 | 5 | 4 | 4 | 4 | 0 | 3 | 5 |
| 41 Water bodies | 4 | 2 | 4 | 3 | 0 | 4 | 4 | 4 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 4 | 0 | 5 | 0 | 5 | 5 | 4 | 4 | 0 | 3 | 4 |
| 42 Coastal lagoons | 5 | 4 | 4 | 3 | 0 | 5 | 4 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 4 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 0 | 2 | 4 |
| 43 Estuaries | 5 | 4 | 2 | 3 | 0 | 5 | 3 | 3 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 3 | 0 | 4 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 4 | 0 | 0 | 0 | 0 | 4 | 5 | 4 | 0 | 2 | 3 |
| 44 Sea and ocean | 3 | 2 | 1 | 4 | 0 | 3 | 2 | 2 | 5 | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 3 | 5 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 1 | 3 | 4 | 5 | 4 | 0 | 4 | 2 |

scale for assessing capacities:

- 0 = no relevant capacity
- 1 = low relevant capacity
- 2 = relevant capacity
- 3 = medium relevant capacity
- 4 = high relevant capacity
- 5 = very high relevant capacity

after Burkhard et al. (2009, 2012)

# Demand for ecosystem services in different land covers

*- basic assumptions -*

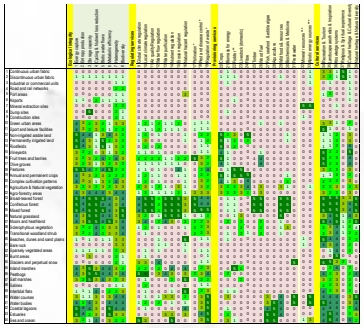
| | | Regulating services | | | | | | | | | | | Provisioning services | | | | | | | | | | | | | | | | | | | Cultural services | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 9 Global climate regulation | 10 Local climate regulation | 11 Air Quality Regulation | 12 Water flow regulation | 13 Water purification | 14 Nutrient regulation | 15 Erosion Regulation | 16 Natural hazard regulation | 17 Pollination | 18 Pest and disease control | 19 Regulation of waste | 20 Crops | 21 Biomass for energy | 22 Fodder | 23 Livestock | 24 Fibre | 25 Timber | 26 Wood Fuel | 27 Capture Fisheries | 28 Aquaculture | 29 Wild Foods & resources | 30 Biochemicals / Medicine | 31 Freshwater | 32 Mineral resources | 33 Abiotic energy sources | 34 Recreation& Tourism | 35 Landscape aesthetics | 36 Knowledge systems | 37 Religious experience | 38 Cultural heritage & diversity | 39 Natural heritage & diversity |
| 1 | Continuous urban fabric | 3 | 5 | 5 | 4 | 1 | 1 | 1 | 5 | 3 | 5 | 3 | 5 | 5 | 1 | 5 | 3 | 3 | 2 | 5 | 5 | 5 | 5 | 5 | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 2 |
| 2 | Discontinuous urban fabric | 3 | 5 | 5 | 5 | 2 | 2 | 1 | 4 | 4 | 4 | 2 | 4 | 4 | 2 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 3 | 3 | 4 | 4 | 3 | 3 | 2 | 3 |
| 3 | Industrial or commercial units | 5 | 1 | 5 | 4 | 3 | 3 | 1 | 5 | 4 | 3 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 1 | 1 | 4 | 1 | 3 | 1 |
| 4 | Road and rail networks | 4 | 2 | 4 | 4 | 0 | 0 | 3 | 4 | 1 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 2 | 1 | 1 | 1 | 0 |
| 5 | Port areas | 3 | 2 | 2 | 5 | 3 | 0 | 4 | 5 | 1 | 4 | 3 | 2 | 5 | 2 | 2 | 2 | 5 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 1 | 2 | 1 |
| 6 | Airports | 5 | 2 | 4 | 1 | 2 | 1 | 1 | 5 | 0 | 5 | 1 | 2 | 5 | 0 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 3 | 2 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 7 | Mineral extraction sites | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 3 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Dump sites | 2 | 2 | 3 | 0 | 2 | 0 | 0 | 5 | 0 | 3 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Construction sites | 0 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 0 | 1 | 2 | 0 | 4 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | Green urban areas | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 4 | 2 | 0 | 2 | 1 |
| 11 | Sport and leisure facilities | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 3 | 0 | 3 | 0 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 1 | 0 | 2 | 0 |
| 12 | Non-irrigated arable land | 2 | 2 | 1 | 2 | 0 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 13 | Permanently irrigated land | 2 | 2 | 1 | 2 | 5 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 14 | Ricefields | 4 | 3 | 1 | 5 | 5 | 3 | 5 | 3 | 1 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 |
| 15 | Vineyards | 2 | 5 | 1 | 0 | 4 | 3 | 5 | 3 | 2 | 3 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 |
| 16 | Fruit trees and berries | 1 | 2 | 1 | 0 | 2 | 3 | 1 | 3 | 5 | 3 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 |
| 17 | Olive groves | 1 | 2 | 1 | 0 | 2 | 2 | 0 | 3 | 2 | 3 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 |
| 18 | Pastures | 3 | 1 | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 1 | 3 | 0 | 1 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 0 |
| 19 | Annual and permanent crops | 1 | 1 | 1 | 1 | 2 | 5 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 20 | Complex cultivation patterns | 1 | 1 | 1 | 1 | 2 | 5 | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 21 | Agriculture & natural vegetation | 2 | 1 | 1 | 0 | 2 | 3 | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| 22 | Agro-forestry areas | 1 | 1 | 1 | 0 | 2 | 3 | 0 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | Broad-leaved forest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | Coniferous forest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | Mixed forest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | Natural grassland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | Moors and heathland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | Sclerophyllous vegetation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | Transitional woodland shrub | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | Beaches, dunes and sand plains | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 31 | Bare rock | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | Sparsely vegetated areas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | Burnt areas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | Glaciers and perpetual snow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | Inland marshes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | Peatbogs | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | Salt marshes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | Salines | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 39 | Intertidal flats | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | Water courses | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | Water bodies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | Coastal lagoons | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | Estuaries | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 44 | Sea and ocean | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |

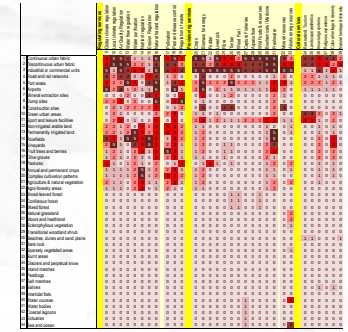
scale for assessing demands:

- 0 = no relevant demand
- 1 = low relevant demand
- 2 = relevant demand
- 3 = medium relevant demand
- 4 = high relevant demand
- 5 = very high relevant demand

after Burkhard et al. (2012)

| | Regulating services | Global climate regulation | Local climate regulation | Air quality regulation | Water flow regulation | Water purification | Nutrient regulation | Erosion regulation | Natural hazard regulation | Pollination | Pest and disease control | Regulation of waste | Provisioning services | Crops | Biomass for energy | Fodder | Livestock | Fibre | Timber | Wood fuel | Capture fisheries | Aquaculture | Wild foods & resources | Biochemicals / medicine | Freshwater | Mineral resources | Abiotic energy sources | Cultural services | Recreation& tourism | Landscape aesthetics | Knowledge systems | Religious experience | Cultural heritage & diversity | Natural heritage & diversity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | | 34 | 35 | 36 | 37 | 38 | 39 |
| Continuous urban fabric | | -3 | -5 | -5 | -4 | -1 | -1 | -1 | -5 | -3 | -5 | -3 | | -5 | -4 | -1 | -5 | -3 | -3 | -2 | -5 | -5 | -5 | -5 | -5 | -4 | -1 | | -1 | -1 | -2 | 1 | -3 | -2 |
| Discontinuous urban fabric | | -3 | -5 | -5 | -5 | -2 | -2 | -1 | -4 | -4 | -4 | -2 | | -3 | -3 | -1 | -4 | -3 | -3 | -3 | -4 | -4 | -3 | -5 | -5 | -3 | -2 | | -1 | -2 | -2 | 2 | -1 | -3 |
| Industrial or commercial units | | -5 | -1 | -5 | -4 | -3 | -3 | -1 | -5 | -4 | -3 | -4 | | -5 | -4 | -5 | -5 | -5 | -5 | -5 | -4 | -4 | -4 | -5 | -5 | -5 | -4 | | -1 | 0 | -4 | -1 | -2 | -1 |
| Road and rail networks | | -4 | -2 | -4 | -4 | 0 | 0 | -3 | -4 | -1 | -2 | | | | -4 | | | | -2 | | | | | | -1 | -2 | | | -2 | -2 | -1 | -1 | 0 | |
| Port areas | | -3 | -2 | -2 | -5 | -3 | | -4 | -2 | -1 | -4 | -3 | | -2 | -5 | -2 | -2 | -2 | -5 | -2 | -2 | -2 | -1 | -1 | -3 | -3 | -1 | | -1 | 0 | -2 | -1 | -1 | -1 |
| Airports | | -5 | -2 | -4 | -1 | -2 | -1 | -1 | -5 | | -5 | -1 | | -2 | -5 | 1 | -2 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | -3 | -2 | | | -1 | -1 | -1 | -1 | 0 | |
| Mineral extraction sites | | | | | -2 | | | -4 | -3 | | | -3 | | | -3 | | | -1 | -2 | | | | | | -2 | 4 | 5 | | | | 1 | | | |
| Dump sites | | -2 | -2 | -3 | | -2 | | | -5 | | -3 | -5 | | | 0 | | | | | | | | | | -2 | | | | | | | | | |
| Construction sites | | | -2 | -1 | -2 | -2 | -2 | -2 | -3 | | -1 | -2 | | | -4 | | | -4 | -4 | | | | | | -2 | -3 | | | | | | | | |
| Green urban areas | | 1 | 0 | 0 | 2 | 1 | 1 | 2 | -2 | -1 | -2 | 1 | | -1 | -1 | | -1 | | | 1 | | | 1 | | -2 | | | | -1 | -1 | -1 | | 0 | -1 |
| Sport and leisure facilities | | 1 | -1 | -2 | 2 | 0 | 1 | 1 | -3 | 1 | -2 | 1 | | -2 | -3 | -1 | -2 | -1 | -1 | -1 | -2 | -2 | -2 | -3 | -3 | -1 | -1 | | 2 | -2 | -1 | | -1 | |
| Non-irrigated arable land | | -1 | 0 | -1 | -1 | | -3 | -2 | -2 | -3 | -1 | 0 | | 4 | 1 | 3 | | 5 | | | | | | 0 | | | -1 | | 1 | 1 | 1 | | 2 | |
| Permanently irrigated land | | -1 | 1 | -1 | -2 | -5 | -3 | -2 | -2 | -3 | -2 | 0 | | 4 | -1 | 2 | | 2 | | | | | | 0 | -5 | | -1 | | 1 | 1 | 1 | | 2 | |
| Ricefields | | -4 | -1 | -1 | -3 | -5 | -3 | -5 | -3 | -1 | -2 | -1 | | 4 | -2 | 2 | | | | | | | | -1 | -5 | | | | 1 | 1 | 0 | | 1 | |
| Vineyards | | -1 | -4 | -1 | 1 | -4 | -3 | -5 | -3 | -2 | -2 | 0 | | 3 | -1 | | | -1 | -1 | 1 | | | | -2 | -4 | | | | 5 | 2 | 0 | | 2 | |
| Fruit trees and berries | | 1 | 0 | 1 | 2 | -1 | -2 | 1 | -1 | 0 | 0 | 1 | | 4 | -1 | | | -1 | 3 | 4 | | | | -2 | -3 | | | | 5 | 2 | 0 | | 2 | |
| Olive groves | | 0 | -1 | 0 | 1 | -1 | -1 | 1 | -3 | -2 | 0 | 1 | | 3 | 0 | | | -1 | 4 | 4 | | | | -2 | -1 | | | | 5 | 2 | 0 | | 2 | |
| Pastures | | -2 | 0 | | 0 | -2 | -1 | 4 | -1 | | 1 | 1 | | | 0 | 2 | 4 | | -1 | | | | | -1 | -2 | | -2 | | 3 | 2 | 1 | | 2 | |
| Annual and permanent crops | | 0 | 1 | 0 | 0 | -2 | -5 | 0 | -1 | -2 | -1 | 1 | | 4 | -1 | 5 | 5 | 5 | | | | | | 0 | -1 | | -1 | | 1 | 1 | 1 | | 1 | |
| Complex cultivation patterns | | 0 | 1 | -1 | 0 | -2 | -5 | -1 | -1 | -3 | 0 | 0 | | 3 | -1 | 3 | | 4 | | | | | | 1 | -1 | | | | 2 | 2 | 1 | | 2 | |
| Agriculture & natural vegetation | | 0 | 2 | 0 | 2 | -1 | -3 | 2 | 0 | -2 | 0 | 1 | | 2 | 0 | 2 | 3 | 4 | 3 | 3 | | | 3 | 0 | -2 | | -1 | | 2 | 2 | 2 | | 2 | 3 |
| Agro-forestry areas | | 0 | 1 | 0 | 1 | -1 | -2 | 2 | 0 | 1 | 2 | 3 | | 2 | 1 | 2 | 3 | 2 | 3 | 3 | | | | -1 | -2 | | | | 3 | 2 | 2 | | 3 | |
| Broad-leaved forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | | | 1 | 1 | | | 4 | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 3 | 5 |
| Coniferous forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | | | 1 | 1 | | | 4 | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 4 | 5 |
| Mixed forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | | | 1 | 1 | | | 4 | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 4 | 5 |
| Natural grassland | | 3 | 2 | | 1 | 5 | 5 | 5 | 1 | | 1 | 2 | | | | 1 | 3 | | | | | | 5 | | | | -2 | | 3 | 4 | 5 | 1 | 4 | 3 |
| Moors and heathland | | 3 | 4 | | 2 | 4 | 3 | | 2 | 2 | 2 | 3 | | | 2 | | 2 | | | 2 | | | 1 | | | | -2 | | 5 | 4 | 5 | 1 | 2 | 5 |
| Sclerophyllous vegetation | | 1 | 2 | | 1 | | | | 1 | 2 | 2 | 3 | | | | | 2 | | | 2 | | | 1 | 3 | | | -1 | | 2 | 3 | 4 | 1 | 2 | 4 |
| Transitional woodland shrub | | | 1 | | | | | | | 2 | 2 | 3 | | | 1 | | 2 | 1 | | 2 | | | 1 | | | | | | 2 | 3 | 4 | 1 | 2 | 2 |
| Beaches, dunes and sand plains | | | | | 1 | | | | 5 | | 1 | 1 | | | 1 | | | | | | | | | | | 1 | | | 4 | 3 | 4 | | 2 | 1 |
| Bare rock | | | | | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | 1 | | | 4 | 3 | 4 | | 2 | |
| Sparsely vegetated areas | | | 1 | | 1 | | | | 1 | | 1 | 1 | | | | | | | | | | | | | | | -1 | | | 1 | 4 | | 2 | |
| Burnt areas | | | 1 | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 5 | | | |
| Glaciers and perpetual snow | | 3 | 3 | | 4 | | | | | | 1 | 1 | | | | | | | | | | | | | 5 | | | | 5 | 5 | 3 | 2 | | |
| Inland marshes | | 2 | 2 | | 2 | | 4 | | 4 | | 2 | 3 | | | | 5 | 2 | | | | | | | | | | | | | 2 | 4 | | 2 | |
| Peatbogs | | 5 | 4 | | 3 | 4 | 3 | | 3 | 2 | 3 | 4 | | | 2 | | | | | | | | | | | | | | 4 | 2 | 3 | | 2 | 4 |
| Salt marshes | | | 1 | | | | 2 | | 5 | | 2 | 2 | | | | | 2 | | | | | | | | | | | | 3 | 2 | 3 | | 2 | |
| Salines | | | 2 | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | 1 | |
| Intertidal flats | | | 1 | | | | 1 | | 5 | | 2 | 3 | | | 1 | | | | | | | | | | | | | | 4 | 2 | 3 | | 2 | |
| Water courses | | | 1 | | 1 | 3 | 3 | | 2 | | 3 | 5 | | | 3 | | | | | | 2 | | 4 | | 5 | | 2 | | 4 | 4 | 4 | | 3 | 5 |
| Water bodies | | 1 | 2 | | 2 | | 1 | | 1 | | 3 | 5 | | | | | | | | | 2 | 5 | 4 | | 5 | | 5 | | 5 | 4 | 4 | | 3 | 4 |
| Coastal lagoons | | | 1 | | | | | | 4 | | 3 | 5 | | | 1 | | | | | | 3 | 5 | 4 | | | | | | 4 | 4 | 4 | | 2 | 4 |
| Estuaries | | | | | | 3 | 3 | | 3 | | 4 | 5 | | | 2 | | | | | | 4 | 5 | 4 | | | | | | 4 | 5 | 4 | | 2 | 3 |
| Sea and ocean | | 5 | 3 | | | | 5 | | | | 3 | 5 | | | 3 | 1 | | | | | 4 | 5 | | | | 1 | -1 | | 4 | 5 | 4 | | 4 | 2 |



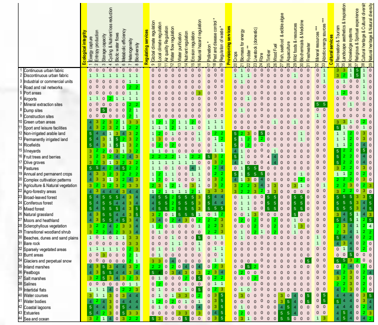


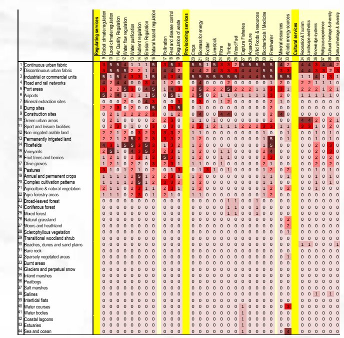
ecosystem services balances:

- 5
- 4 demand exceeeds
- 3 supply
- 2
- 1
- 0 neutral balance
- 1
- 2
- 3 supply exceeds
- 4 demand
- 5

after Burkhard et al. (2012)

| | Regulating services | 9 Global climate regulation | 10 Local climate regulation | 11 Air quality regulation | 12 Water flow regulation | 13 Water purification | 14 Nutrient regulation | 15 Erosion regulation | 16 Natural hazard regulation | 17 Pollination | 18 Pest and disease control | 19 Regulation of waste | Provisioning services | 20 Crops | 21 Biomass for energy | 22 Fodder | 23 Livestock | 24 Fibre | 25 Timber | 26 Wood fuel | 27 Capture fisheries | 28 Aquaculture | 29 Wild foods & resources | 30 Biochemicals / medicine | 31 Freshwater | 32 Mineral resources | 33 Abiotic energy sources | Cultural services | 34 Recreation& tourism | 35 Landscape aesthetics | 36 Knowledge systems | 37 Religious experience | 38 Cultural heritage & diversity | 39 Natural heritage & diversity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Continuous urban fabric | | -3 | -5 | -5 | -4 | -1 | -1 | -1 | -5 | -3 | -5 | -3 | | -5 | -4 | -1 | -5 | -3 | -3 | -2 | -5 | -5 | -5 | -5 | -5 | -4 | -1 | | -1 | -1 | -2 | 1 | -3 | -2 |
| 2 Discontinuous urban fabric | | -3 | -5 | -5 | -5 | -2 | -2 | -1 | -4 | -4 | -4 | -2 | | -3 | -3 | -1 | -4 | -3 | -3 | -3 | -4 | -4 | -3 | -5 | -5 | -3 | -2 | | -1 | -2 | -2 | 2 | -1 | -3 |
| 3 Industrial or commercial units | | -5 | -1 | -5 | -4 | -3 | -3 | -1 | -5 | -4 | -3 | -4 | | -5 | -4 | -5 | -5 | -5 | -5 | -5 | -4 | -4 | -4 | -5 | -5 | -5 | -4 | | -1 | 0 | -4 | -1 | -2 | -1 |
| 4 Road and rail networks | | -4 | -2 | -4 | -4 | 0 | 0 | -3 | -4 | -1 | -2 | | | | -4 | | | | -2 | | | | | | -1 | -2 | | | -2 | -2 | -1 | -1 | 0 | |
| 5 Port areas | | -3 | -2 | -2 | -5 | -3 | | -4 | -2 | -1 | -4 | -3 | | -2 | -5 | -2 | -2 | -2 | -5 | -2 | -2 | -2 | -1 | -1 | -3 | -3 | -1 | | -1 | 0 | -2 | -1 | -1 | -1 |
| 6 Airports | | -5 | -2 | -4 | -1 | -2 | -1 | -1 | -5 | | -5 | -1 | | -2 | -5 | 1 | -2 | -1 | -1 | 0 | -1 | -1 | -1 | -1 | -3 | -2 | | | -1 | -1 | -1 | -1 | 0 | |
| 7 Mineral extraction sites | | | | | -2 | | | -4 | -3 | | | -3 | | | -3 | | | -1 | -2 | | | | | | -2 | 4 | 5 | | | | 1 | | | |
| 8 Dump sites | | -2 | -2 | -3 | | -2 | | | -5 | | -3 | -5 | | | 0 | | | | | | | | | | -2 | | | | | | | | | |
| 9 Construction sites | | | -2 | -1 | -2 | -2 | -2 | -2 | -3 | | -1 | -2 | | | -4 | | | -4 | -4 | | | | | | -2 | -3 | | | | | | | | |
| 10 Green urban areas | | 1 | 0 | 0 | 2 | 1 | 1 | 2 | -2 | -1 | -2 | 1 | | -1 | -1 | | -1 | | | 1 | | | 1 | | -2 | | | | -1 | -1 | -1 | | 0 | -1 |
| 11 Sport and leisure facilities | | 1 | -1 | -2 | 2 | 0 | 1 | 1 | -3 | 1 | -2 | 1 | | -2 | -3 | -1 | -2 | -1 | -1 | -1 | -2 | -2 | -2 | -3 | -3 | -1 | -1 | | 2 | -2 | -1 | | -1 | |
| 12 Non-irrigated arable land | | -1 | 0 | -1 | -1 | | -3 | -2 | -2 | -3 | -1 | 0 | | 4 | 1 | 3 | | 5 | | | | | | 0 | | | -1 | | 1 | 1 | 1 | | 2 | |
| 13 Permanently irrigated land | | -1 | 1 | -1 | -2 | -5 | -3 | -2 | -2 | -3 | -2 | 0 | | 4 | -1 | 2 | | 2 | | | | | | 0 | -5 | | -1 | | 1 | 1 | 1 | | 2 | |
| 14 Ricefields | | -4 | -1 | -1 | -3 | -5 | -3 | -5 | -3 | -1 | -2 | -1 | | 4 | -2 | 2 | | | | | | | | -1 | -5 | | | | 1 | 1 | 0 | | 1 | |
| 15 Vineyards | | -1 | -4 | -1 | 1 | -4 | -3 | -5 | -3 | -2 | -2 | 0 | | 3 | -1 | | | -1 | -1 | 1 | | | | -2 | -4 | | | | 5 | 2 | 0 | | 2 | |
| 16 Fruit trees and berries | | 1 | 0 | 1 | 2 | -1 | -2 | 1 | -1 | 0 | 0 | 1 | | 4 | -1 | | | -1 | 3 | 4 | | | | -2 | -3 | | | | 5 | 2 | 0 | | 2 | |
| 17 Olive groves | | 0 | -1 | 0 | 1 | -1 | -1 | 1 | -3 | -2 | 0 | 1 | | 3 | [illegible] | | | [illegible] | 4 | 4 | | | | -2 | -1 | | | | 5 | 2 | 0 | | 2 | |
| 18 Pastures | | -2 | 0 | | 0 | -2 | -1 | 4 | -1 | | 1 | 1 | | | | | | | [illegible] | | | | | -1 | -2 | | -2 | | 3 | 2 | 1 | | 2 | |
| 19 Annual and permanent crops | | 0 | 1 | 0 | 0 | -2 | -5 | 0 | -1 | -2 | -1 | [illegible] | | | | | | | | | | | | 0 | -1 | | -1 | | 1 | 1 | 1 | | 1 | |
| 20 Complex cultivation patterns | | 0 | 1 | -1 | 0 | -2 | -5 | -1 | -1 | -3 | | | | | | | | | | | | | | 1 | -1 | | | | 2 | 2 | 1 | | 2 | |
| 21 Agriculture & natural vegetation | | 0 | 2 | 0 | 2 | -1 | -3 | 2 | 0 | -2 | 0 | 1 | | | | | | | | 3 | | | 3 | 0 | -2 | | -1 | | 2 | 2 | 2 | | 2 | 3 |
| 22 Agro-forestry areas | | 0 | 1 | 0 | 1 | -1 | -2 | 2 | 0 | 1 | 2 | 3 | | | | | | | | 3 | | | | -1 | -2 | | | | 3 | 2 | 2 | | 3 | |
| 23 Broad-leaved forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | | | | | | | | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 3 | 5 |
| 24 Coniferous forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 4 | 4 | | | [illegible] | [illegible] | | | [illegible] | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 4 | 5 |
| 25 Mixed forest | | 4 | 5 | 5 | 2 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | | | [illegible] | [illegible] | | | [illegible] | 4 | | | 4 | 5 | | | | | 5 | 5 | 5 | 3 | 4 | 5 |
| 26 Natural grassland | | 3 | 2 | | 1 | 5 | 5 | 5 | 1 | | 1 | 2 | | | | 1 | 3 | | | | | | 5 | | | | -2 | | 3 | 4 | 5 | 1 | 4 | 3 |
| 27 Moors and heathland | | 3 | 4 | | 2 | 4 | 3 | | 2 | 2 | 2 | 3 | | | 2 | | 2 | | | 2 | | | 1 | | | | -2 | | 5 | 4 | 5 | 1 | 2 | 5 |
| 28 Sclerophyllous vegetation | | 1 | 2 | | 1 | | | | 1 | 2 | 2 | 3 | | | | | 2 | | | 2 | | | 1 | 3 | | | -1 | | 2 | 3 | 4 | 1 | 2 | 4 |
| 29 Transitional woodland shrub | | | 1 | | | | | | | 2 | 2 | 3 | | | 1 | | 2 | 1 | | 2 | | | 1 | | | | | | 2 | 3 | 4 | 1 | 2 | 2 |
| 30 Beaches, dunes and sand plains | | | | | 1 | | | | 5 | | 1 | 1 | | | 1 | | | | | | | | | | | 1 | | | 4 | 3 | 4 | | 2 | 1 |
| 31 Bare rock | | | | | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | 1 | | | 4 | 3 | 4 | | 2 | |
| 32 Sparsely vegetated areas | | | 1 | | 1 | | | | 1 | | 1 | 1 | | | | | | | | | | | | | | | -1 | | | 1 | 4 | | 2 | |
| 33 Burnt areas | | | 1 | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 5 | | | |
| 34 Glaciers and perpetual snow | | 3 | 3 | | 4 | | | | | | 1 | 1 | | | | | | | | | | | | | 5 | | | | 5 | 5 | 3 | 2 | | |
| 35 Inland marshes | | 2 | 2 | | 2 | | 4 | | 4 | | 2 | 3 | | | | 5 | 2 | | | | | | | | | | | | | 2 | 4 | | 2 | |
| 36 Peatbogs | | 5 | 4 | | 3 | 4 | 3 | | 3 | 2 | 3 | 4 | | | 2 | | | | | | | | | | | | | | 4 | 2 | 3 | | 2 | 4 |
| 37 Salt marshes | | | 1 | | | | 2 | | 5 | | 2 | 2 | | | | | 2 | | | | | | | | | | | | 3 | 2 | 3 | | 2 | |
| 38 Salines | | | 2 | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | 1 | |
| 39 Intertidal flats | | | 1 | | | | 1 | | 5 | | 2 | 3 | | | 1 | | | | | | | | | | | | | | 4 | 2 | 3 | | 2 | |
| 40 Water courses | | | 1 | | 1 | 3 | 3 | | 2 | | 3 | 5 | | | 3 | | | | | | 2 | | 4 | | 5 | | 2 | | 4 | 4 | 4 | | 3 | 5 |
| 41 Water bodies | | 1 | 2 | | 2 | | 1 | | 1 | | 3 | 5 | | | | | | | | | 2 | 5 | 4 | | 5 | | 5 | | 5 | 4 | 4 | | 3 | 4 |
| 42 Coastal lagoons | | | 1 | | | | | | 4 | | 3 | 5 | | | 1 | | | | | | 3 | 5 | 4 | | | | | | 4 | 4 | 4 | | 2 | 4 |
| 43 Estuaries | | | | | | 3 | 3 | | 3 | | 4 | 5 | | | 2 | | | | | | 4 | 5 | 4 | | | | | | 4 | 5 | 4 | | 2 | 3 |
| 44 Sea and ocean | | 5 | 3 | | | | 5 | | | | 3 | 5 | | | 3 | 1 | | | | | 4 | 5 | | | | 1 | -1 | | 4 | 5 | 4 | | 4 | 2 |





ecosystem services balances:

- 5
- 4 demand exceeeds supply
- 3
- 2
- 1

0 neutral balance

1
2
3 supply exceeds demand
4
5

after Burkhard et al. (2012)

# Presentation Structure

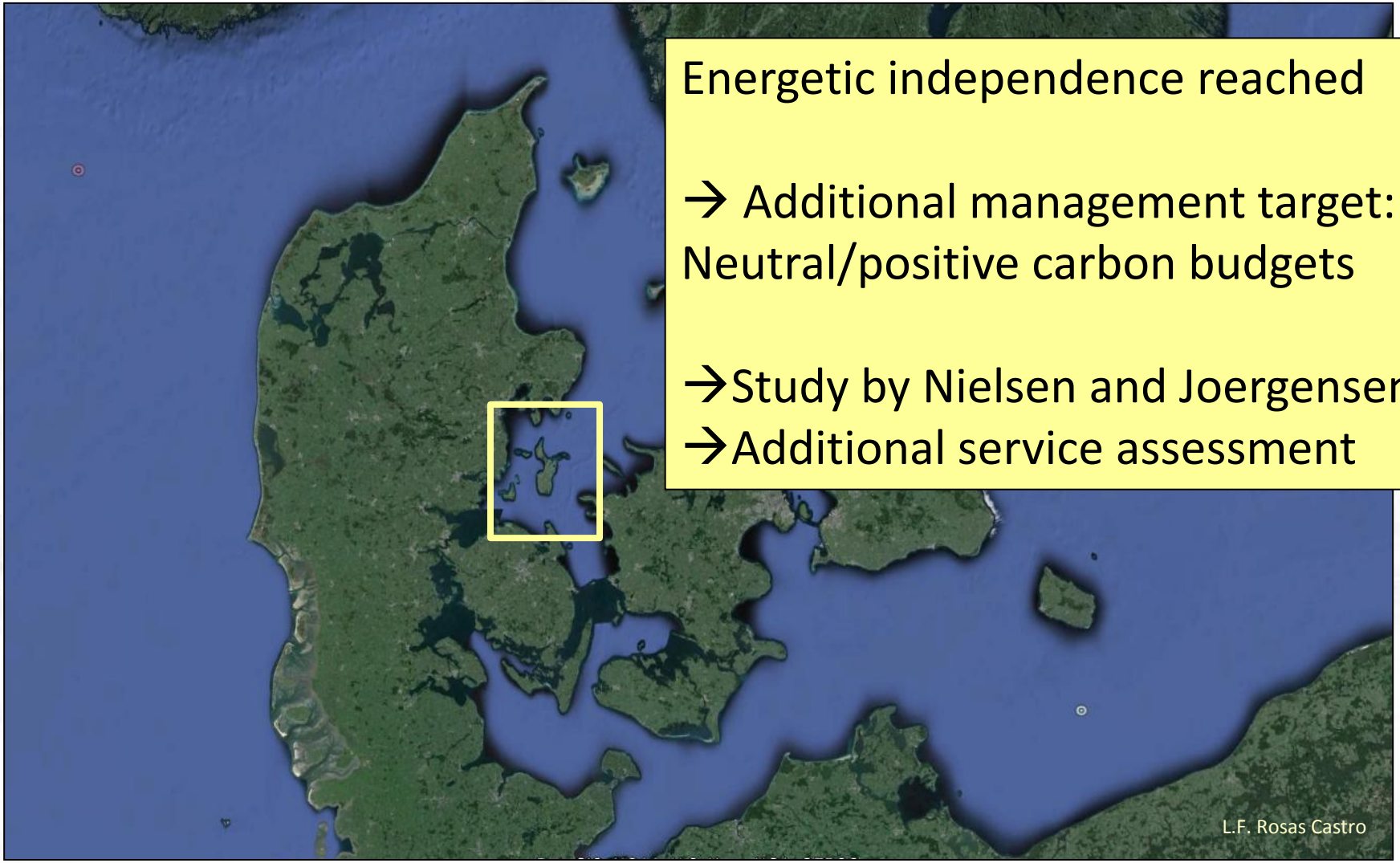
Case study Matrix application Samsoe

Recent problems of the ecosystem service approach

Linking sustainability indicators

Concluding remarks

# An exemplary matrix application: Samsoe




Energetic independence reached

→ Additional management target: Neutral/positive carbon budgets

→Study by Nielsen and Joergensen
→Additional service assessment

# Basic information: Soil distribution

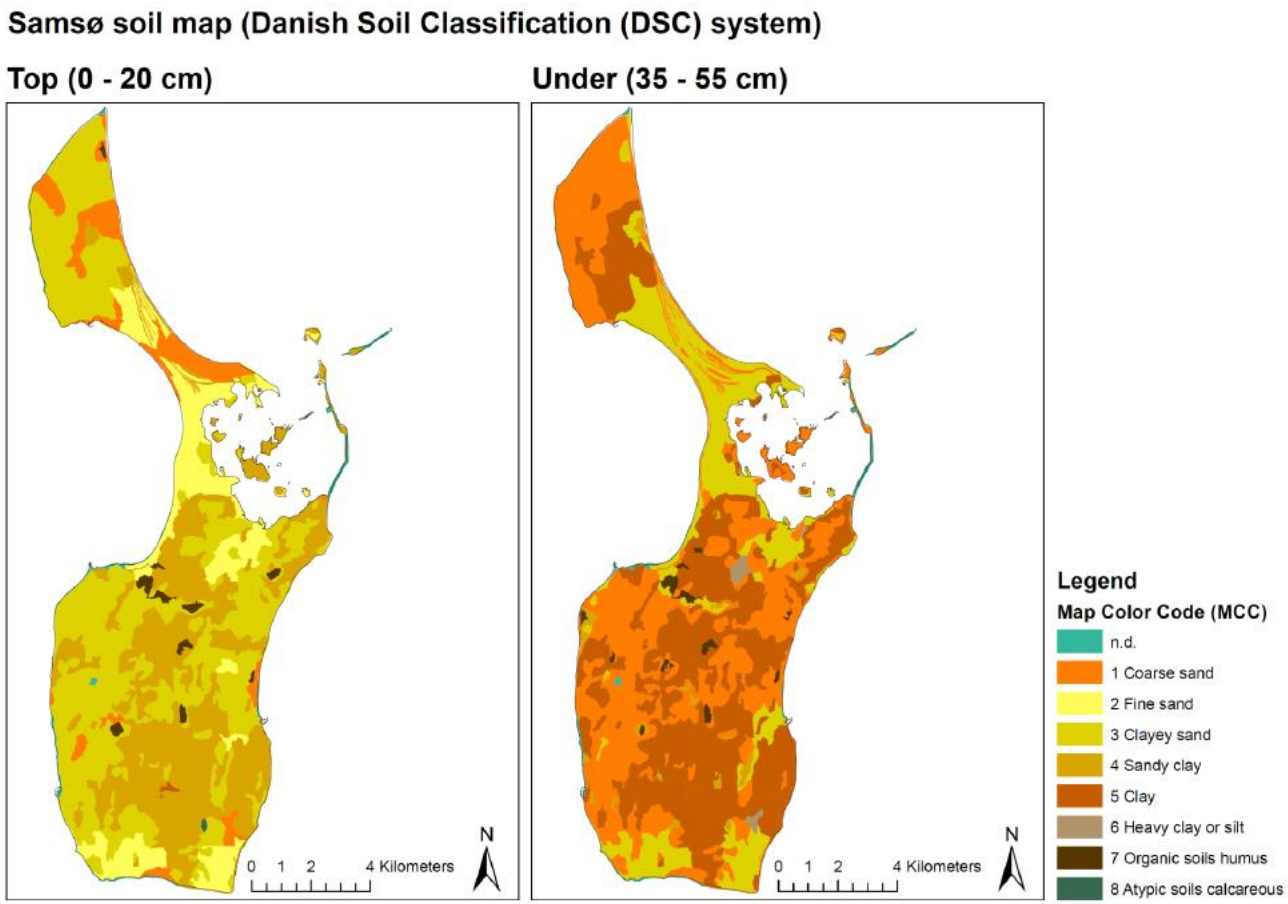



Figure 8. Samsø soil map: Danish Soil Classification System (DSC). Layers: Top (0 – 20 cm) and under (35 – 55 cm)

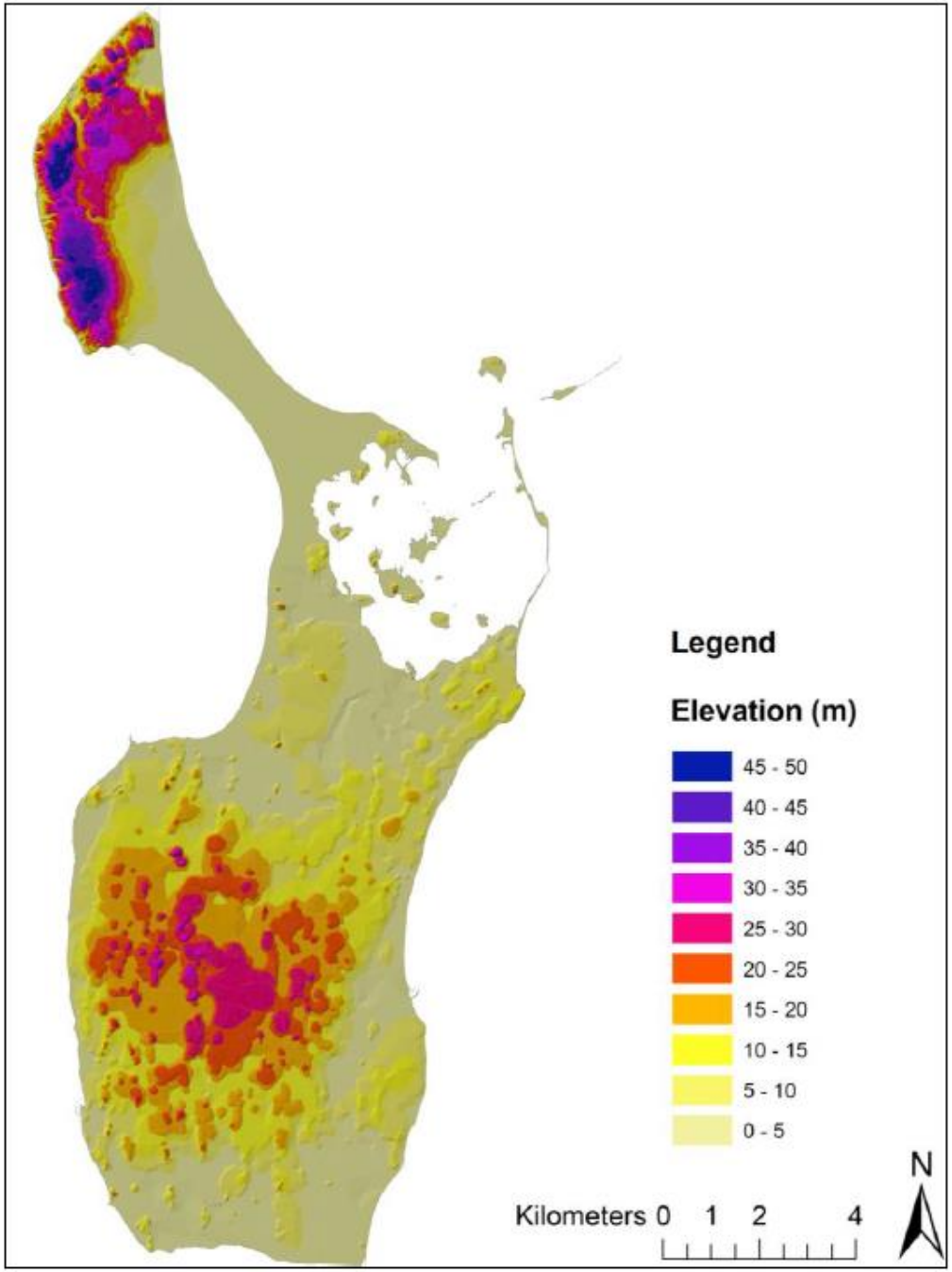



Figure 9. Digital Elevation Model of Samsø

**Basic information:**

**Digital elevation model**

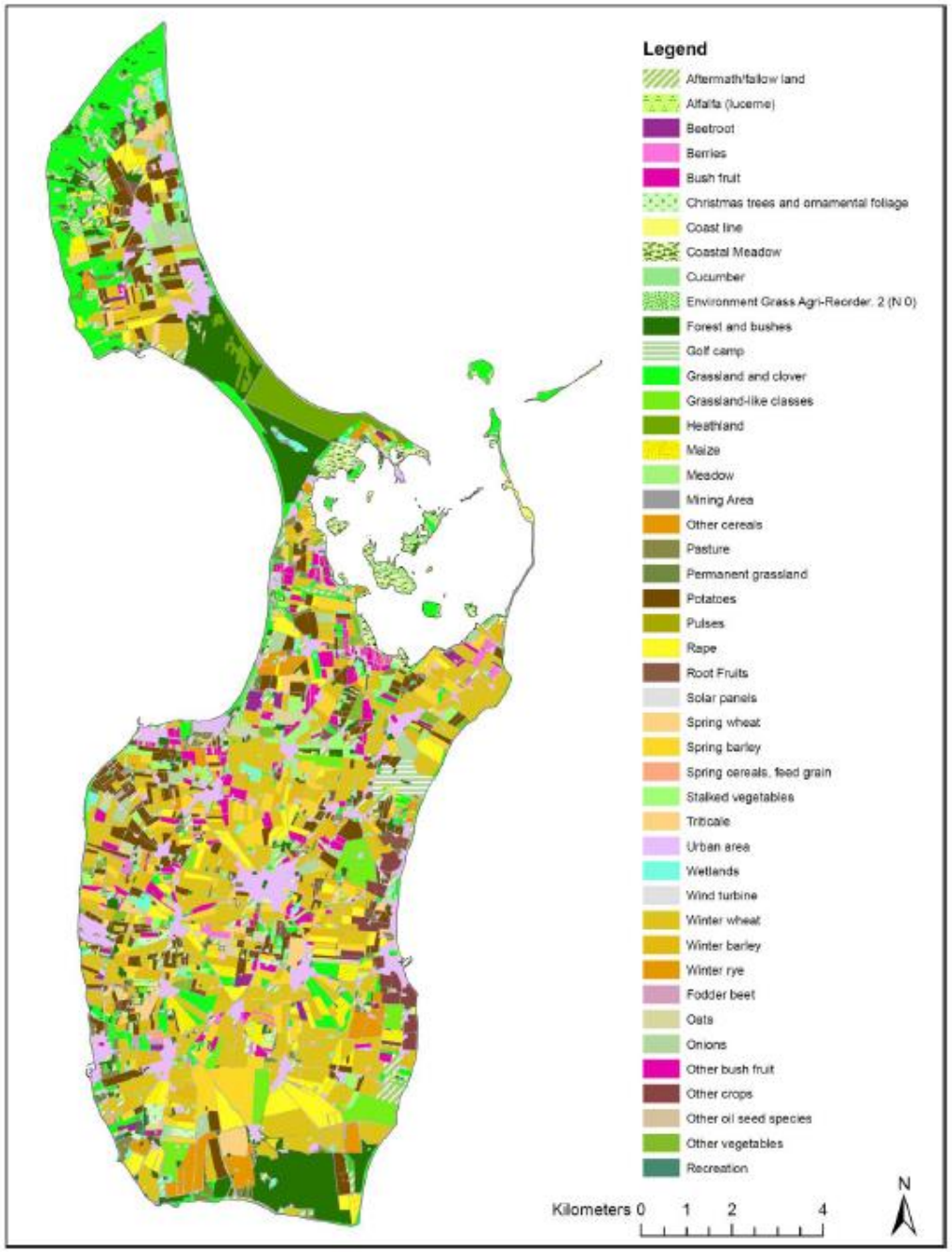



Figure 10. Aggregated land use/land cover classes on Samsø in 2011

**Basic information:**

**Land use distribution**

# Matrix classification: Integrity indicators

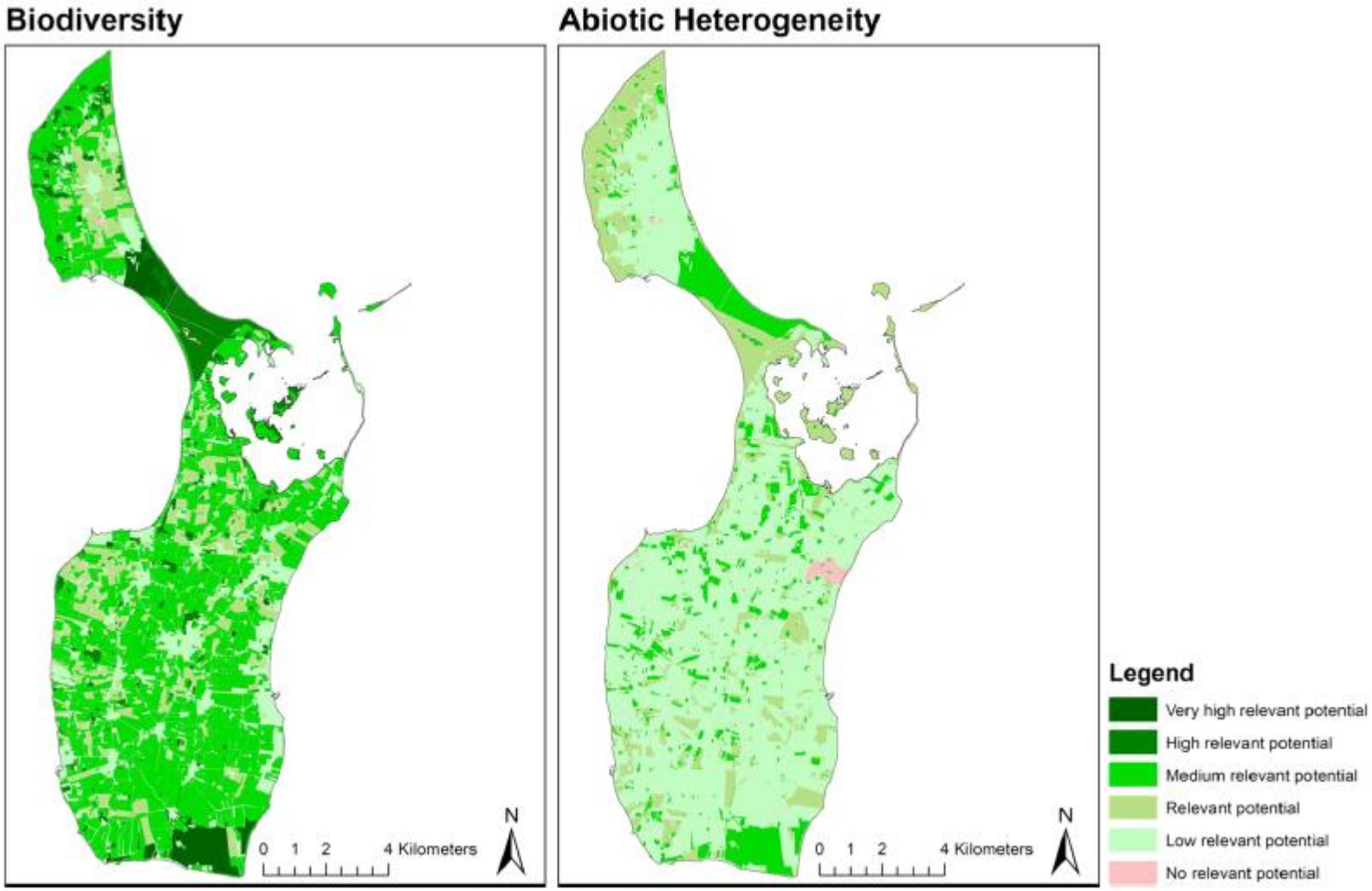



Figure 12. Ecological Integrity indicated by Abiotic Heterogeneity and Biodiversity on Samsø

# Matrix classification: Provisioning services

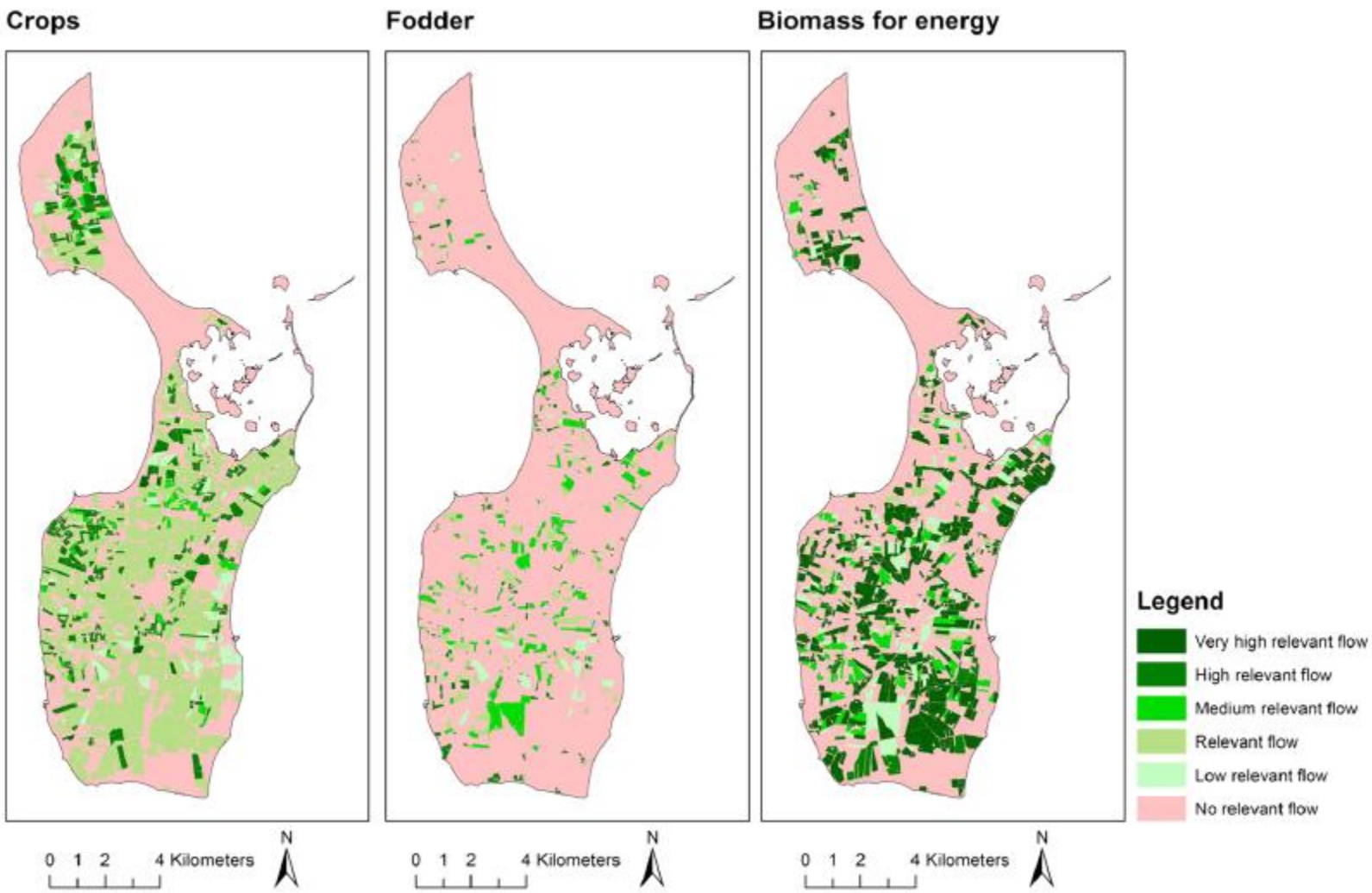



Figure 13. Provisioning ecosystem services flow Samsø 2011

# Matrix classification: Regulating services

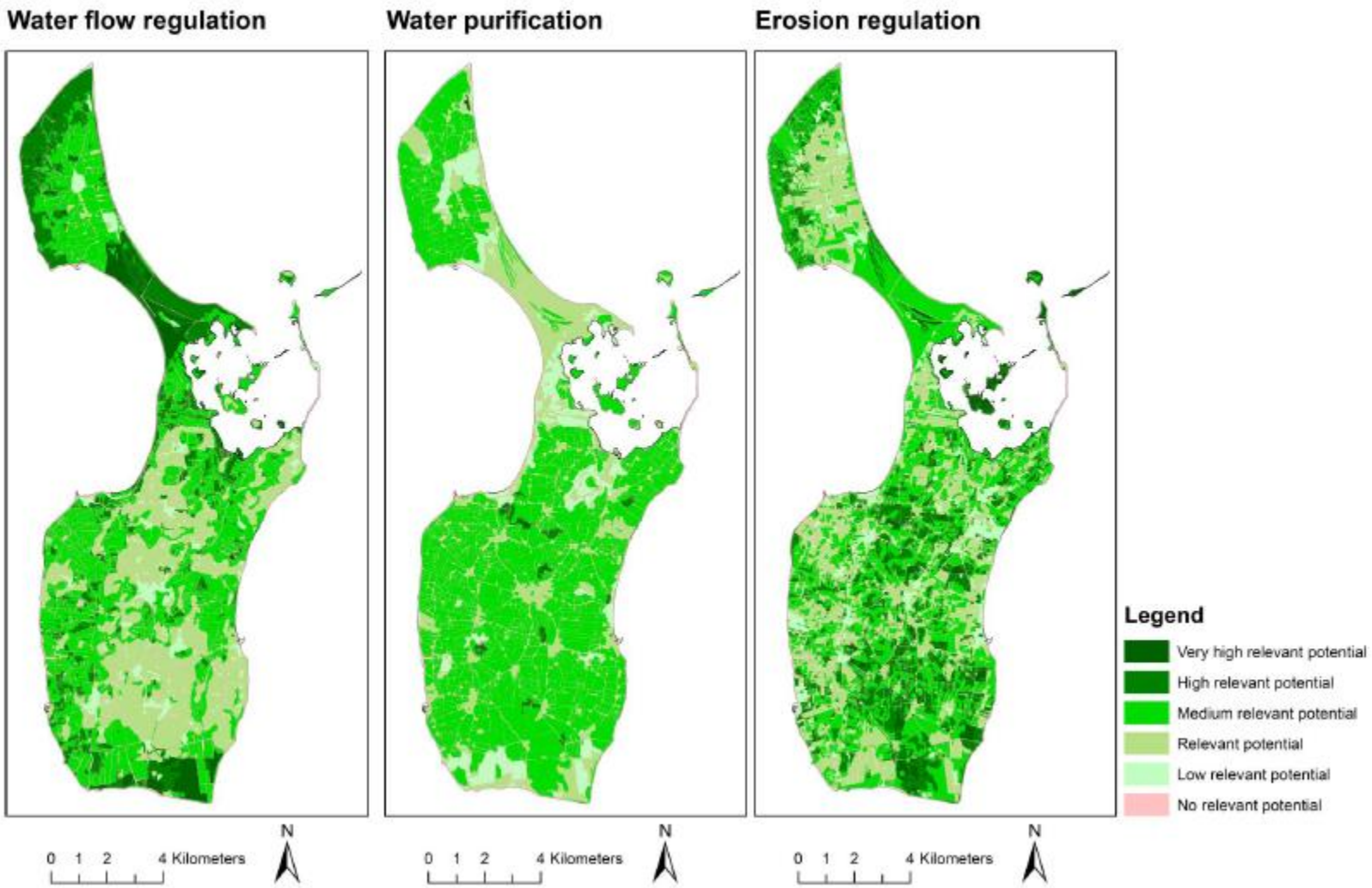



Figure 20. Regulation ecosystem services supply potential Samsø

# Matrix classification: Cultural services

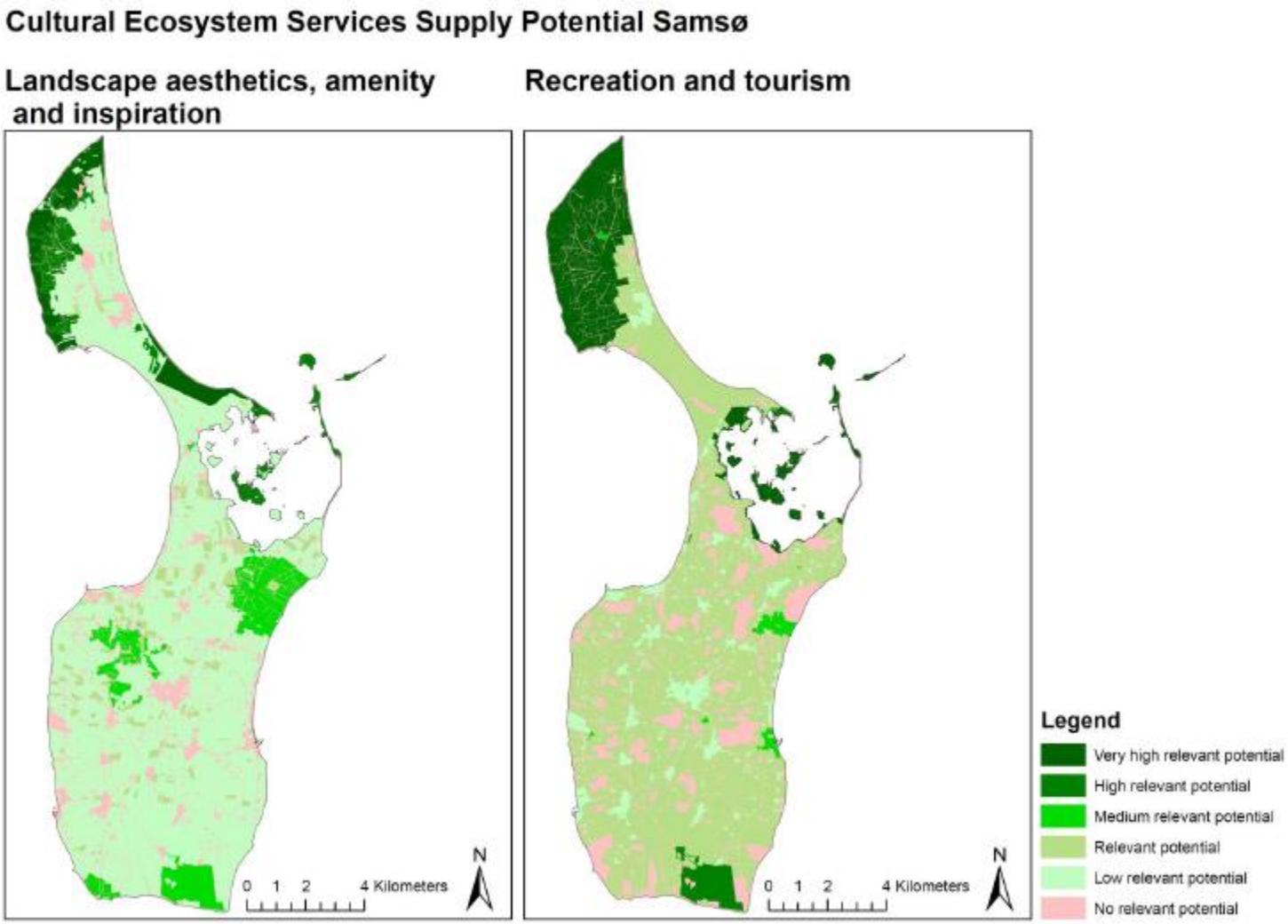



Figure 21. Cultural ecosystem services supply potential Samsø

# Quantitative calculation: Carbon components

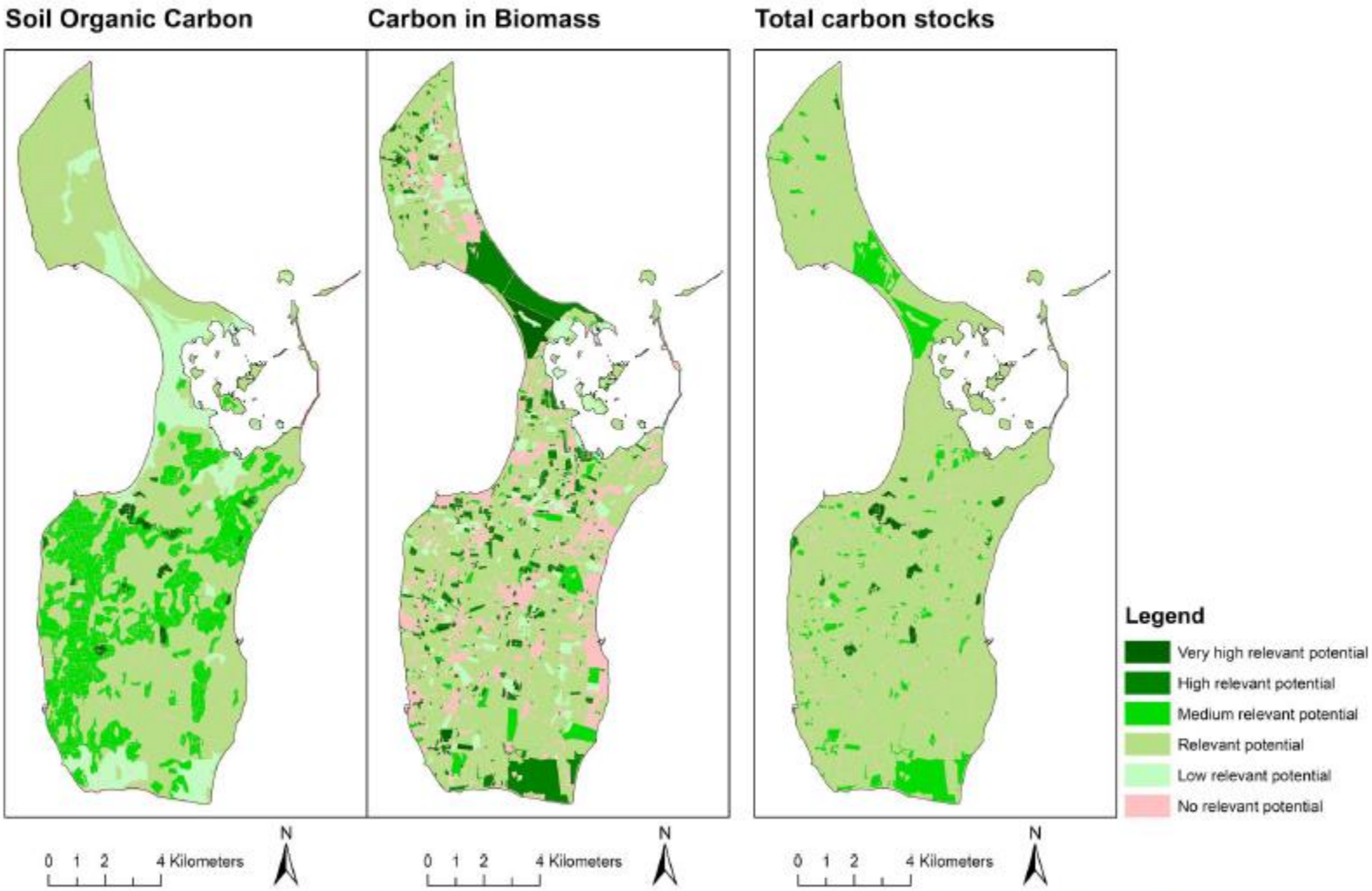


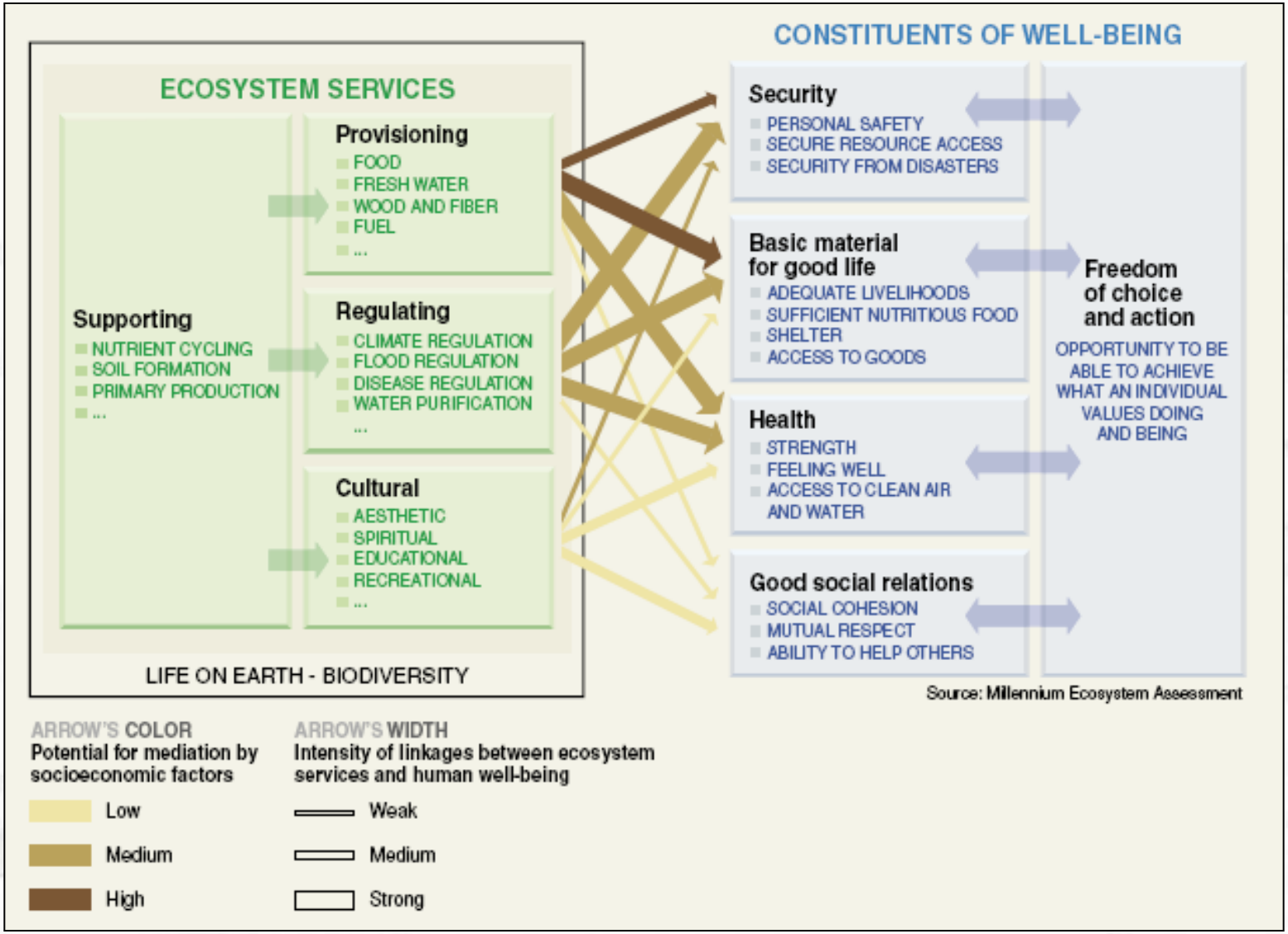

Figure 17. Global climate regulation supply potential Samsø. Potential carbon stocks in SOC (left), biomass (middle) and total (right)

# Presentation Structure

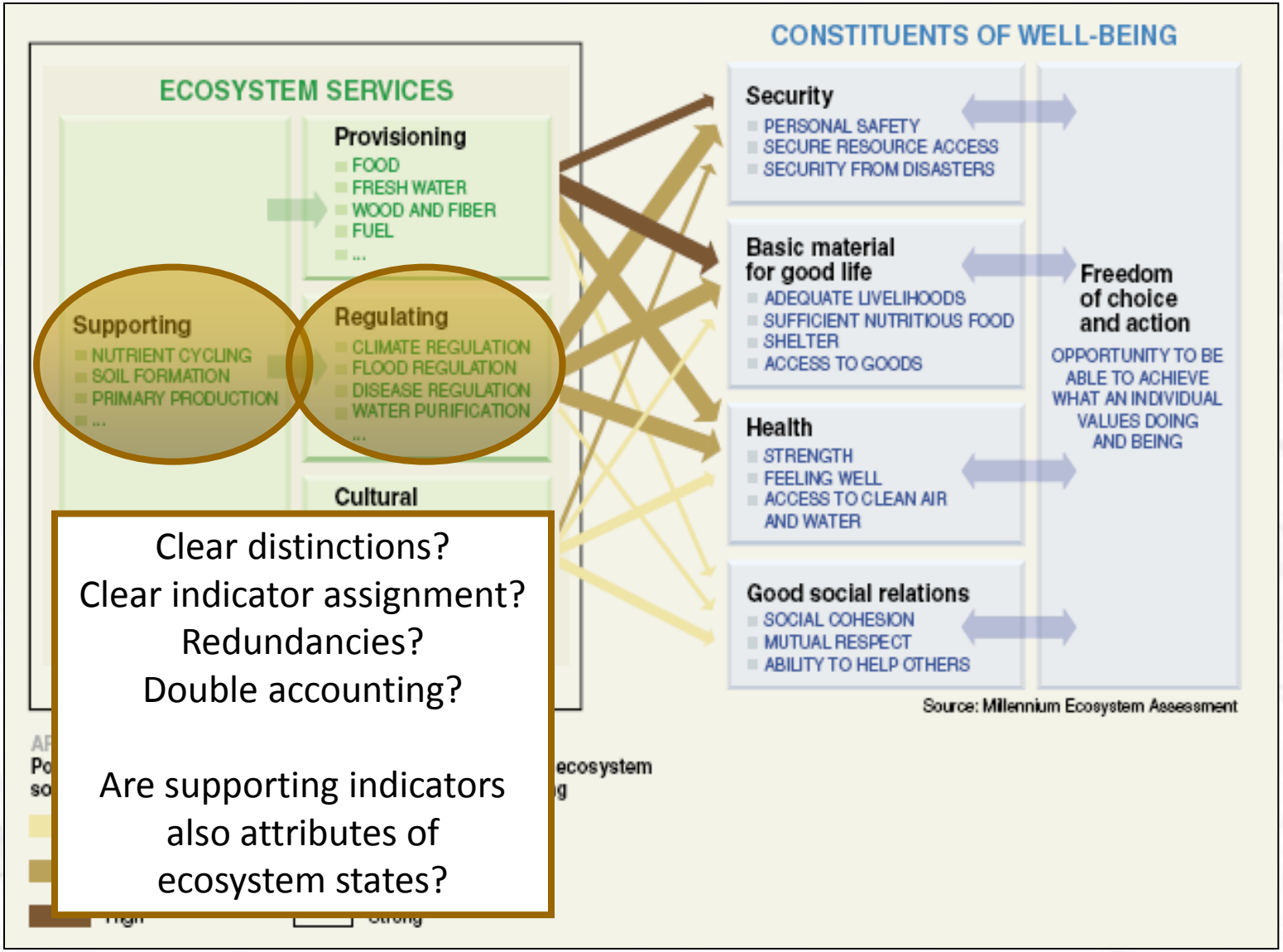
Recent problems of the ecosystem service approach

Linking sustainability indicators

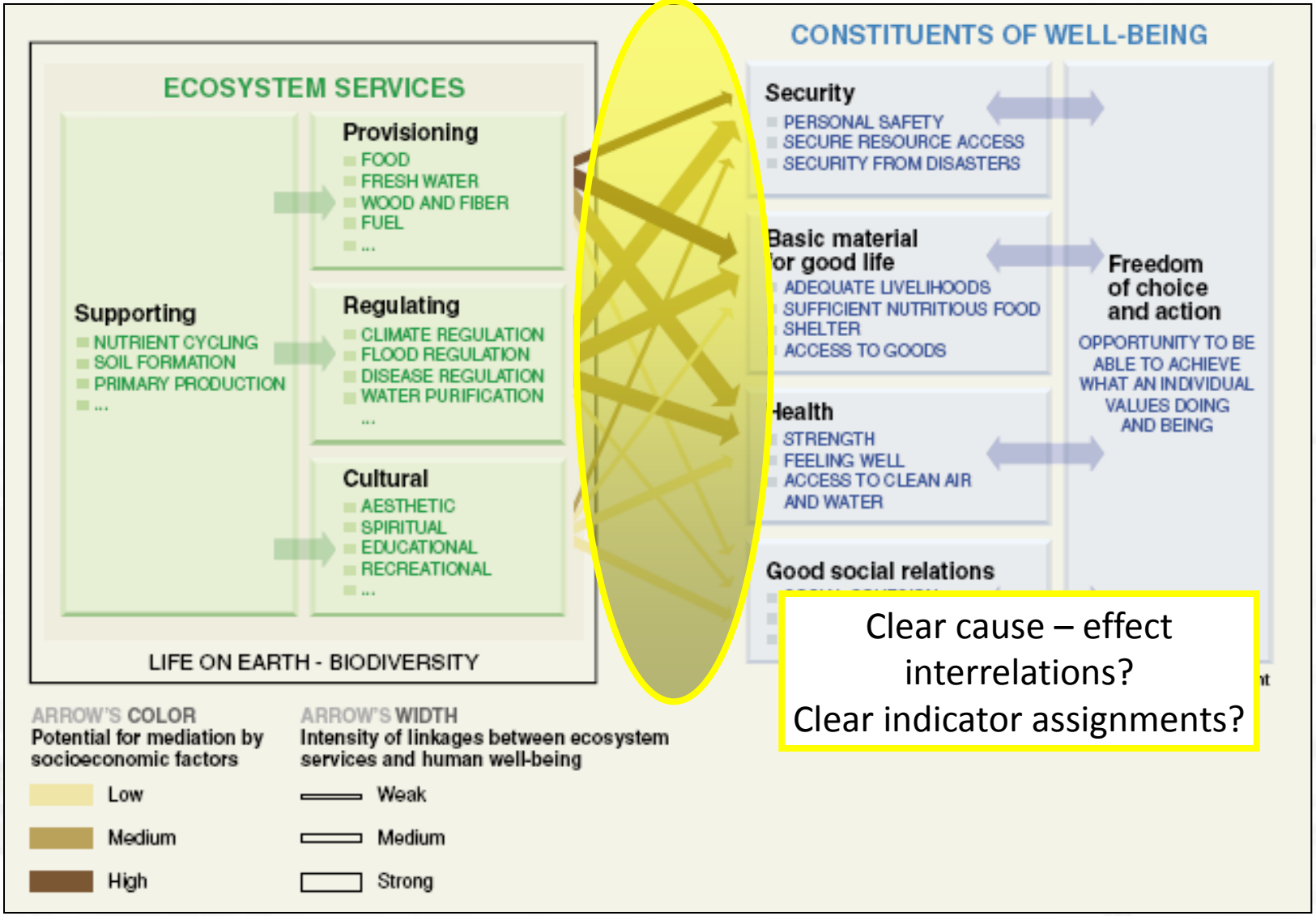
Concluding remarks




**Is the basic concept of ecosystem service types really structurized consistently?**

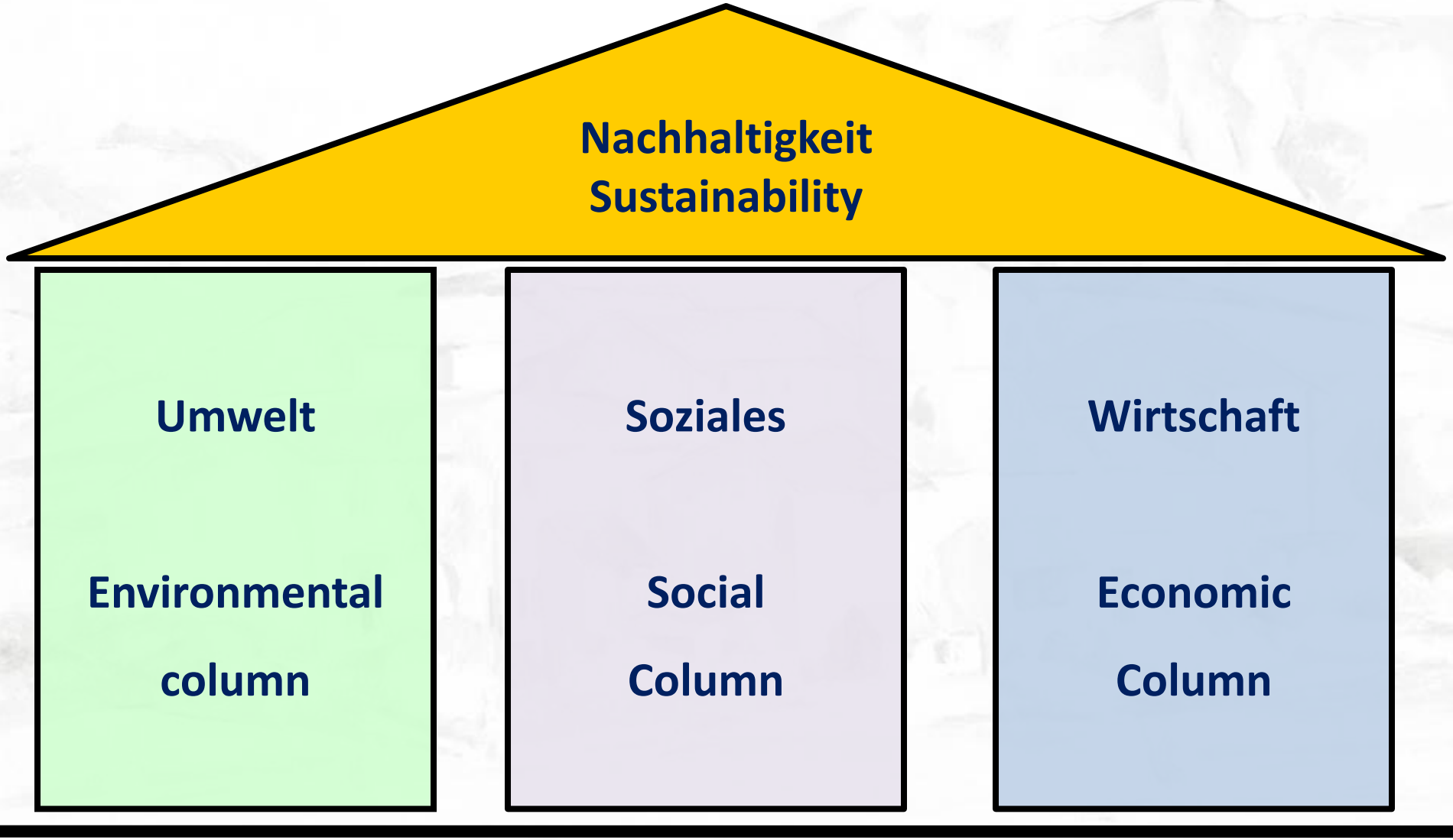



**Is the basic concept of ecosystem service types really structurized consistently?**

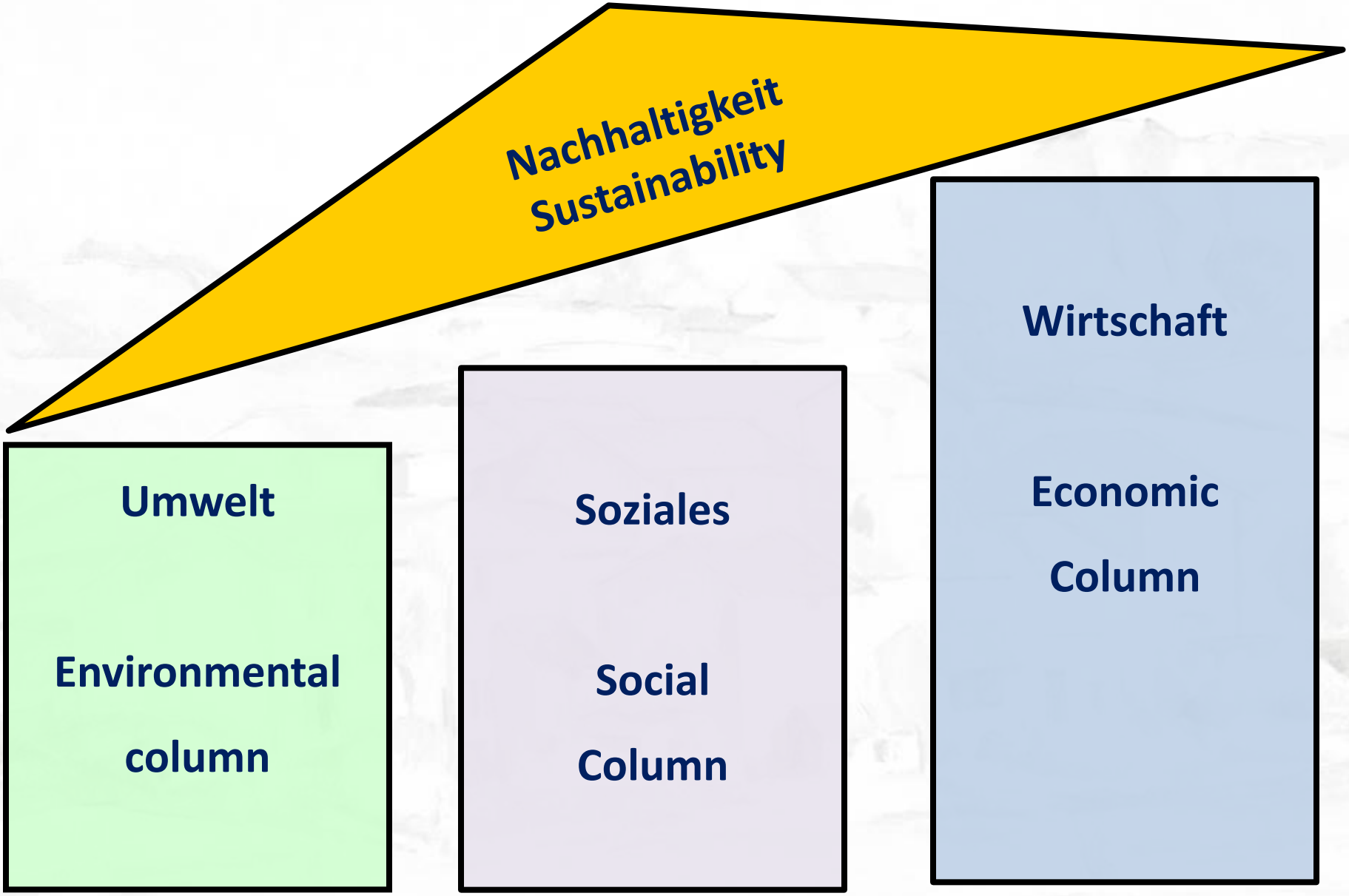



Clear cause – effect interrelations?
Clear indicator assignments?

**Can we really find clear interrelations between service provision and human well-being?**




**Are we in danger of loosing the intrinsic values of nature?**




**Are we in danger of loosing the intrinsic values of nature?**

http://www.yannarthusbertrand.org/

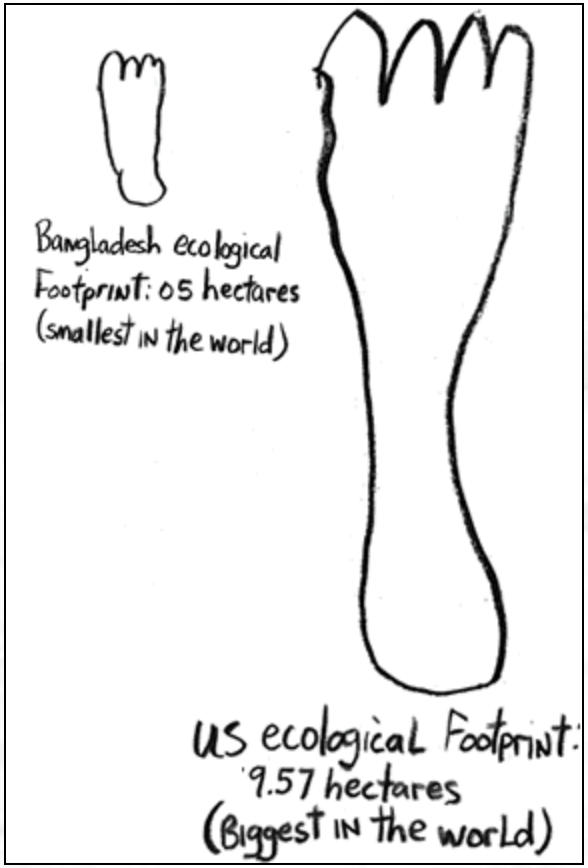
http://www.sueddeutsche.de/panorama/624/373435/text/

http://www.schwarzaufweiss.de/deutschland/wedel.htm

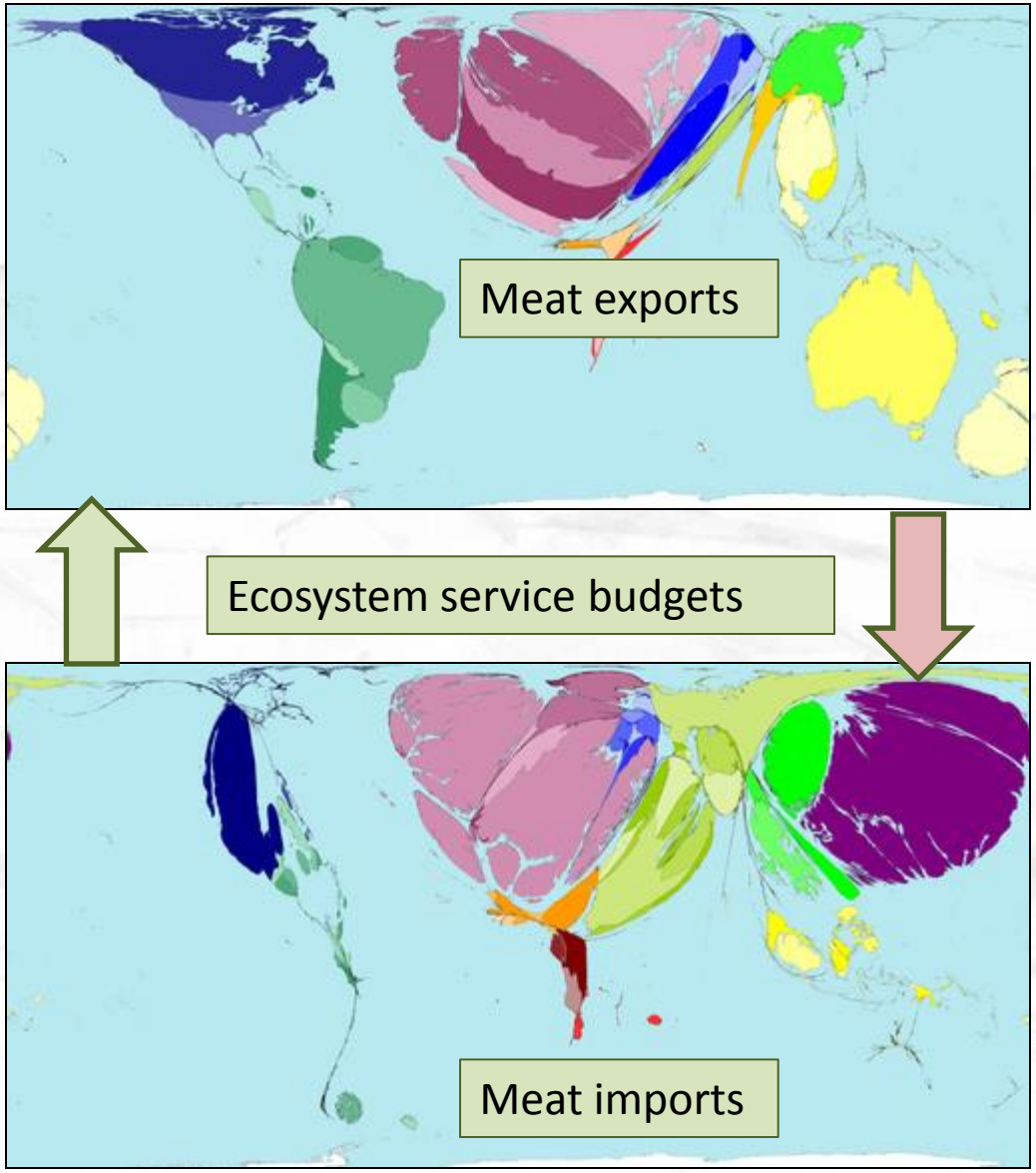
http://www.bepa-galerie.de/Rinder/

http://www.expli.de/anleitung/rezept-rinder-rouladen-kinderleicht-zubereiten/fleisch-anbraten-4218/

**How can we cope with the large regional differences of ecosystem service valuation?**




http://www.adbusters.org/campaigns/truecosteconomics/footprint.html




http://www.worldmapper.org/display.php?selected=50

**Don‘t we have to take into account ecosystem service footprints?**

**How can we calculate the economic value of a service?**

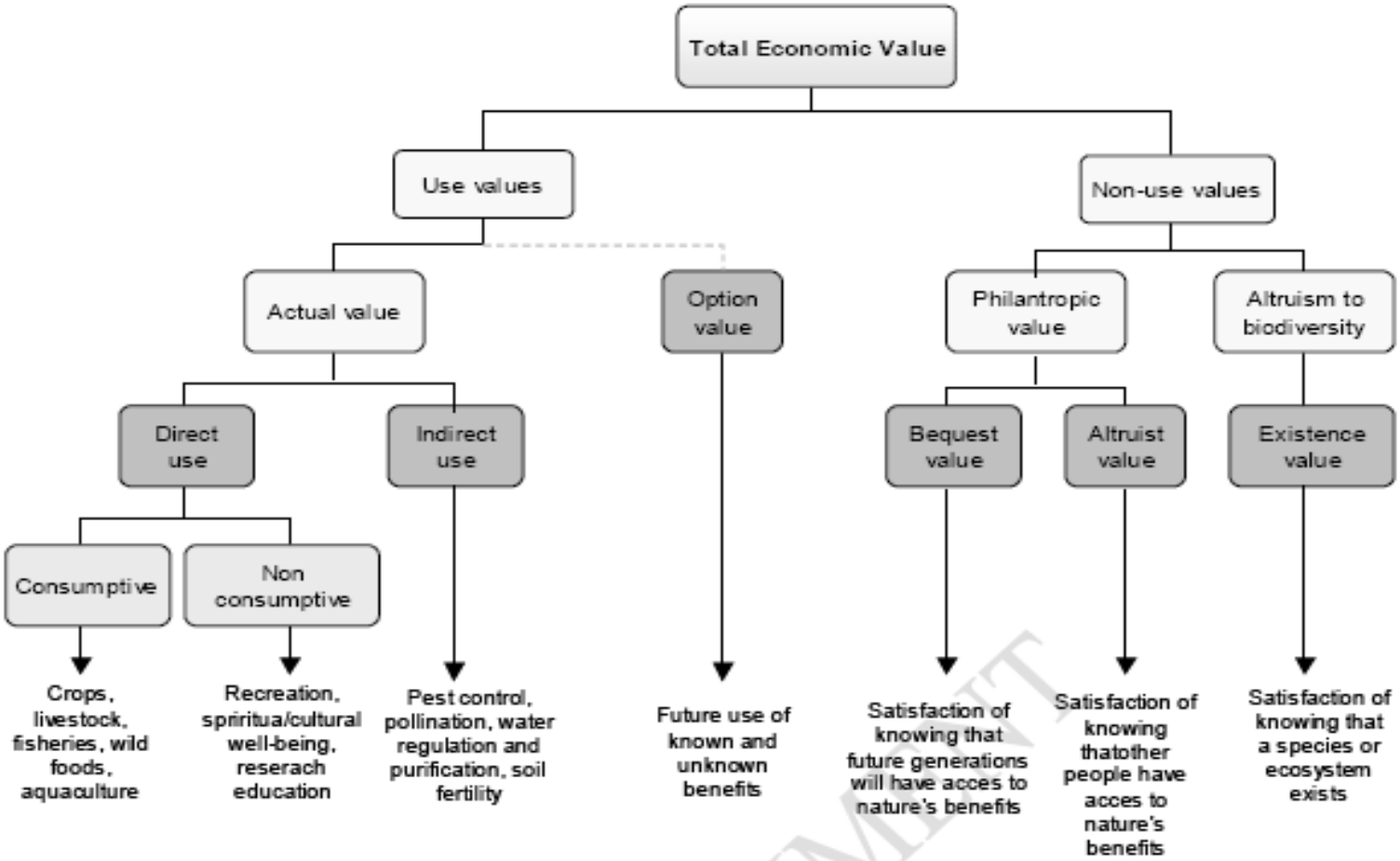
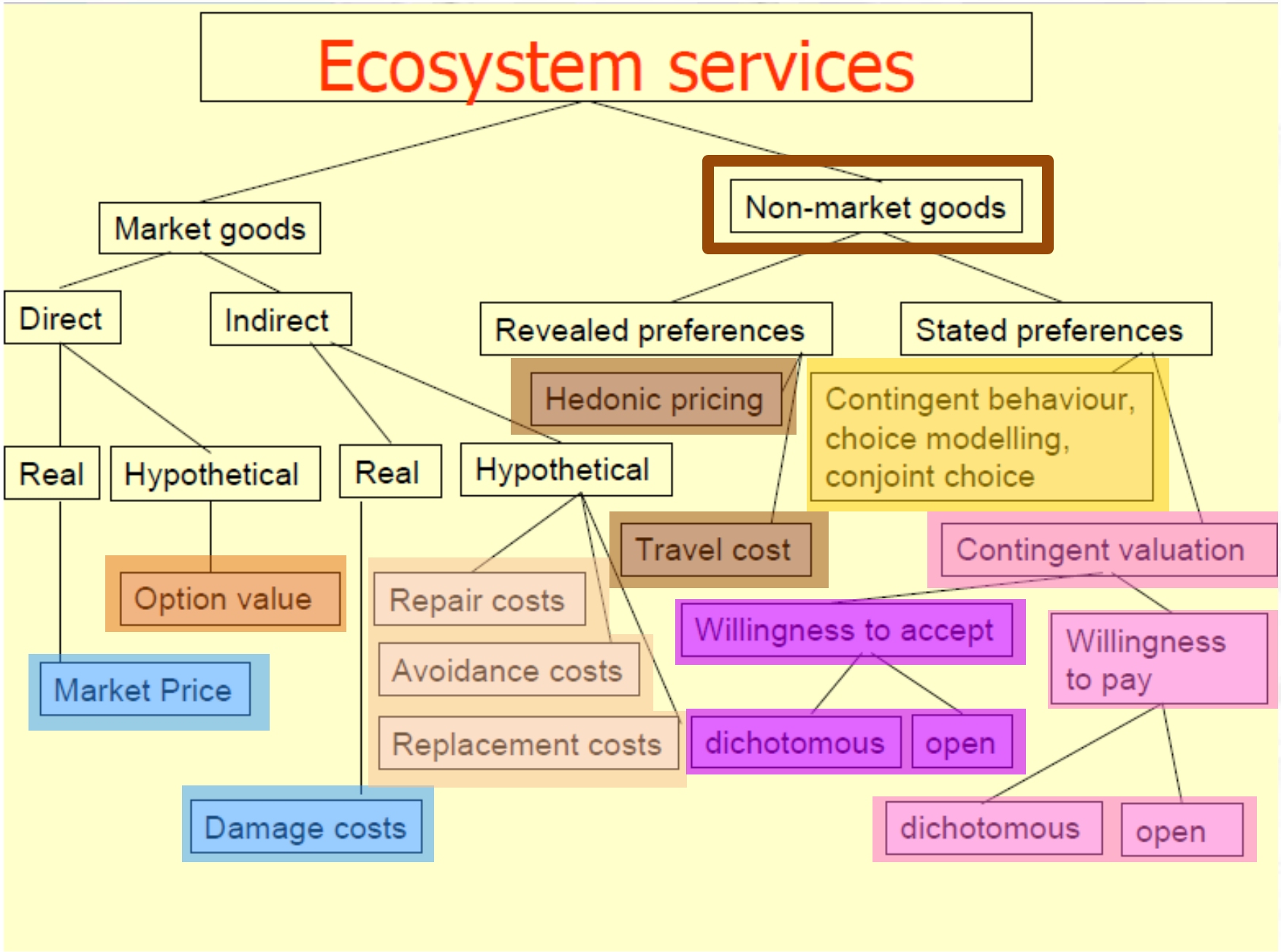



**Figure 3:** **Value types within the TEV approach**

Figure 3 reviews the value types that are addressed in the literature on nature valuation. Boxes in dark gray and the examples below the arrows are those that are directly addressed by value elicitation methods related to the TEV framework.

DOCUMENT

http://www.teebweb.org/LinkClick.aspx?fileticket=JUukugYJHTg%3d&tabid=1018&language=en-US




Spangenberg (Salzau 2008)

**How to unify these approaches in a comparable manner?**

## Do we really need the economic price dimension?

- **Market price**
  - E.g. farm products
- **Shadow price**
  - Mitigation costs
  - Avoided damage costs
  - Replacement costs
- **Questionnaire based price**
  - Willingness to pay
  - Willingness to travel

Consistent with economic theory

Hypothetical Constructions?

**Can we really compare (and add) the different monetary service values if they have been quantified on the base of different methodologies?**

## Do we really need the economic price dimension?

- **Market price**
  - E.g. farm products
- **Shadow price**
  - Mitigation costs
  - Avoided damage costs
  - Replacement costs
- **Questionnaire based price**
  - Willingness to pay
  - Willingness to travel

Consistent with economic theory

Hypothetical Constructions?

↓

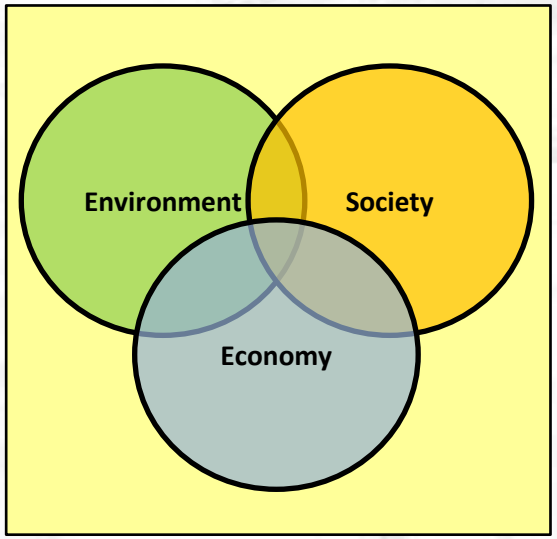
Could physical assessemts be sufficient?

**Can we really compare (and add) the different monetary service values if they have been quantified on the base of different methodologies?**

# How to link the components of sustainability?

Concluding remarks

# Nature in culture or culture in nature?



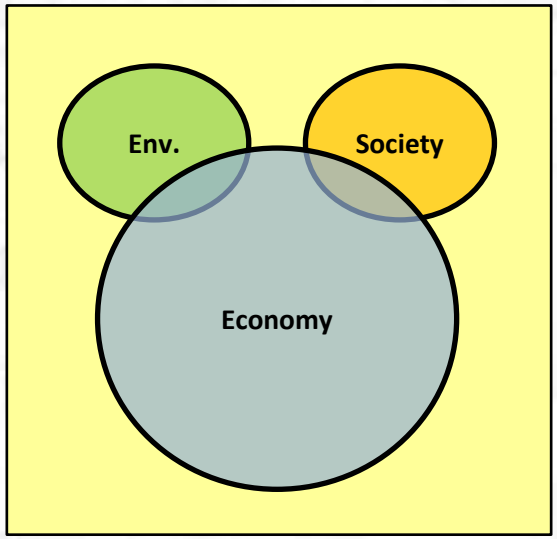

„Venn“

↓

3 equal pillars

↓

„weak“ sustainability



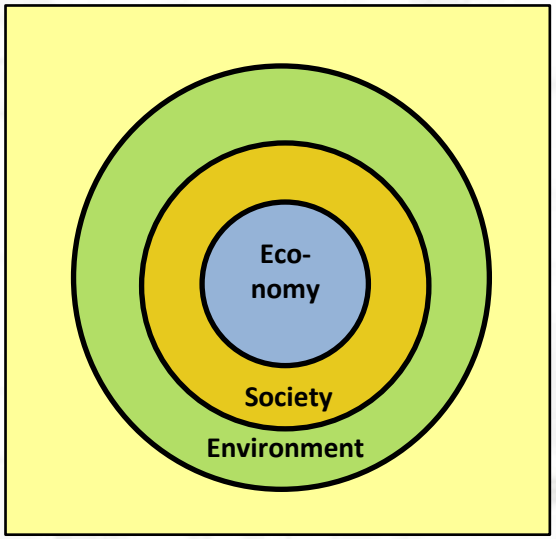

„Mickey Mouse“

↓

Economic dominance

↓

„very weak“ sustainability



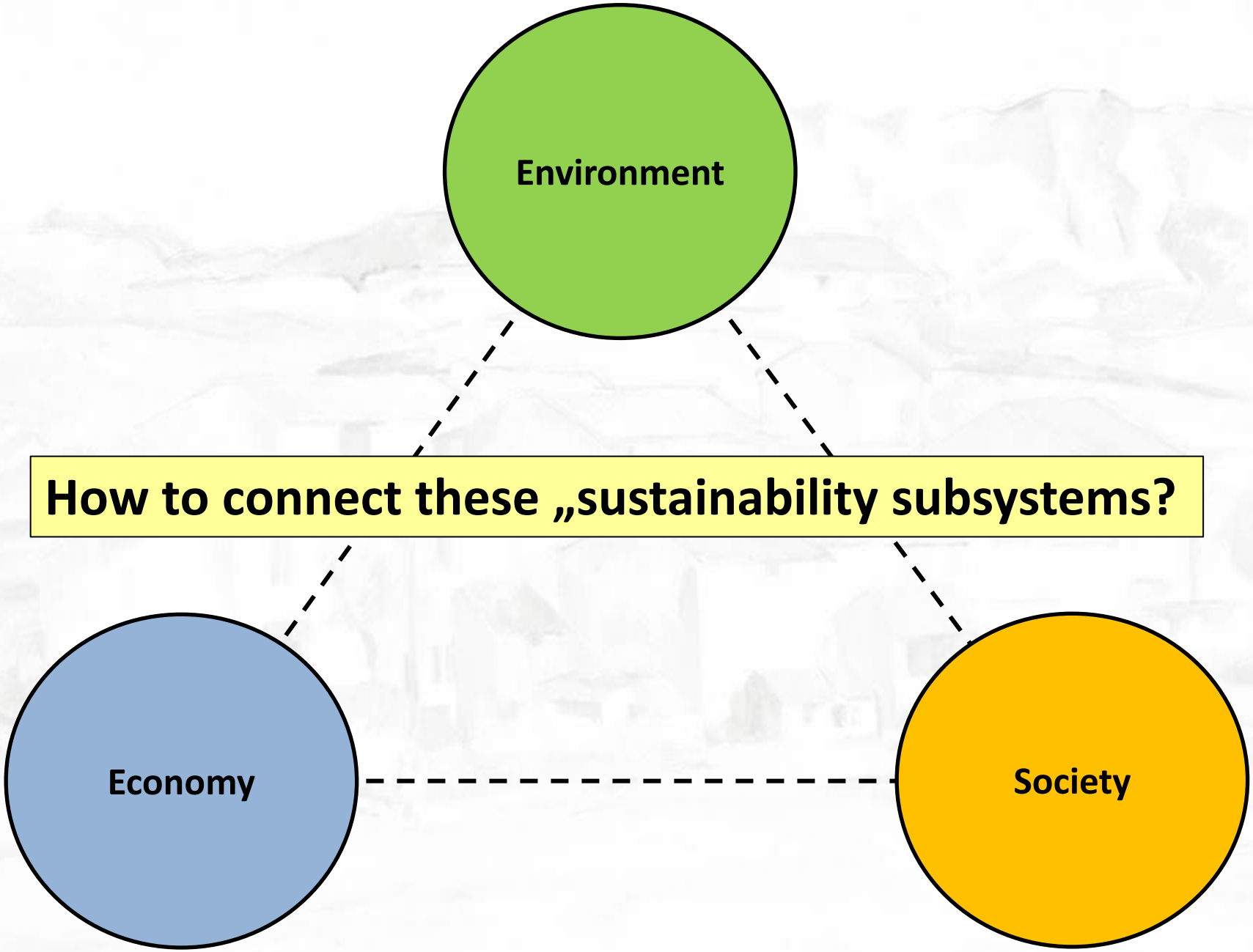

„Bull‘s eye“

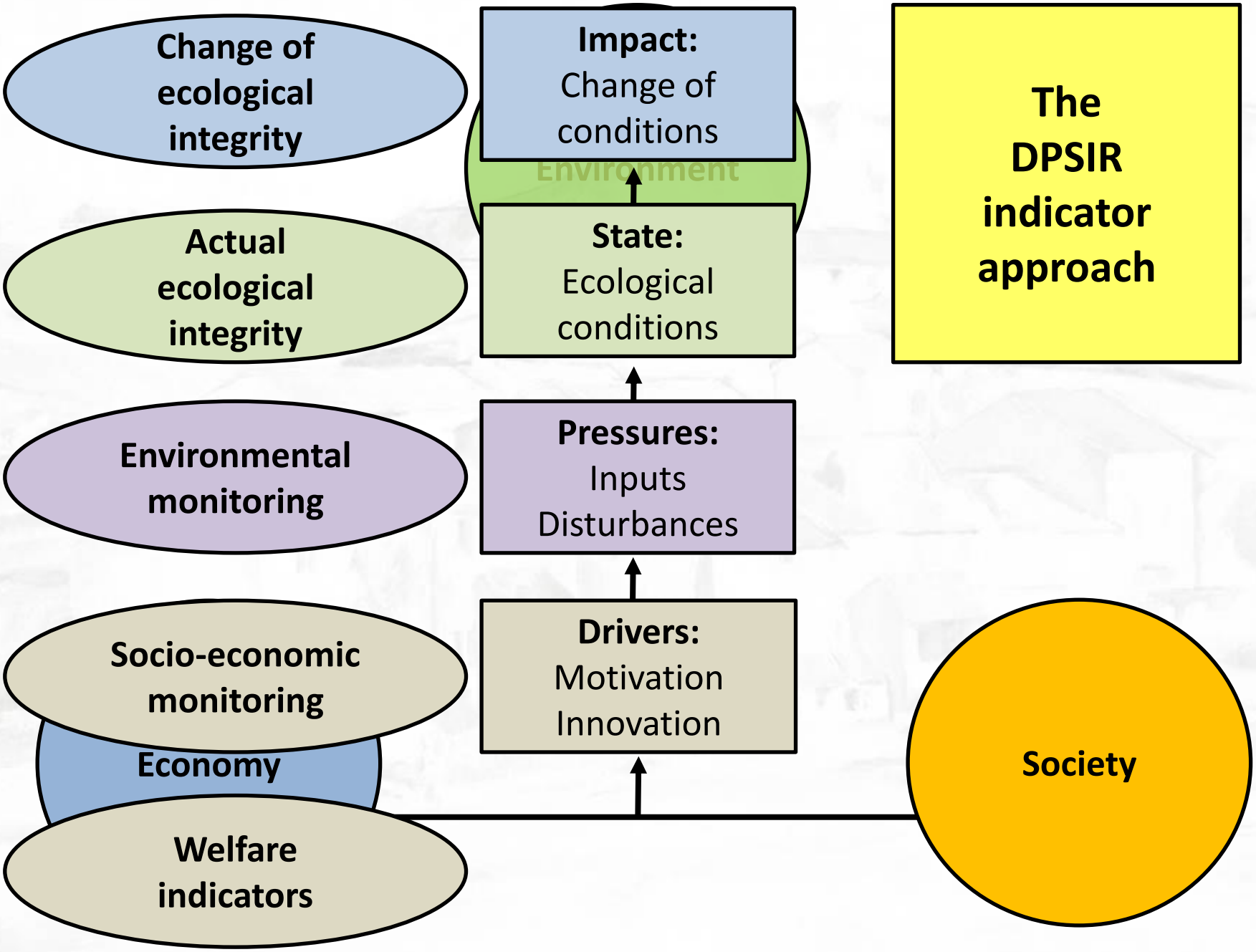
↓

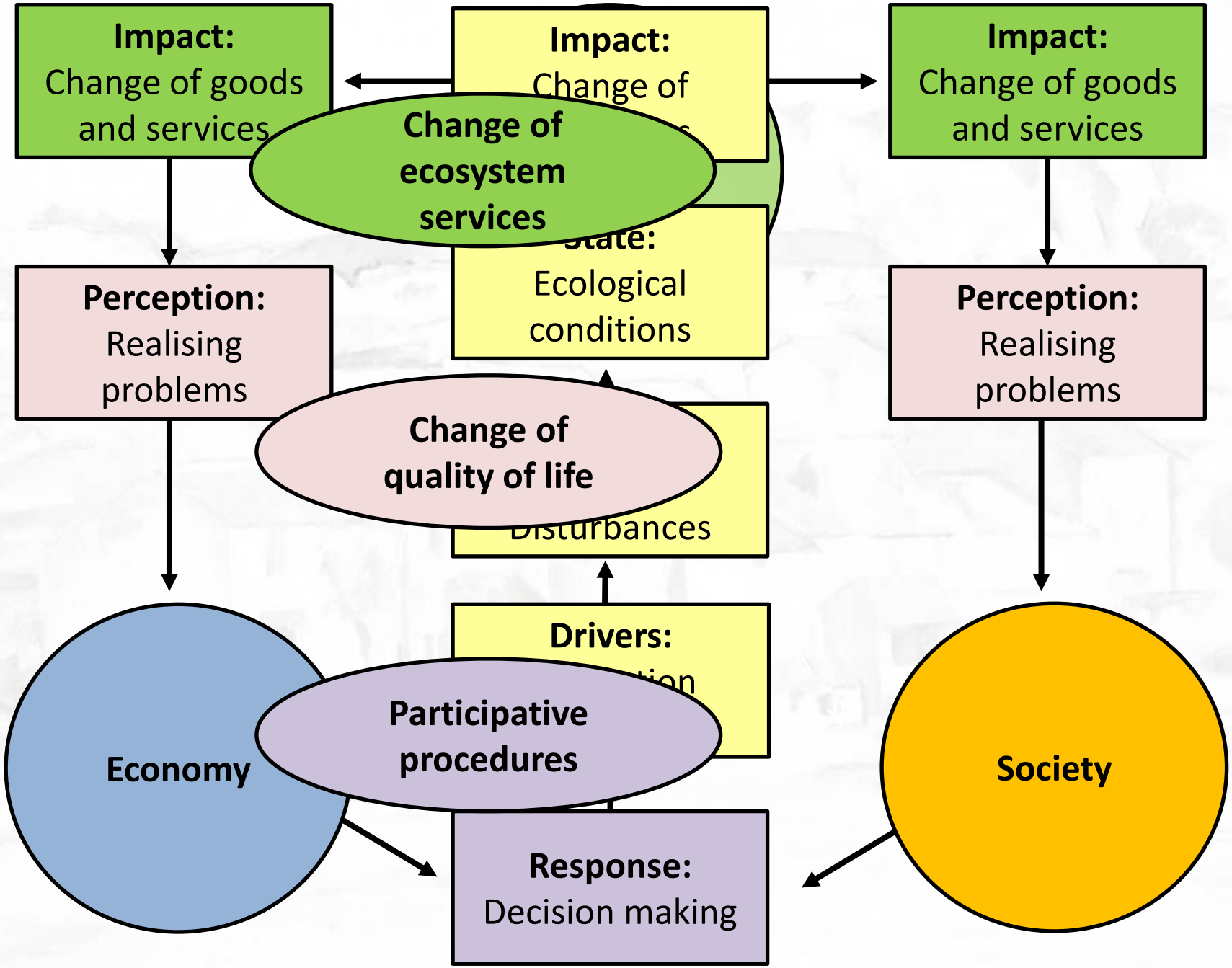
Environmental constraints

↓

„strong“ sustainability


Environment
How to connect these „sustainability subsystems?
Economy
Society


Change of ecological integrity
Actual ecological integrity
Environmental monitoring
Socio-economic monitoring
Economy
Welfare indicators
Impact: Change of conditions
Environment
State: Ecological conditions
Pressures: Inputs Disturbances
Drivers: Motivation Innovation
Society
The DPSIR indicator approach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Perception:
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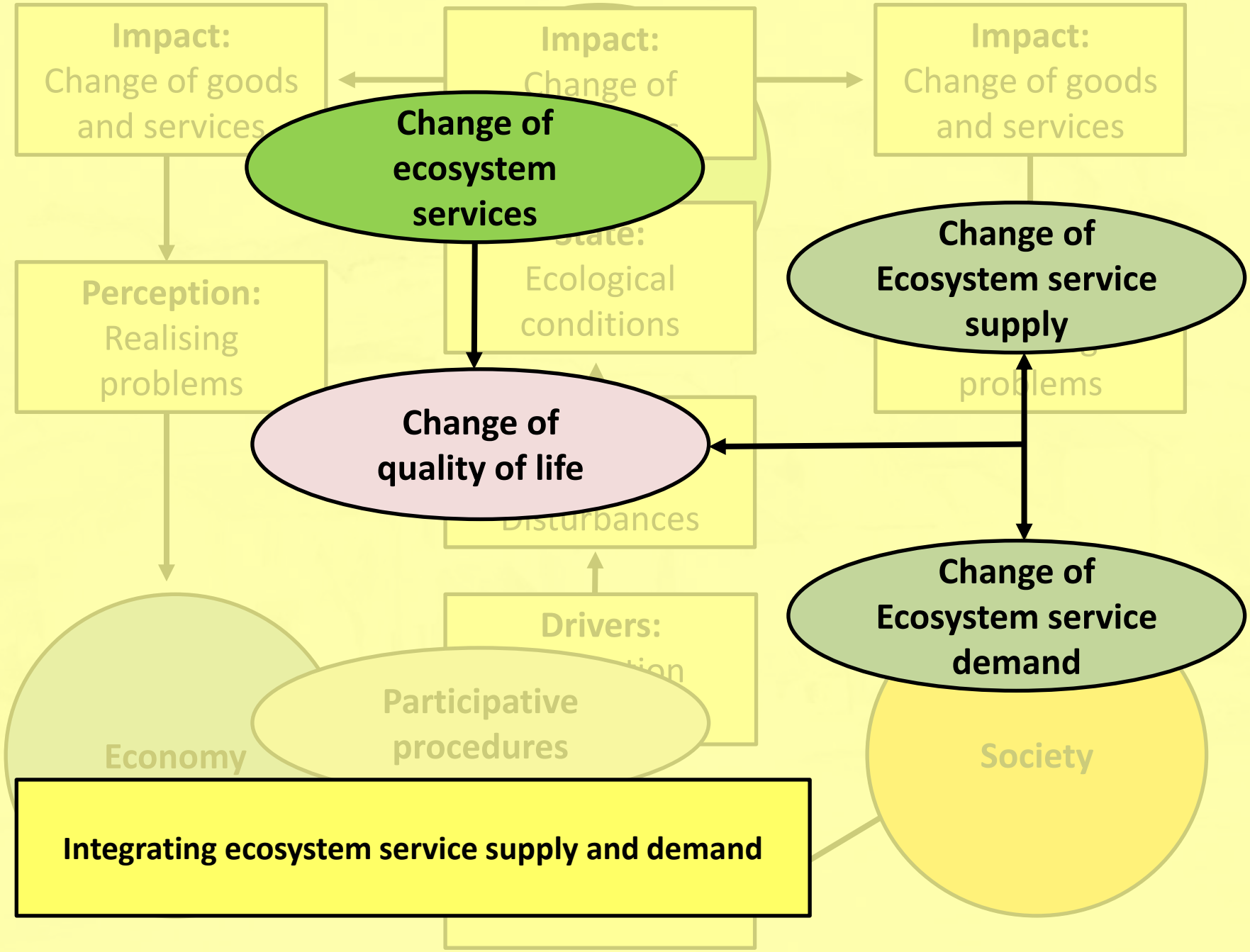
Change of quality of life
Disturbances
Drivers:
Economy
Participative procedures
Society
Response:
Decision making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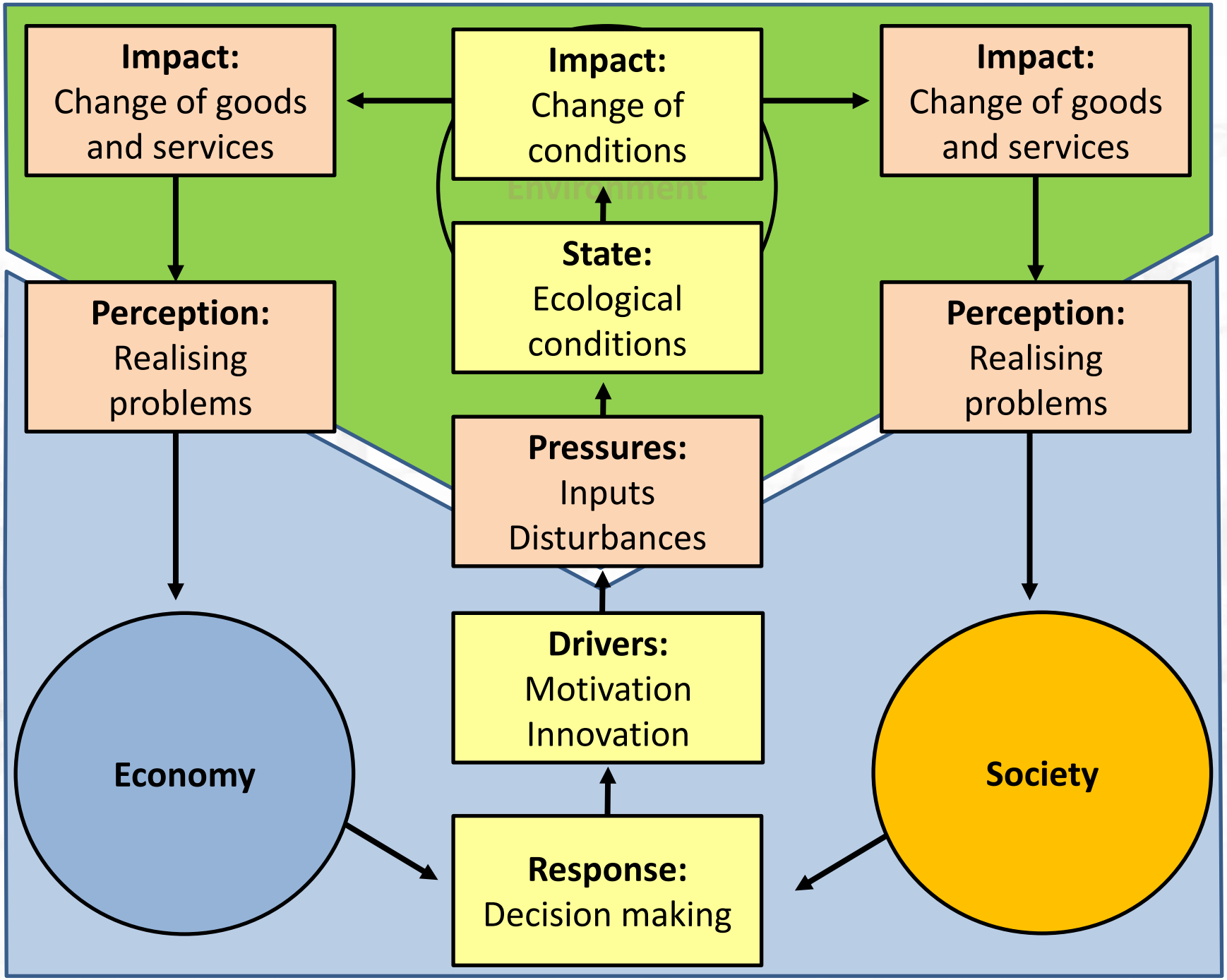
Economy
Society
Integrating ecosystem service supply and demand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Realising problems
Pressures:
Inputs
Disturbances
Drivers:
Motivation
Innovation
Economy
Society
Response:
Decision making

# Conclusions

- **Terminological proposals**
  - Indicators
  - Socio-ecological systems
  - Sustainable development
- **Requirements for sustainability indicators**
- **Recent concepts and future demands**
- **Ecological aspects of sustainability**
  - Ecosystem integrity
  - Ecosystem services
- **DPSIR as an integrated indicator scheme**

# Conclusions

- **Ecosystem services comprise of all components of natural capital** which are influenced by ecological processes.
- **Ecosystem services are *the* essential prerequisites for human life.**
- **Ecosystem services are strongly related with**
  - *Environmental quality*
  - *Social interrelations* and quality of human life
  - *Economic demands* and human wellfare
  - Ecosystem services can be *depicted in many different currencies* (also as money)
- **Ecosystem services are suitable linkages for sustainability indication.**

# Conclusions

**Future demands for sustainability indication:**

- **Enhanced integration** of sustainability columns
- **Fair indication** of sustainability sectors
- **Critical review of GDP**
- Enhanced **consideration of causalities**
- Stronger integration of **ecological issues**
- Better **communication of uncertainties**
- Increasing research on **services and ecosystem protection concepts**
- **Consequent application of systems conceptions**

# Thank you very much for the attention!