# Measuring Ecosystem Services

The Resilience and Development Programme (Swedbio)

Stockholm Resilience Centre
Research for Governance of Social-Ecological Systems

Stockholm University

GEO BON

CSIR
our future through science

ProEcoServ
Project for Ecosystem Services

# Measure, indicator, index….

**Measure** (or measurement) = actual measurement of a state, quantity or process derived from observations or monitoring. E.g. bird counts, total dissolved solids, biomass, runoff

An **indicator** uses measures to communicate something of interest E.g. bird counts over time show a trend which can indicate the success of conservation actions for a specific group of species. They are purpose and audience specific

An **index** comprises a number of measures combined in a particular way to increase their sensitivity, reliability or ease of communication. E.g. Red List Index for birds shows changes in threat status over time obtained through a specific formula. Disaggregation & traceability are important

# What I am going to talk about

- **Current challenges** of indicators and measures
  - **Complexity** of what we are trying to measure
- A **framework** that tries to untangle the complexity of what to measure
- Sources of **data** with which to measure ES
- An **example**

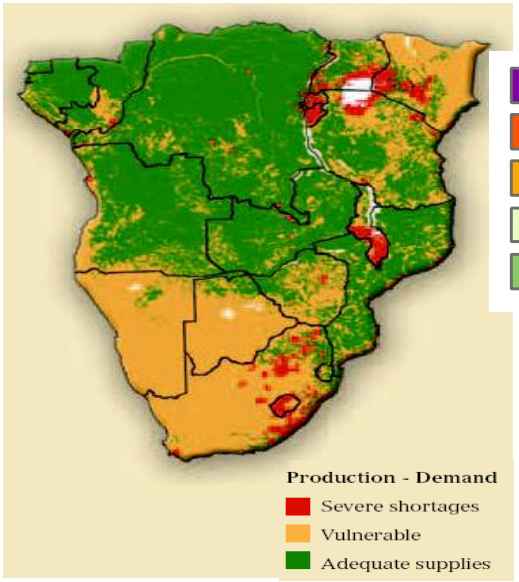


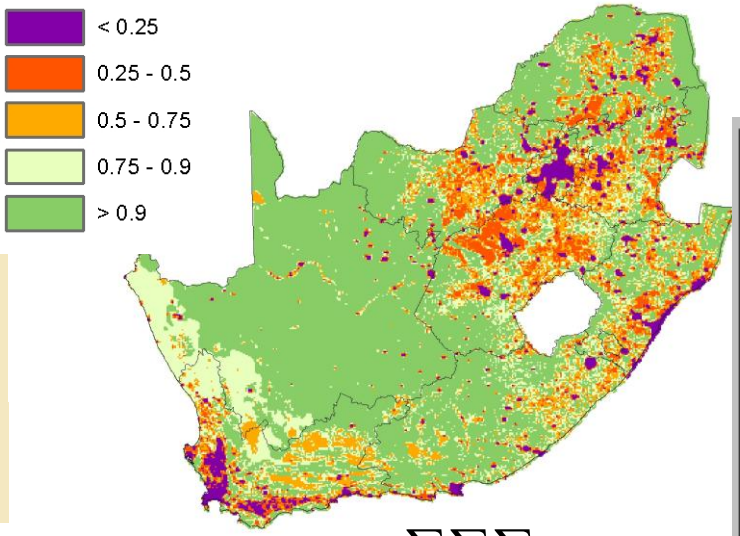

# CURRENT CHALLENGES IN ECOSYSTEM SERVICE MEASUREMENT & INDICATORS

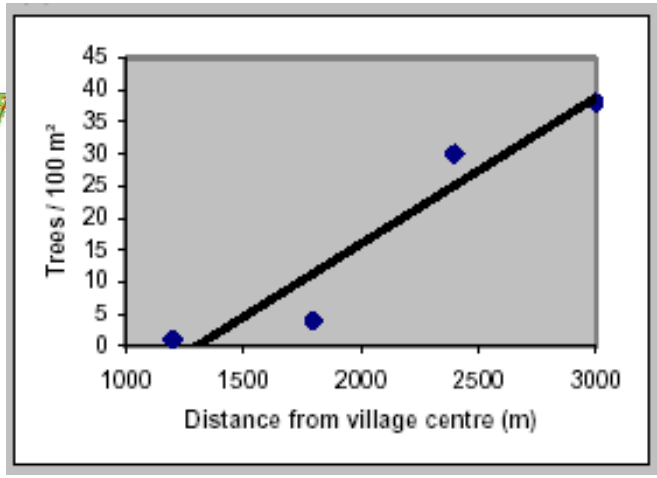
# Current challenges

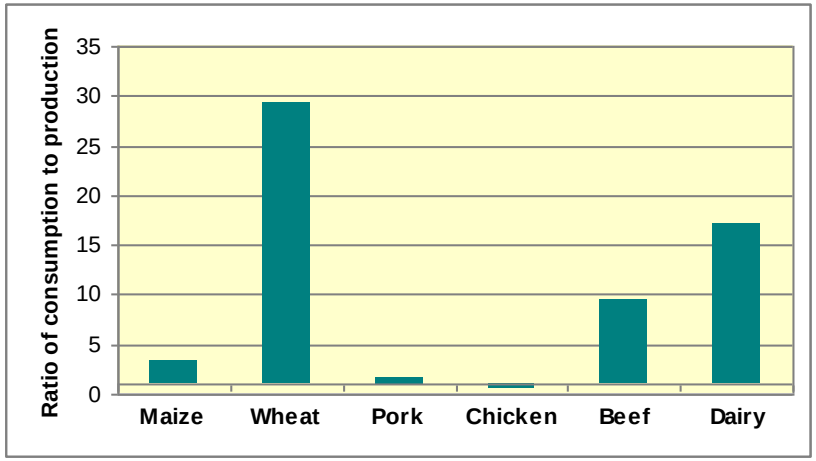
| Components of biodiversity | |
|---|---|
| Trends in extent of selected biomes, ecosystems, habitats | |
| Trends in abundance of selected species | |
| Coverage of protected areas | |
| Changes in status of threatened species | |
| Trends in genetic diversity | |
| **Sustainable use** | |
| Area under sustainable management | |
| Proportion of products from sustainable sources | |
| Ecological footprint and related concepts | |
| **Threats to biodiversity** | |
| Nitrogen deposition | |
| Trends in invasive alien species | |
| **Ecosystem integrity, goods and services** | |
| Marine Trophic Index | |
| Water quality of freshwater ecosystems | |
| Trophic integrity of other ecosystems | |
| Connectivity/fragmentation of ecosystems | |
| Human-induced ecosystem failure | |
| Health and well-being of communities | |
| Biodiversity for food and medicine | |

# Current challenges: Existing measures and indicators

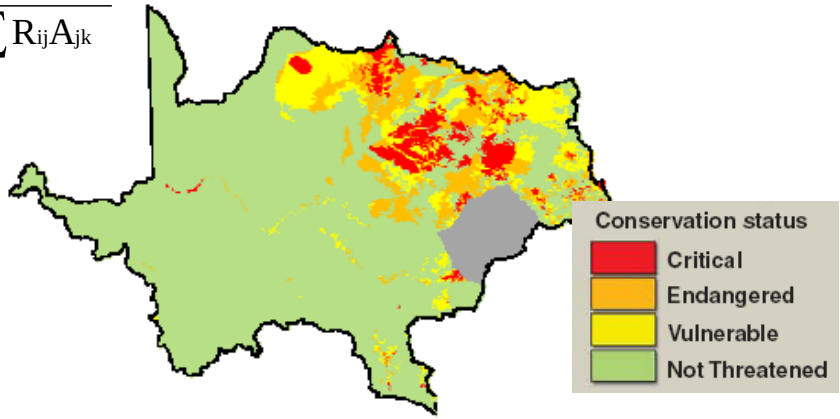



$$BII = \frac{\sum_i \sum_j \sum_k R_{ij} A_{jk} I_{ijk}}{\sum_i \sum_j \sum_k R_{ij} A_{jk}}$$



# Current challenges: Existing measures and indicators

| Ecosystem Service | Number of Indicators Identified | Ability to Convey Information | Data Availability | Global Compiling Agency |
|---|---|---|---|---|
| **PROVISIONING** | | | | |
| **Food** | | | | |
| Crops | 4 | | | FAO |
| Livestock | 3 | | | FAO |
| Capture fisheries | 7 | | | FAO |
| Aquaculture | 2 | | | FAO |
| Wild foods | 1 | | | None |
| **Biological raw materials** | | | | |
| Timber | 6 | | | FAO |
| Fibers and resins, animal skins, sand, and ornamental resources | 4 | | | FAO |
| **Biomass fuel** | 4 | | | FAO |
| **Freshwater** | 5 | | | FAO |
| **Genetic resources** | 3 | | | None |
| **Biochemicals, natural medicines, and pharmaceuticals** | 2 | | | None |
| **REGULATING** | | | | |
| **Air quality regulation** | 2 | | | None |
| **Climate regulation** | | | | |
| Global climate regulation | 7 | | | IPCCC |
| Regional and local climate regulation | 4 | | | None |
| **Water regulation** | 2 | | | None |
| **Erosion regulation** | No Indicators Identified | | | |
| **Water purification and waste treatment** | 3 | | | None |
| **Disease regulation** | 3 | | | None |
| **Soil quality regulation** | No Indicators Identified | | | |
| **Pest regulation** | No Indicators Identified | | | |
| **Pollination** | No Indicators Identified | | | |
| **Natural hazard regulation** | 7 | | | None |
| **CULTURAL** | | | | |
| **Aesthetic/ ethical values** | 4 | | | None |
| **Spiritual and religious values** | No Indicators Identified | | | |
| **Recreation and ecotourism** | 5 | | | None |

# Current challenges

- The indicators available for most ecosystem services are **not comprehensive** and are often **inadequate** to characterize the diversity and complexity of the **benefits** they provide;
- Data are often **insufficient** to support the use of these indicators;
  - Are largely without an **evidence basis**, i.e. reported on with no supporting data, results or figures
  - Where they are based on evidence they focus on **provisioning services**
- Indicators for **regulating and cultural services** lag behind provisioning services.
- The ability of indicators to **convey information** about ecosystem services is low overall, although it varies widely among services



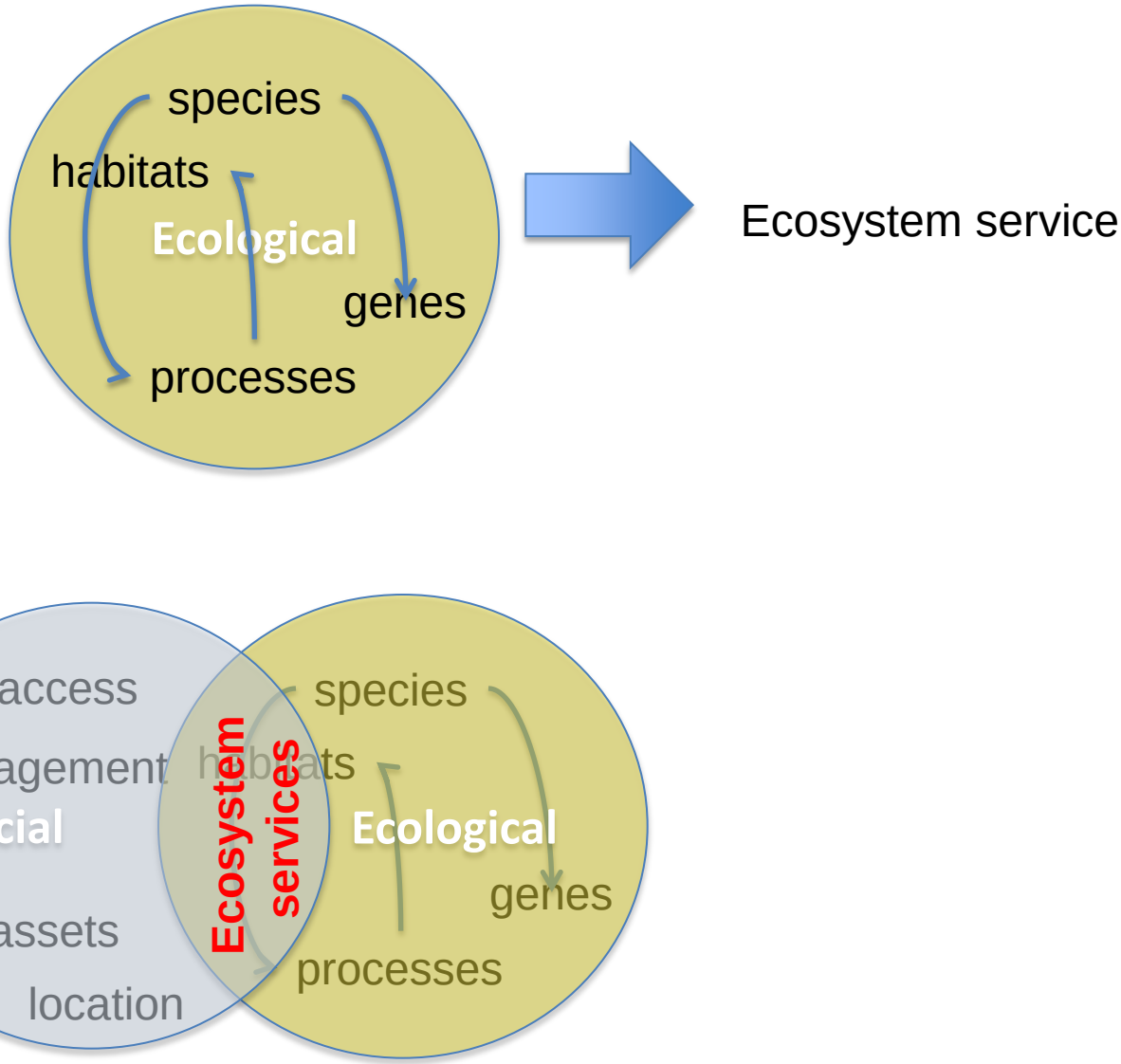

# THE COMPLEXITY INVOLVED IN ECOSYSTEM SERVICE MEASUREMENT

# Complexity of ES

| Definition of ecosystem services | Citation |
|---|---|
| …"the benefits human populations derive, directly or indirectly, from ecosystem functions." | (Costanza et al., 1997) |
| …"the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life." | (Daily, 1997) |
| …"the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly." | (de Groot et al., 2002) |
| …"the set of ecosystem functions that is useful to humans." | (Kremen, 2005) |
| …"the benefits people obtain from ecosystems." | (MEA, 2005) |
| …"components of nature, directly enjoyed, consumed, or used to yield human well-being." | (Boyd and Banzhaf, 2007) |
| …"the aspects of ecosystems utilized (actively or passively) to produce human well-being." | (Fisher et al., 2009) |
| …"a range of goods and services generated by ecosystems that are important for human well-being." | (Nelson et al., 2009) |
| …"Benefits that humans recognize as obtained from ecosystems that support, directly or indirectly, their survival and quality of life." | (Harrington et al., 2010) |
| …"a collective term for the goods and services produced by ecosystems that benefit humankind." | (Jenkins et al., 2010) |

Nahlik et al. 2012

# Complexity of ES



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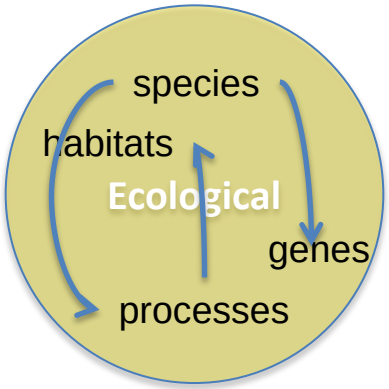


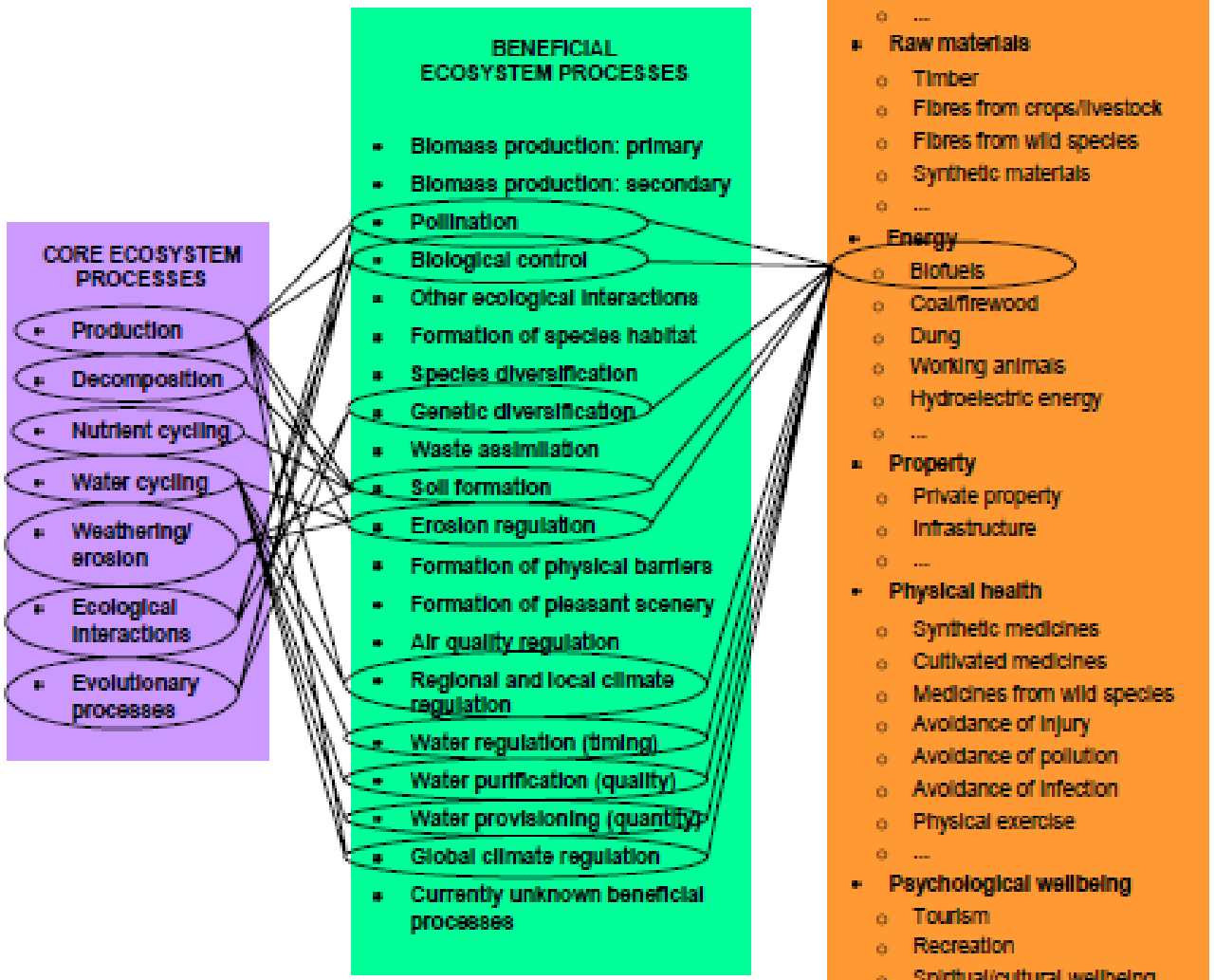

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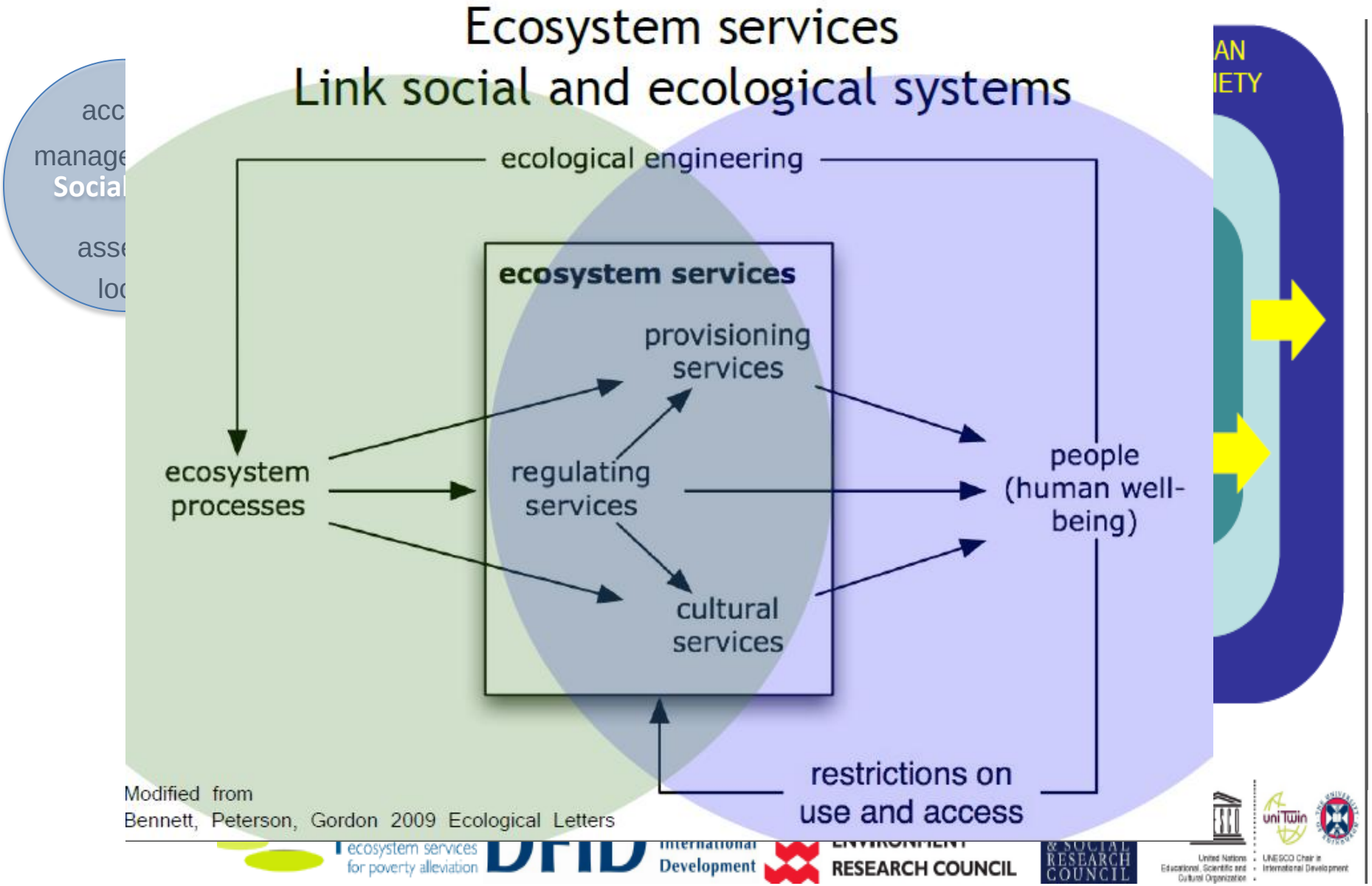

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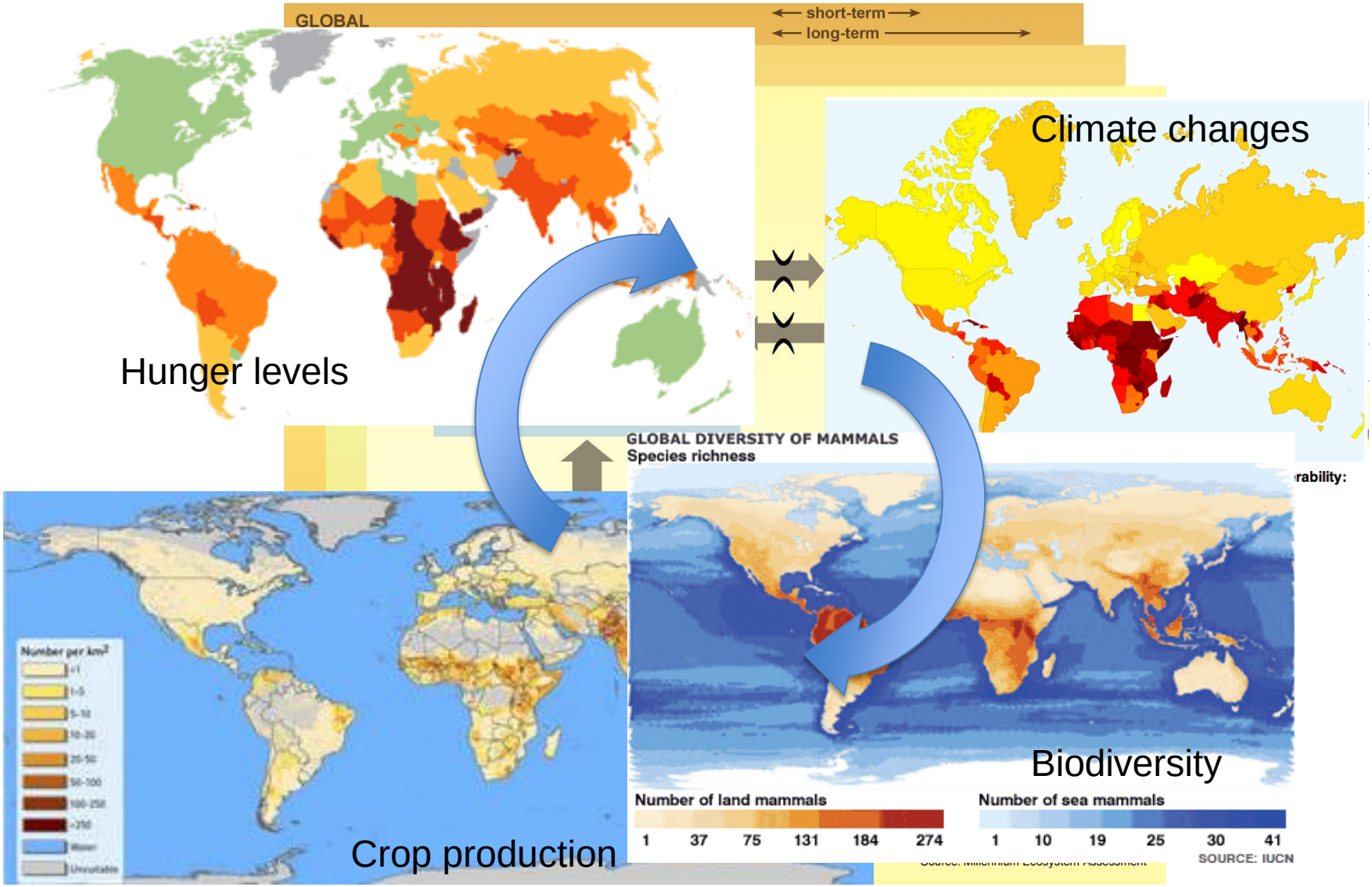
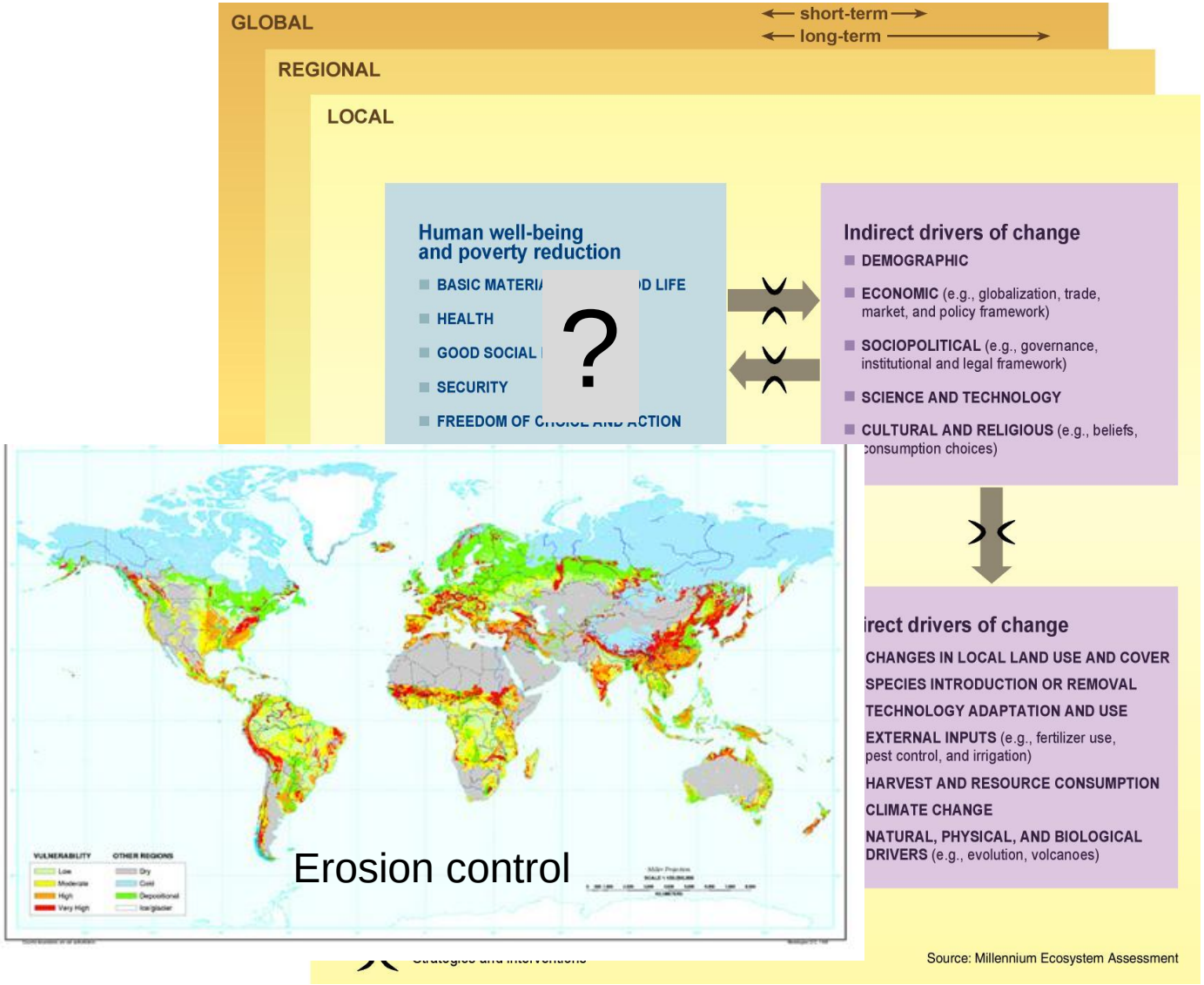


# Complexity of ES



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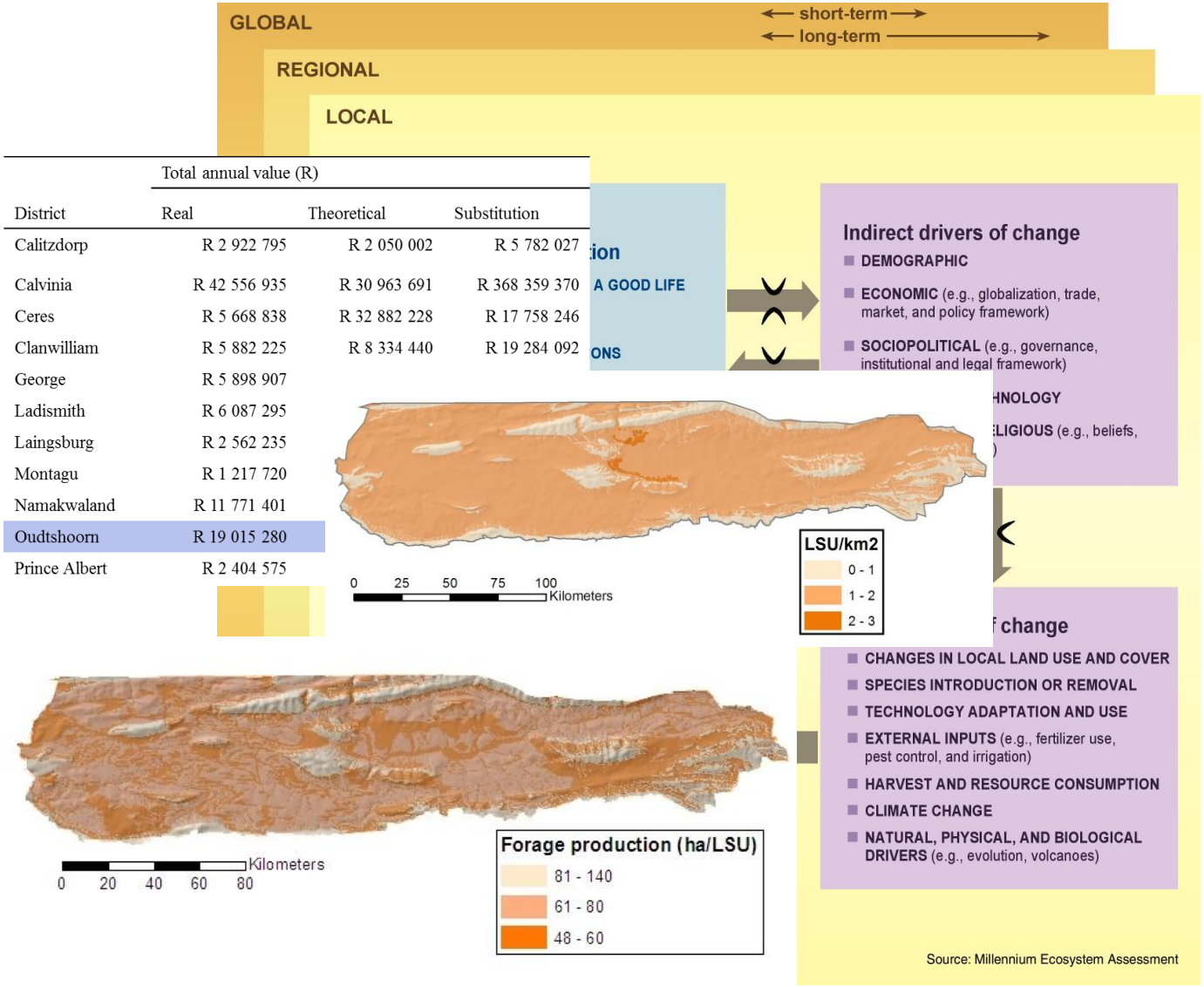
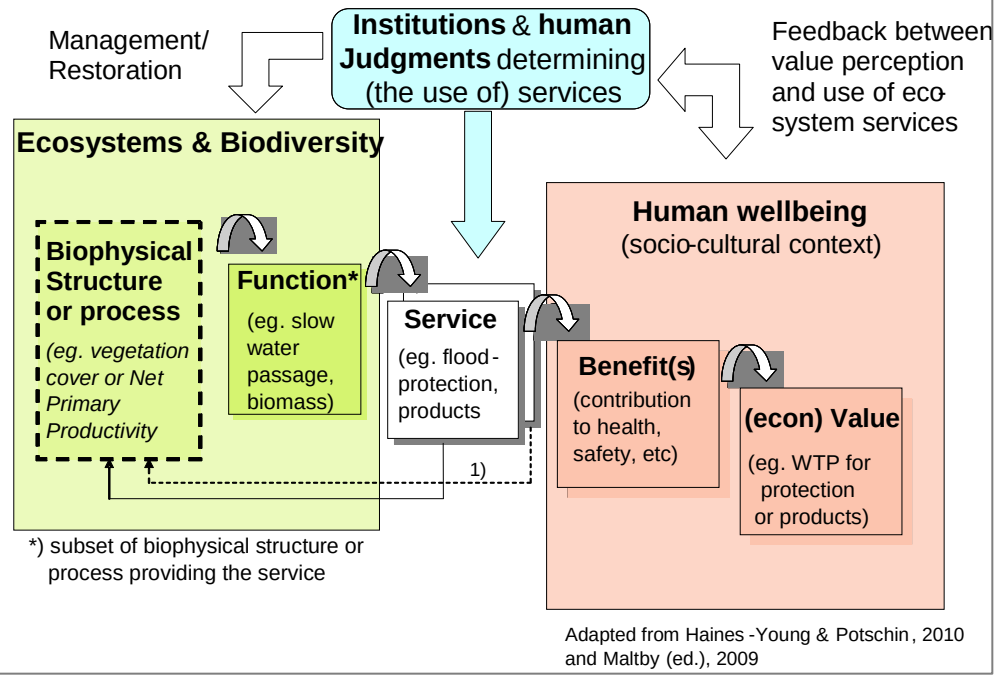
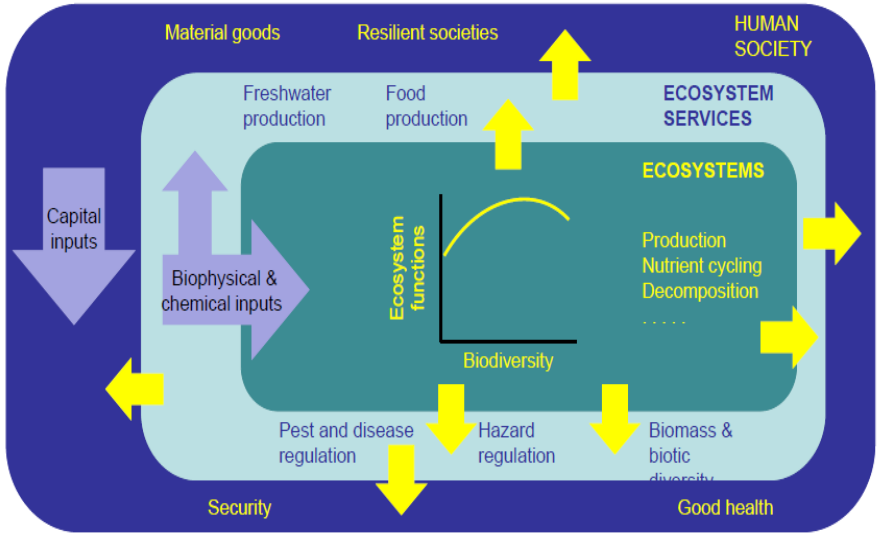





# A FRAMEWORK FOR ECOSYSTEM SERVICE MEASUREMENT



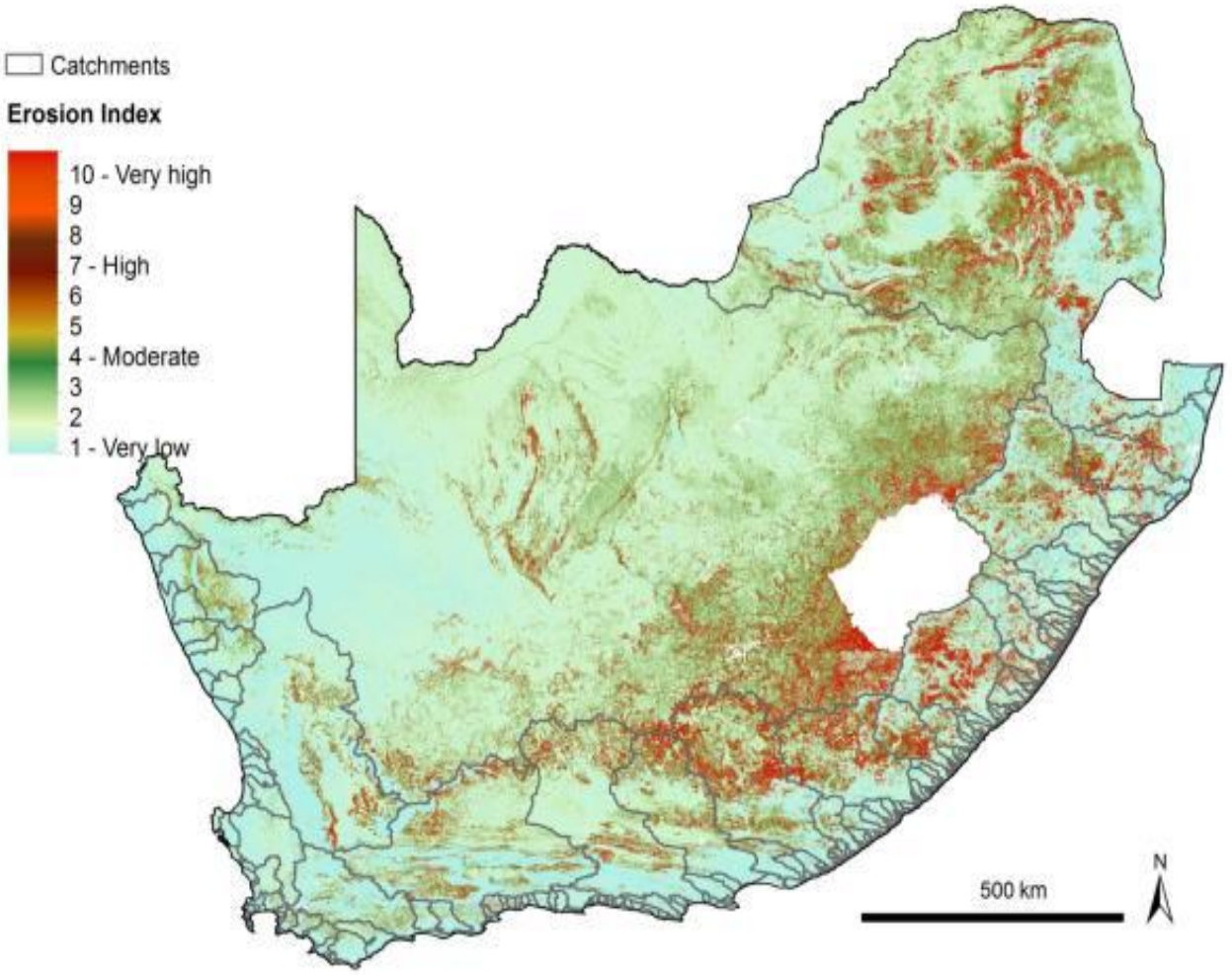




espa ecosystem services for poverty alleviation
DFID Department for International Development
NATURAL ENVIRONMENT RESEARCH COUNCIL
E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

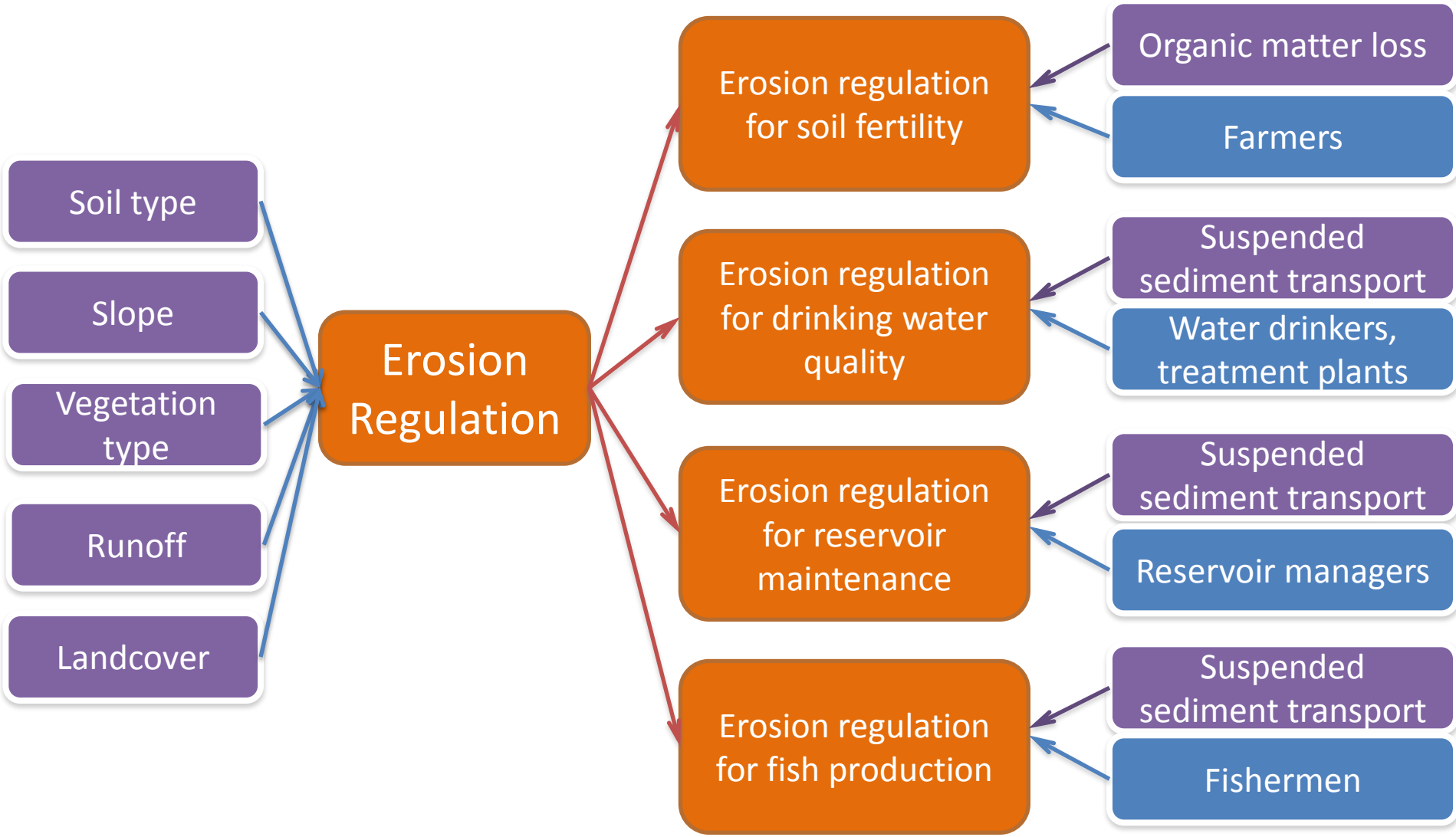
**Table 1 – Illustrative example of relationships between some intermediate services, final services and benefits**

| Abiotic inputs | Intermediate services | Final services | Benefits |
|---|---|---|---|
| Sunlight rainfall nutrients, etc. | Soil formation<br>primary productivity<br>nutrient cycling | Water regulation | Water for irrigation<br>drinking water<br>electricity from hydro-power |
| | Photosynthesis<br>pollination<br>pest regulation | Primary productivity | Food<br>timber<br>nontimber products |

# Example – erosion regulation



# A framework



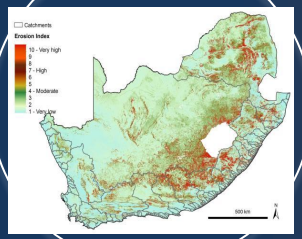

*Tallis et al. 2012*

# A framework for measurement?

## S O C I A L – E C O L O G I C A L  S Y S T E M

Elements & Functions

Soil, veg, landcover




BIOPHYSICAL

HUMAN

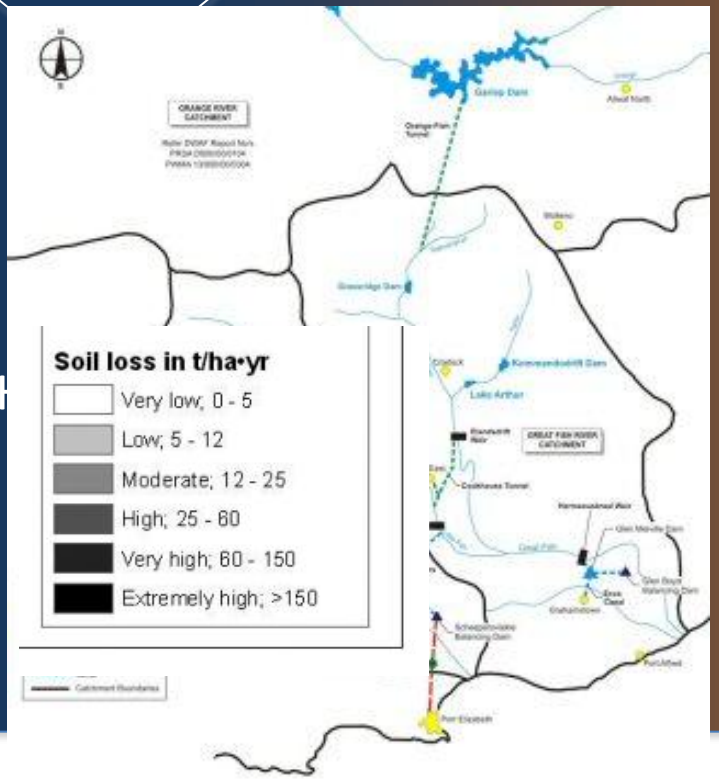
# SOCIAL–ECOLOGICAL SYSTEM

Elements & Functions

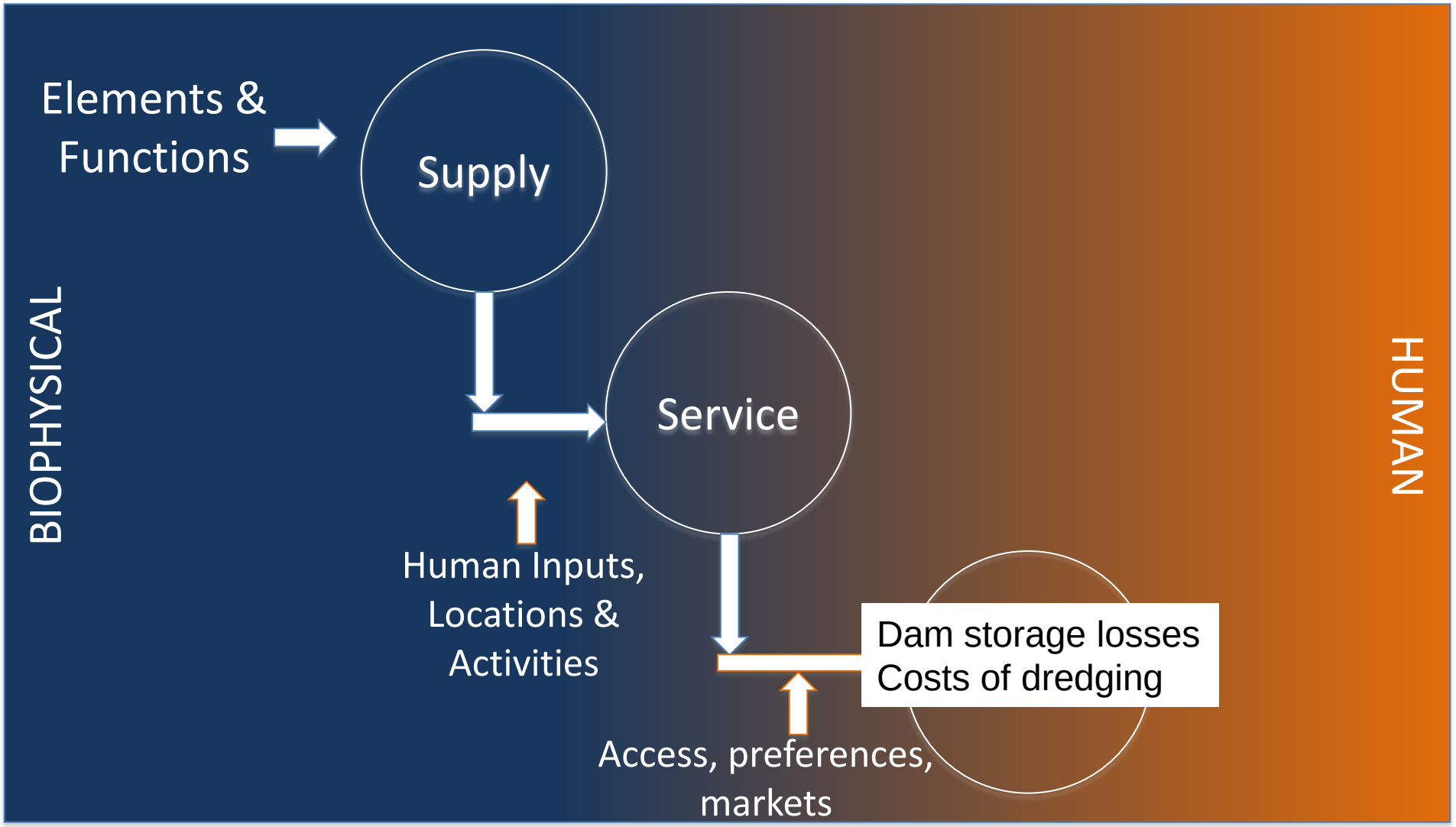
Supply

BIOPHYSICAL

HUMAN

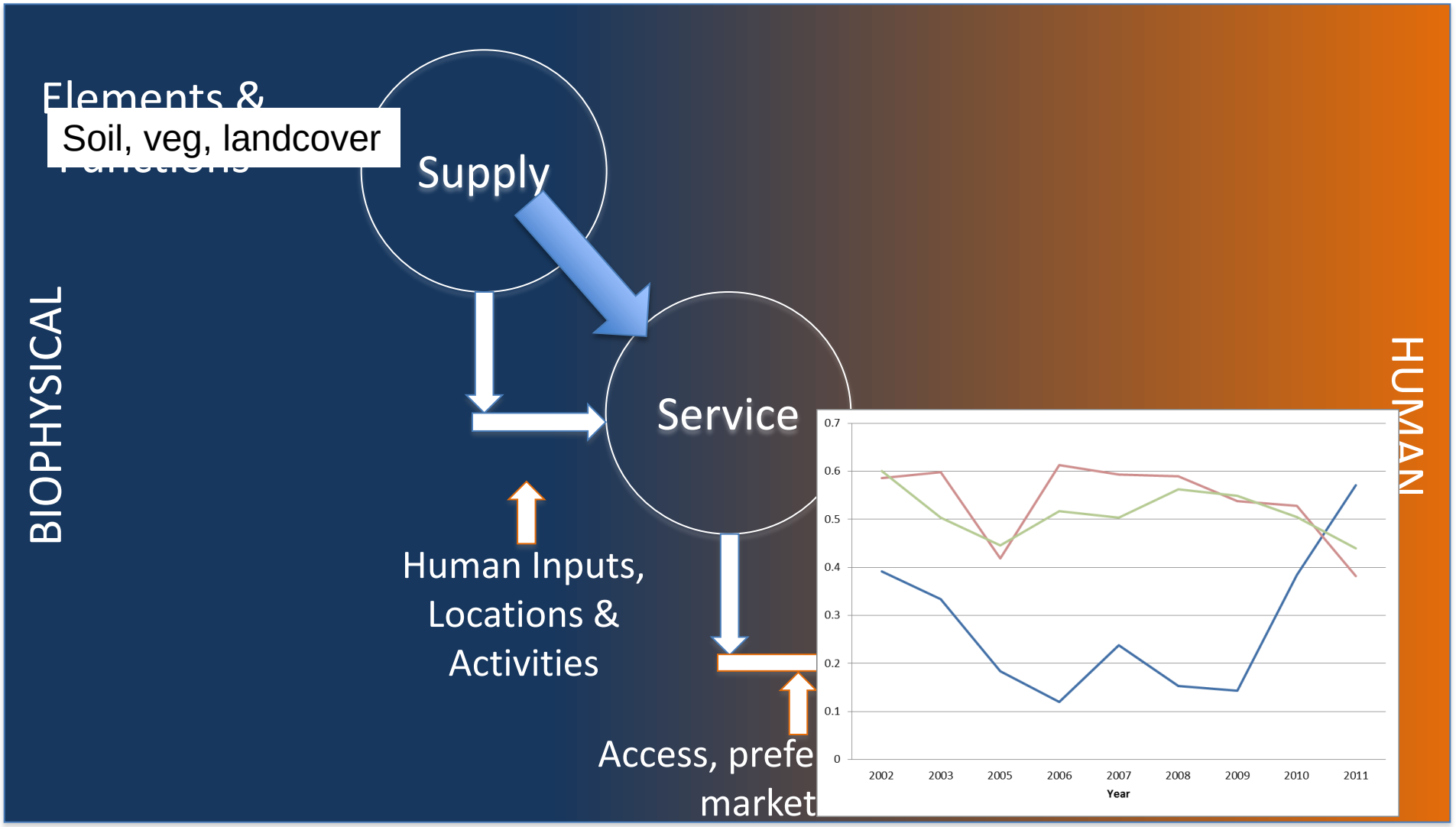


# SOCIAL–ECOLOGICAL SYSTEM




*Tallis et al. 2012*

# SOCIAL–ECOLOGICAL SYSTEM

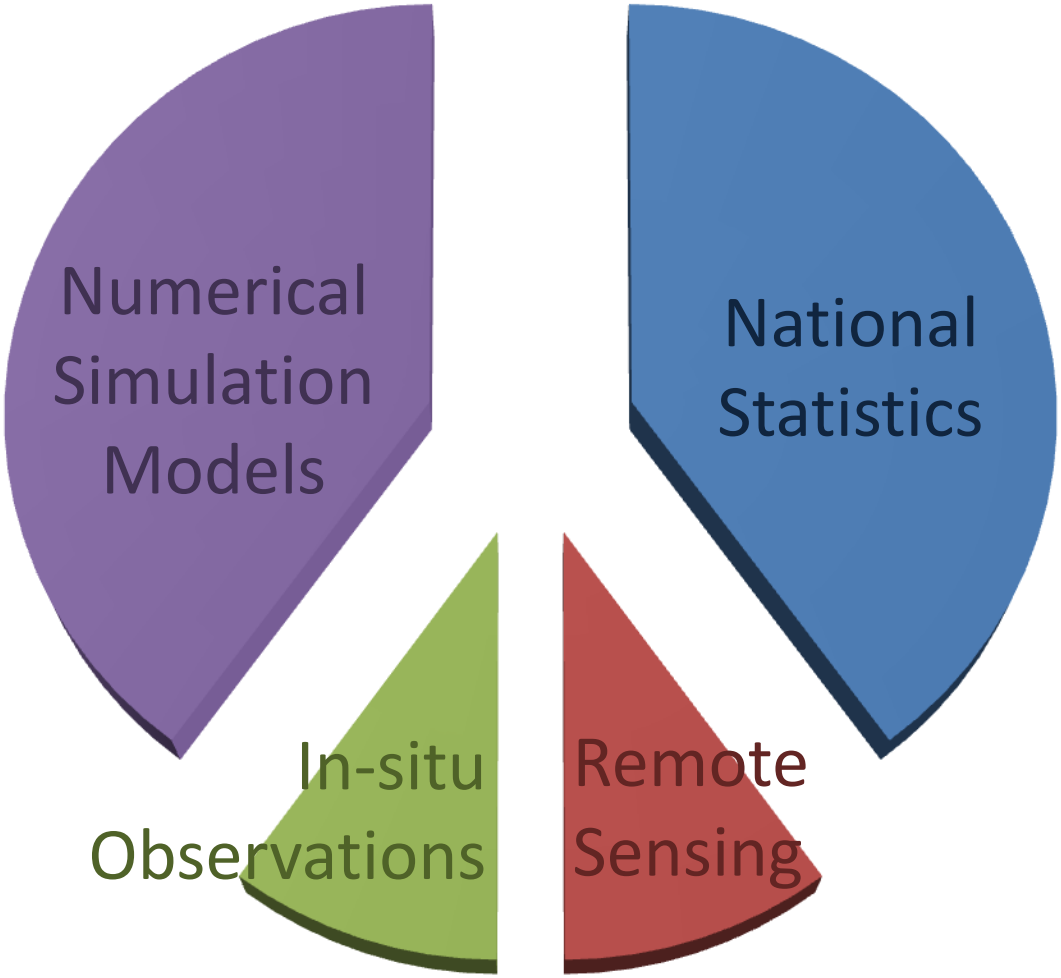



*Tallis et al. 2012*

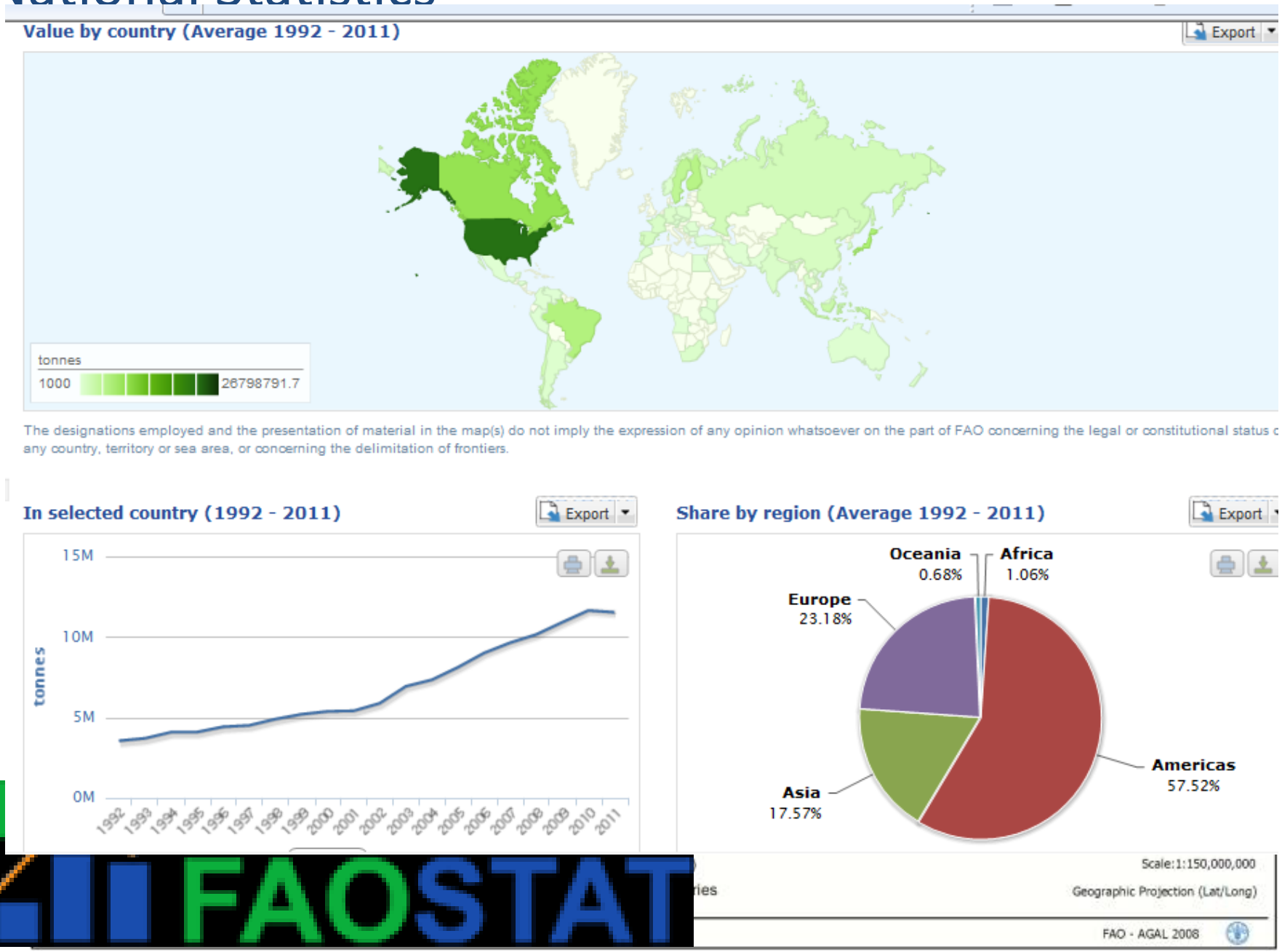



# DATA FOR ECOSYSTEM SERVICE MEASUREMENT

# Sources of data

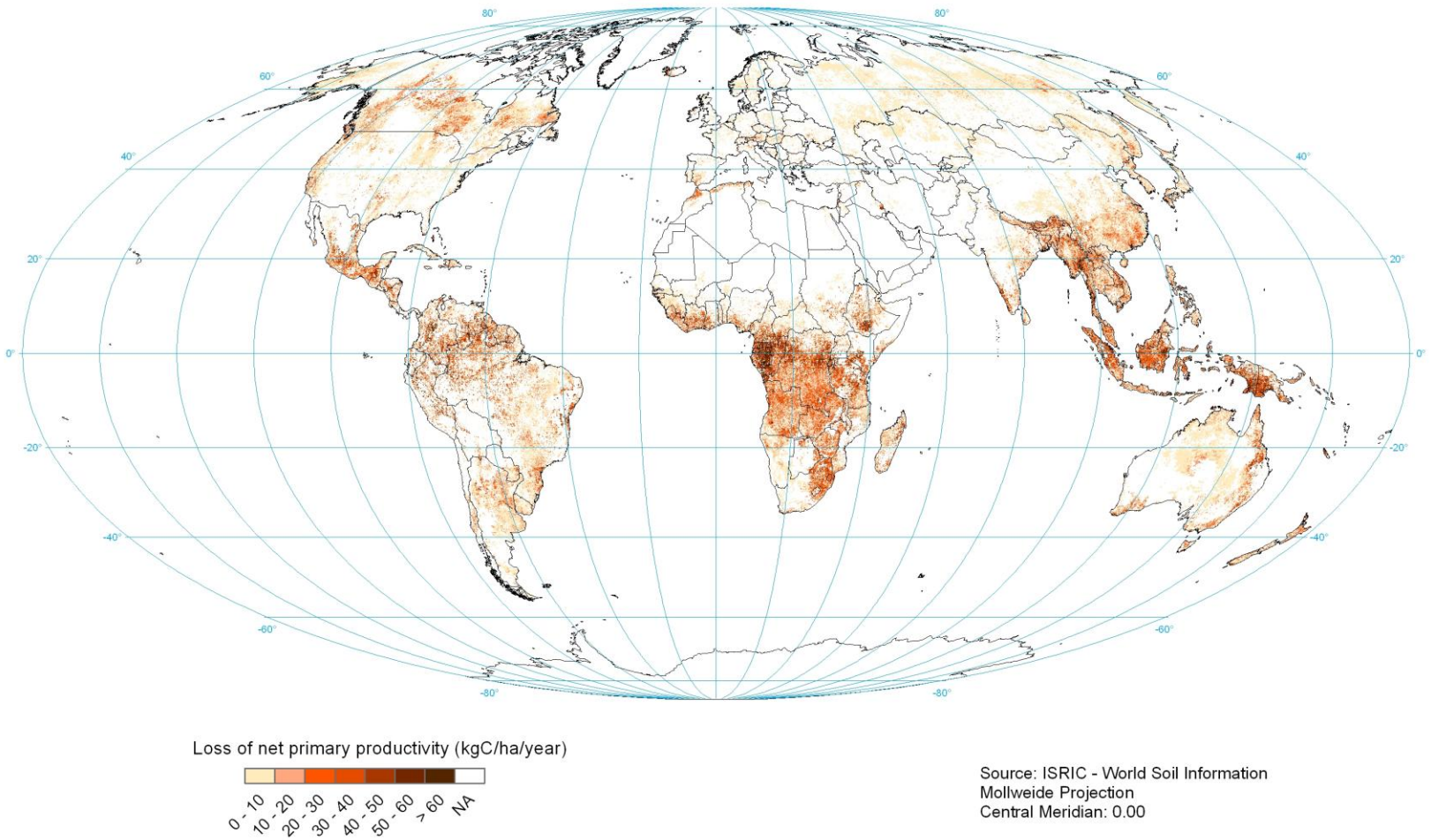


# National Statistics



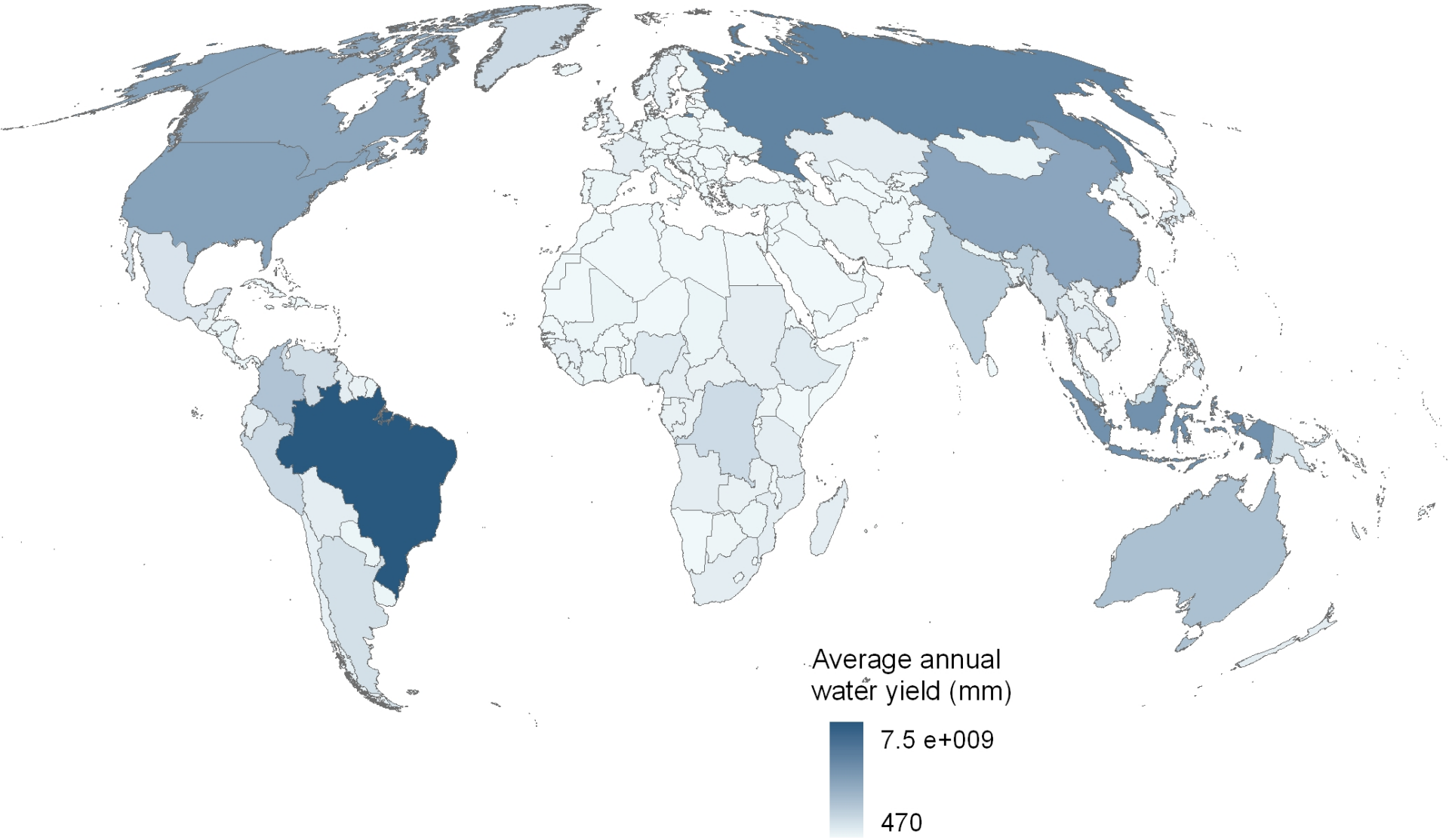
# Remote Sensing

Global loss of annual net primary productivity between 1981 and 2003



# Numerical Simulation Models

## Total Annual Water Yield Per Country



# Numerical Simulation Models

## Models

InVEST currently includes 15 models that analyze different aspects of marine and terrestrial environments:


**Aesthetic Quality**
Maps the visibility of features on a seascape or landscape

**Biodiversity**
Characterizes habitat quality and quantifies relative habitat loss

**Carbon**
Quantifies and values carbon storage and sequestration in terrestrial ecosystems

**Coastal Protection**
Quantifies and values the benefits of nearshore habitats for coastal protection

**Coastal Vulnerability**
Assesses the relative risk to coastal areas from storms

**Crop Pollination**
Quantifies and values the contribution of wild pollinators to agricultural production

**Habitat Risk Assessment**
Evaluates the risk to marine or terrestrial habitats from anthropogenic factors

**Managed Timber Production**
Values timber harvest

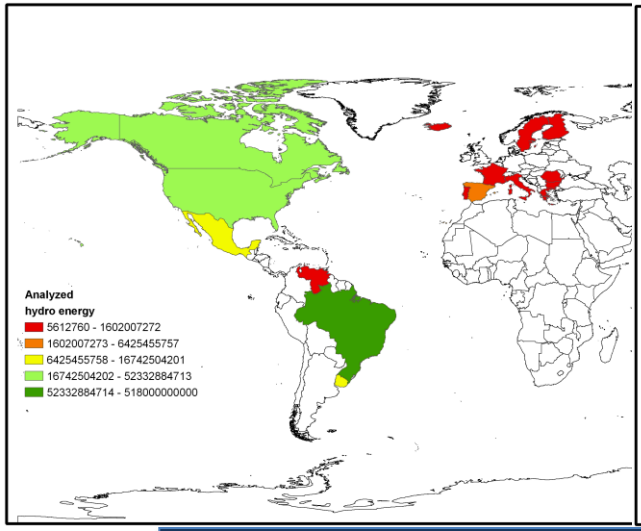
**Marine Fish Aquaculture**
Estimates the harvest weight and value of farmed salmon

**Marine Water Quality**
Models concentration of pollutants at sea

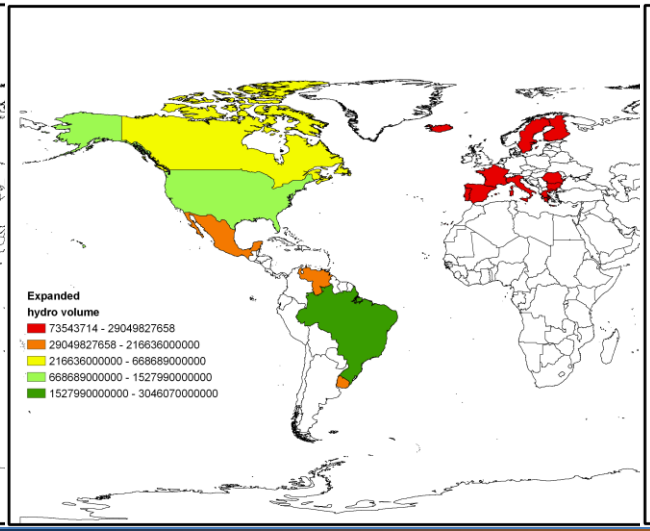
**Overlap Analysis**
Identifies areas of potential conflict between various human uses

# Numerical Simulation Models

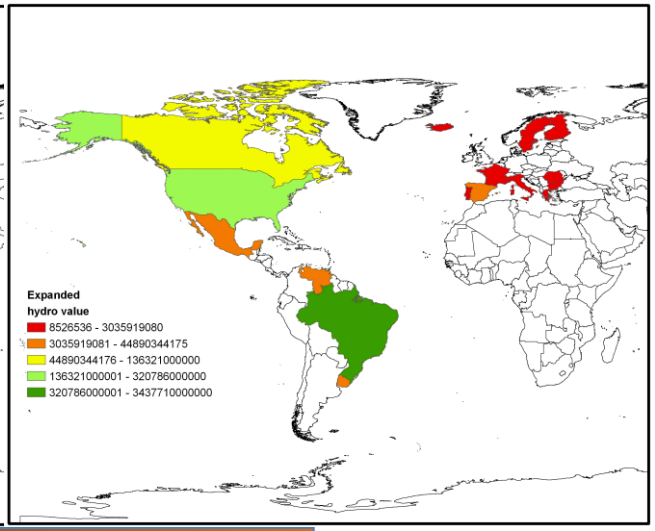
(Service)
Volume Delivered

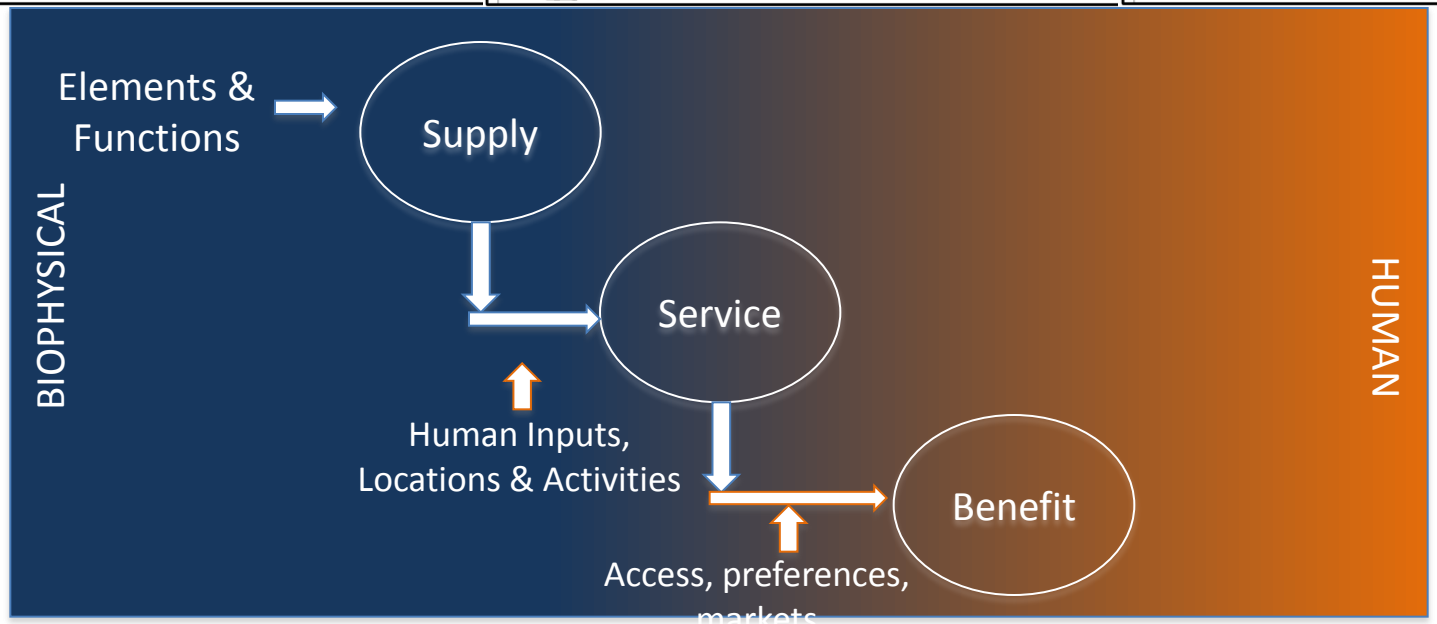



(Service)
Hydropower Produced




NPV



# In-Situ Observations

ILTER

SGA NETWORK

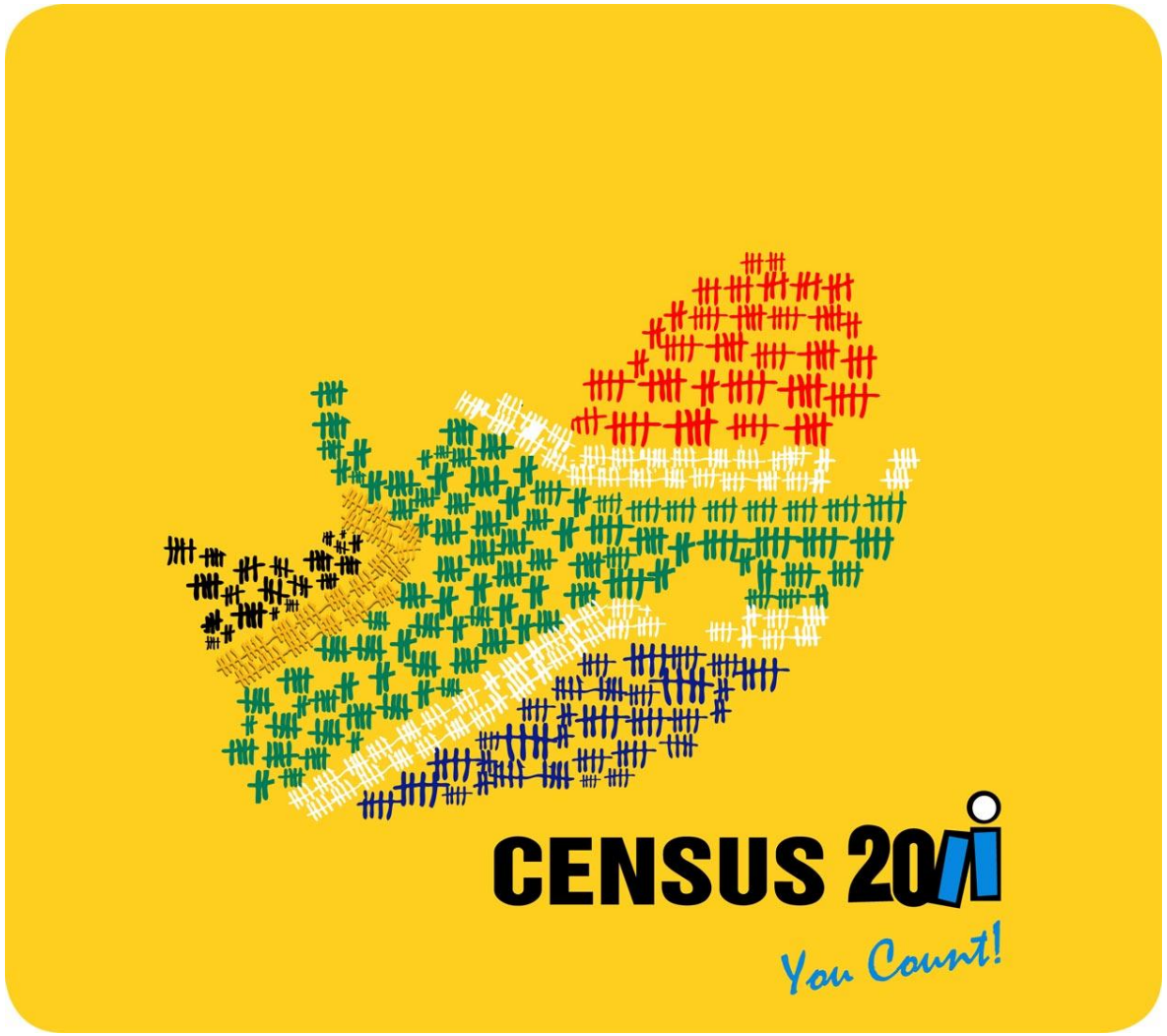
LATIN AMERICAN WATER FUNDS PARTNERSHIP

Tropical Ecology Assessment & Monitoring Network

*Early Warning System for Nature*

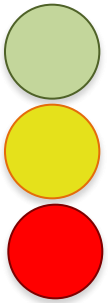
LSMS Living Standards Measurement Study

# In-Situ Observations: Census & surveys

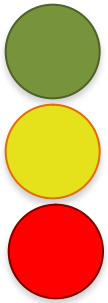



# State of Ecosystem Service Observations

Provisioning services
Regulating services
Cultural services



Supply metrics
Service metrics
Benefit metrics



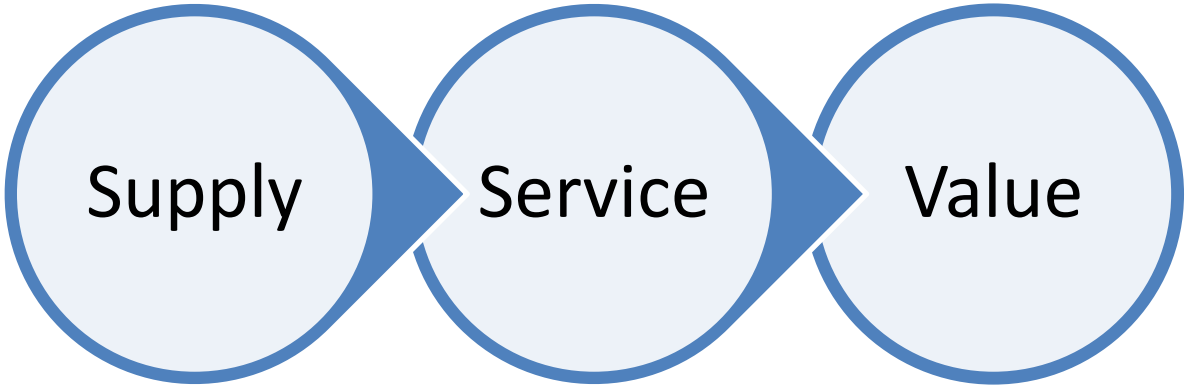
# Measuring ecosystem service benefits

## Benefit – change in well-being

- Economic value *one* metric
- Many services not captured
- Non-market, marginal value is difficult
- Big challenges related to equity and distribution of services.

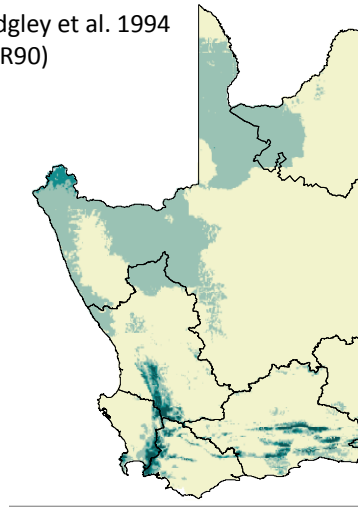


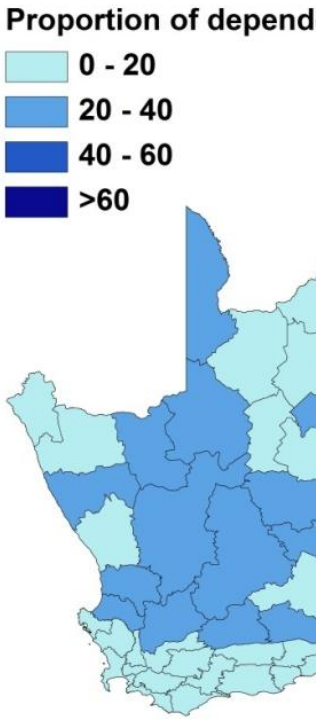
# An example: Water services and human wellbeing

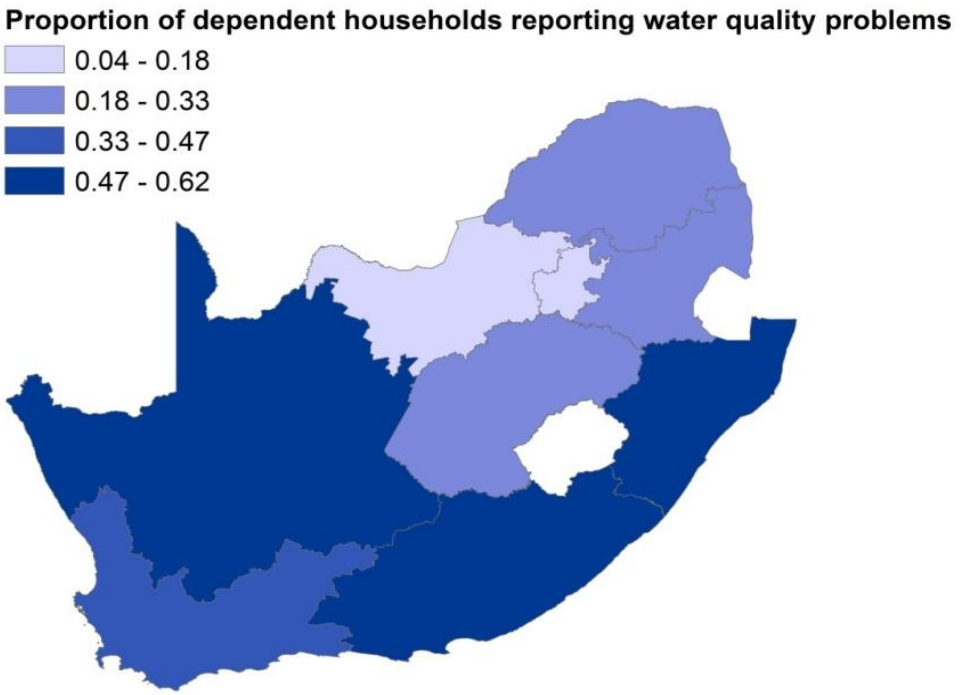



Surface water runoff (m
*Improving catchment yield*
*by keeping ecosystems he*

(Midgley et al. 1994 – WR90)

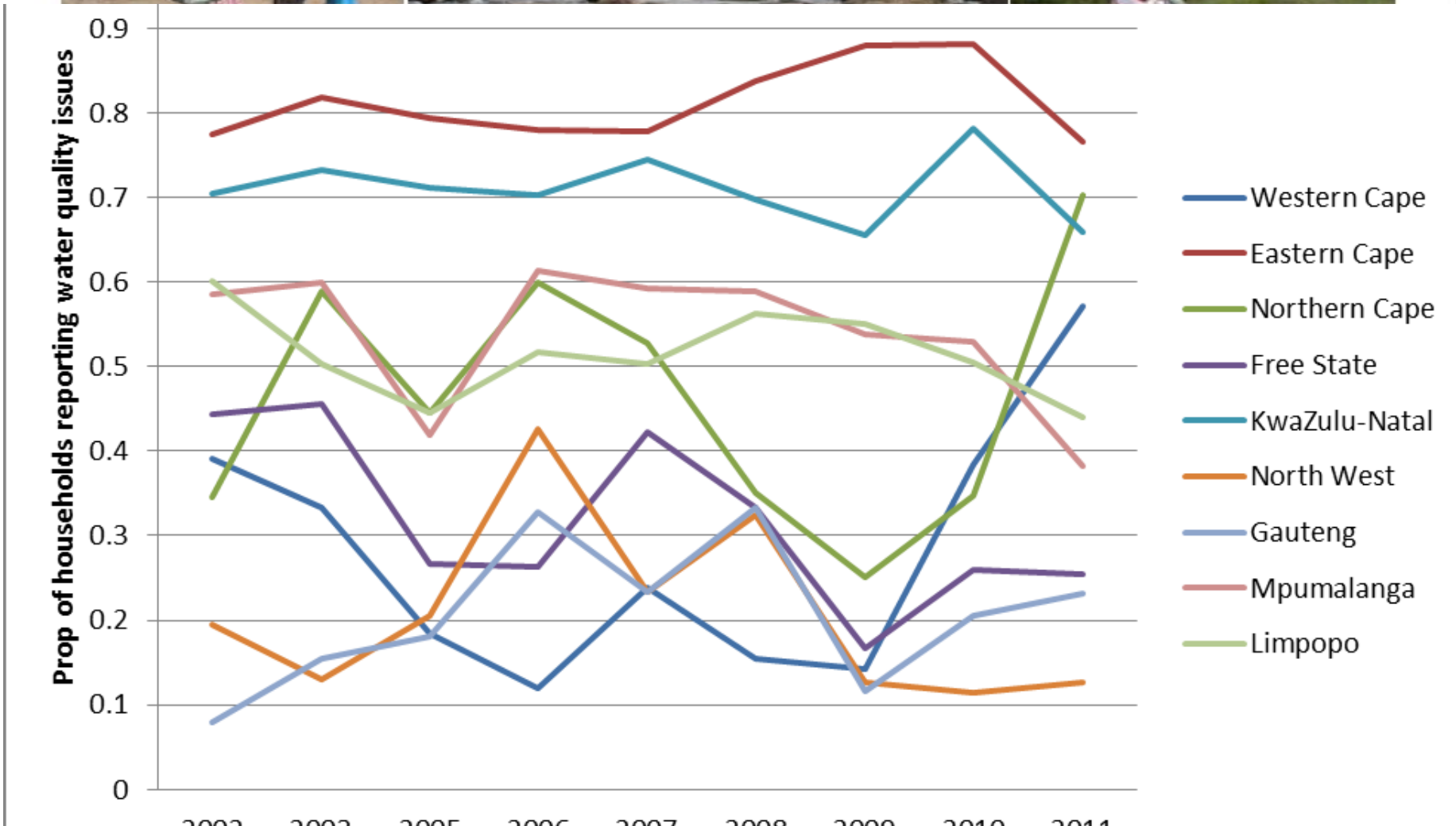




# Water quality trends in communities directly dependent on water ecosystem services





# Conclusions

- What we are trying to measure is complex and not well understood
- There are some frameworks that can help simplify the complexity and help us figure out what to measure
- There are some data sources that might help but the gaps are problematic
- Social data sources should be explored (and engaged) in developing indicators