Monitoring ecosystem services for policy design

Patricia Balvanera

Institute for Ecosystem and Sustainability Research (IIES)
National University of Mexico (UNAM)
pbalvanera@cieco.unam.mx

GEOBON WG6
Conserving Biodiversity and Ecosystem Services

The value of the world’s ecosystem services and natural capital

Robert Costanza†*, Ralph d’Arge†, Rudolf de Groot§, Stephen Farber§, Monica Grasso†, Bruce Hannon†, Karin Limburg§, Shahid Naeem†*, Robert V. O’Neill†*, Jose Paruelo§, Robert G. Raskin§, Paul Sutton§ & Marjan van den Belt§
A comparative assessment of decision-support tools for ecosystem services quantification and valuation

Kenneth J. Bagstad, Darius J. Semmens, Sissel Waage, Robert Winthrop

* U.S. Geological Survey, Geosciences & Environmental Change Science Center, Denver, CO, USA
* ISER, San Francisco, CA, USA
* Socioeconomics Program, USDA—Bureau of Land Management, Washington, DC, USA

A blueprint for mapping and modelling ecosystem services

Neville D. Crossman, Benjamin Burkhard, Stoyan Nedkov, Louise Willemen, Katalin Petz, Ignacio Palomo, Evangelia G. Drakou, Berta Martin-Lopez, Timon McPhearson, Kremena Boyanova, Rob Alkemade, Benis Ego, Martha B. Dunbar, Joachim Maes

* CSIRO Ecosystem Sciences, PMB 2, Glen Osmond, South Australia, 5064, Australia
* Institute for Natural Resource Conservation, University of Kiel, Olshausenstr. 40, 24098 Kiel, Germany
* National Institute of Geophysics, Geodesy and Geophysics, Bulgarian Academy of Sciences Acad. G. Bonchev Street, bl. 3, 1113 Sofia, Bulgaria
* European Commission, Joint Research Centre, Via E. Fermi 2745, TP 450, Ispra, VA 21027, Italy
* Environmental Systems Analysis Group, Wageningen University, PO Box 47, 6700 AA, Wageningen, The Netherlands
* Social-Ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid, Madrid, Spain
* Tübingen Environment and Design Center, The New School, 79 Fifth Avenue, 16th Floor, New York, NY 10003, USA
* Netherlands Environmental Assessment Agency (PBL), PO Box 303, 3720 AH Bilthoven, The Netherlands
ValuES

Methods for integrating ecosystem services into policy, planning, and practice
Objective 1: Strengthen the capacity and knowledge foundations of the science-policy interface to implement key IPBES functions

Objective 2: Strengthen the science-policy interface on biodiversity and ecosystem services at and across the sub-regional, regional and global levels

Objective 3: Strengthen the knowledge-policy interface with regard to thematic and methodological issues

Objective 4: Communicate and evaluate IPBES activities, deliverables and findings
How to monitor ecosystem services to support policy design?
Really????
• KEY QUESTIONS
• KEY CHALLENGES
• THE ROLE FOR GEOBON
• KEY QUESTIONS
• KEY CHALLENGES
• THE ROLE FOR GEOBON
What decision is at stake?
The world’s population is expected to grow to 9.6 billion by 2050, requiring an estimated 70–100% increase in food production.

But agricultural activities are affecting ecosystems, and the benefits they provide for people, more than ever before. There is an urgent need for better data and risk management tools that can guide decisions about agricultural development — and ensure that this development protects both people and nature.
What is the context?
Scholes et al. 2014 COSUST

Global scale

- Global data e.g. climate change

Regional scale

- Regional data e.g. adaptation plans, ecosystem service models
- Models & interactions

Local scale

- Local data e.g. human wellbeing components of the poor, livelihood strategies
- Models & interactions
**Biodiversity**

---

**How?**

- Biodiversity strongly influences ecosystem functions
  - Soil microorganisms, soil invertebrates
    - Plants
      - Insects, birds, mammals
      - Pest regulation
      - Food and fiber production
      - Clean water supply and flood regulation
      - Soil fertility regulation

**Is a provisioning service**

- Genes and species are directly consumed
  - Insects, reptiles, birds, mammals
  - Plants
  - Wild food, medicine
  - Germplasm and pharmaceuticals for future options

**Is appreciated *per se***

- Individual target species or species groups appreciated as such
  - Birds, reptiles, mammals
  - Vegetation
    - Identity
    - Aesthetic enjoyment
    - Appreciation of wildlife

---

Balvanera et al. 2016

GEOBONHB WG6
How are ecosystem services being co-produced?
Who is involved?
Win/lose
Access
Benefit
Decisions
Heard
Compensate
Where?
What should we monitor?

Dimensions of ecosystem service change
Which services?
<table>
<thead>
<tr>
<th>Section</th>
<th>Division</th>
<th>Group</th>
<th>Class</th>
<th>CICES</th>
<th>MA</th>
<th>TEEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning</td>
<td>Nutrition</td>
<td>Biomass</td>
<td>Cultivated crops</td>
<td>Peated animals and their outputs</td>
<td>Wild plants, algae and their outputs</td>
<td>Wild animals and their outputs</td>
</tr>
<tr>
<td>Regulation &amp; Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural</td>
<td>Physical and intellectual interactions with life, ecosystems, and land/urban landscapes (environmental settings)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Universal vs. unique lists?
• Exhaustive vs. Strategic?
• Available info vs. Info needed?
<table>
<thead>
<tr>
<th>Primary forest</th>
<th>Secondary forest</th>
<th>Closed species-rich shrubland</th>
<th>Larrea shrubland</th>
<th>Logged pastureland</th>
<th>Intensive annual cropland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence farmers (21)</td>
<td>Cattle ranchers (7)</td>
<td>Large farmers (4)</td>
<td>Extension Officers (15)</td>
<td>Policymakers, conservation agencies (16)</td>
<td></td>
</tr>
<tr>
<td>![Primary forest image]</td>
<td>![Secondary forest image]</td>
<td>![Closed species-rich shrubland image]</td>
<td>![Larrea shrubland image]</td>
<td>![Logged pastureland image]</td>
<td>![Intensive annual cropland image]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>References:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. fodder trees and shrubs for goats</td>
<td>2. wild fruits for human and animal consumption</td>
<td>3. wild animals for medicinal, tinctural, or symbolic use</td>
<td>4. firewood</td>
<td>5. carbon sequestration</td>
<td>6. plants for household uses other than tinctural, medicinal, or symbolic</td>
</tr>
<tr>
<td>2. fodder grasses and other herbs for goats</td>
<td>3. plants for medicinal, tinctural, or symbolic use</td>
<td>4. wild animals for medicinal or symbolic use</td>
<td>5. wood and timber</td>
<td>6. wild flowers for honey production by domestic and native bees</td>
<td>7. soil fertility for crops and pastures</td>
</tr>
<tr>
<td>3. fodder trees and shrubs for cattle and horses</td>
<td>4. wild animals for bushmeat and hides</td>
<td>5. climate regulation for humans and domestic animals</td>
<td>6. wild flowers for honey production by domestic and native bees</td>
<td>7. plants and animals of touristic interest</td>
<td>8. wild pollinators for fruit trees and vegetables</td>
</tr>
<tr>
<td>4. fodder grasses and other herbs for cattle and horses</td>
<td>5. firewood</td>
<td>6. wood and timber</td>
<td>7. wild flowers for honey production by domestic and native bees</td>
<td>8. plants and animals of touristic interest</td>
<td>9. wild pollinators for fruit trees and vegetables</td>
</tr>
</tbody>
</table>

Caceres et al 2014
Ecology & Society
Who will monitor?
• Researchers
  – Individuals
  – Teams
  – Networks
• Governments
  – Local
  – Global
• Practitioners
What is to be measured?

Indicators
What data sources?
High resolution
Patchy coverage

Field-based observations
Standards for site selection and data collection
Commercial timber, agriculture, livestock, carbon storage, water purification, etc.

Models and remote sensing
Crop production, carbon sequestration, water supply, water use, erosion control, fuelwood supply, forage production

National statistics
Recommendations for new data streams to add to census
Commercial timber, livestock, crop production

Low resolution
Global coverage
<table>
<thead>
<tr>
<th>Biological Control</th>
<th>Climate Regulation</th>
<th>Disturbance Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chl-a concentration</td>
<td>Elevation data</td>
<td>Land Surface Temp. NDVI</td>
</tr>
<tr>
<td>2%</td>
<td>11%</td>
<td>42%</td>
</tr>
<tr>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>50%</td>
<td>33%</td>
<td>60%</td>
</tr>
<tr>
<td>17%</td>
<td>22%</td>
<td>60%</td>
</tr>
<tr>
<td>Erosion Regulation</td>
<td>Flood Regulation</td>
<td>Gas Regulation</td>
</tr>
<tr>
<td>Chl-a concentration</td>
<td>Elevation data</td>
<td>Land Surface Temp. NDVI</td>
</tr>
<tr>
<td>10%</td>
<td>33%</td>
<td>17%</td>
</tr>
<tr>
<td>20%</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td>10%</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>Natural hazard regulation</td>
<td>Pollination</td>
<td>Water purif. &amp; waste treatment</td>
</tr>
<tr>
<td>Chl-a concentration</td>
<td>Elevation data</td>
<td>Land Surface Temp. NDVI</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>33%</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>33%</td>
</tr>
<tr>
<td>20%</td>
<td>40%</td>
<td>33%</td>
</tr>
<tr>
<td>Water Regulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chl-a concentration</td>
<td>Elevation data</td>
<td>Land Surface Temp. NDVI</td>
</tr>
<tr>
<td>16%</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>16%</td>
<td>16%</td>
<td>52%</td>
</tr>
</tbody>
</table>

Araujo Barbosa et al 2015
Remote sensing
Fig. 4. Maps of individual cultural (dis)services.
<table>
<thead>
<tr>
<th>Ecosystem service component</th>
<th>National statistics</th>
<th>Remote sensing</th>
<th>Field estimations</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FAOSTAT WORLD BANK</td>
<td>High resolution</td>
<td>Low resolution</td>
<td>TESSA</td>
</tr>
<tr>
<td>Supply</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Delivery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Contribution to well-being</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Economic value</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Spatial scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local/landscape</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>National</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Global</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Balvanera et al. GEOBON Handbook WG6
• KEY QUESTIONS
• KEY CHALLENGES
• THE ROLE FOR GEOBON
Monitoring strategy design
• $  
• Spatial design  
• Frequency of updates
Standards for data collection
Sampling Frame for the Vital Signs Global Monitoring System
Long-term monitoring
The research focus of the ILTER articles according to the ecosystem service cascade model (see Refs. [9,10]).
Validation
Progress towards targets
<table>
<thead>
<tr>
<th>Element</th>
<th>Current Status</th>
<th>Comments</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystems that provide essential services, including services related</td>
<td>![Image]</td>
<td>High variation across ecosystems and services. Ecosystems particularly important for services, e.g., wetlands and coral reefs, still in decline.</td>
<td>Low</td>
</tr>
<tr>
<td>to water, and contribute to health, livelihoods and well-being, are</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>restored and safeguarded...</td>
<td>![Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...taking into account the needs of women, indigenous and local</td>
<td>![Image]</td>
<td>Poor communities and women especially impacted by continuing loss of ecosystem services.</td>
<td>Low</td>
</tr>
<tr>
<td>communities, and the poor and vulnerable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Standards
<table>
<thead>
<tr>
<th>User</th>
<th>Use Context</th>
<th>Definition of terms and approach (1)</th>
<th>Methods for evaluating provision of goods and services (2)</th>
<th>Methods for evaluating values (3)</th>
<th>General Standard Setting Entity</th>
<th>Ecosystem Services Standards Entity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>national income &amp; wealth accounts</td>
<td></td>
<td></td>
<td></td>
<td>UNSC, GA</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>land use and/or development planning</td>
<td></td>
<td></td>
<td></td>
<td>IAIA, GA</td>
<td>GA, WTO</td>
</tr>
<tr>
<td></td>
<td>environmental impact assessment</td>
<td></td>
<td></td>
<td></td>
<td>BBOP, CDM, GA</td>
<td>GA, WTO</td>
</tr>
<tr>
<td></td>
<td>mitigation (environmental offsets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>agricultural subsidies</td>
<td></td>
<td></td>
<td></td>
<td>GA, WTO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mining subsidies</td>
<td></td>
<td></td>
<td></td>
<td>GA, IBNET</td>
<td></td>
</tr>
<tr>
<td></td>
<td>water pricing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governments</td>
<td>electricity pricing</td>
<td>GA, CEER, ERR</td>
<td>GA, TAF</td>
<td>EPRI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>property tax</td>
<td>GA</td>
<td>ISO</td>
<td>TNC</td>
<td>ICES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(flood) disaster response</td>
<td>GA</td>
<td>GA, UN</td>
<td>ICES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>risk assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>fisheries management</td>
<td></td>
<td></td>
<td></td>
<td>UN SC, GA</td>
<td>WAVES</td>
</tr>
<tr>
<td></td>
<td>environmental-economic accounts</td>
<td></td>
<td></td>
<td></td>
<td>GA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>public lands management</td>
<td></td>
<td></td>
<td></td>
<td>GA, UN-REDD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>payments for ecosystem services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FE</td>
</tr>
<tr>
<td>Corporations</td>
<td>supply chain analysis</td>
<td>ISO, CSCP</td>
<td>ISO</td>
<td>NVI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>risk assessment</td>
<td>ISO</td>
<td>IASB, GA</td>
<td>NCD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>corporate accounting</td>
<td>ISO</td>
<td>GRI</td>
<td>NCC, NCD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>corporate sustainability reporting</td>
<td>ISO, LCI</td>
<td>ISO</td>
<td>SABS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>life-cycle assessment</td>
<td>ISO</td>
<td>ISO</td>
<td>LCI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>product certification</td>
<td></td>
<td></td>
<td></td>
<td>RA</td>
<td></td>
</tr>
</tbody>
</table>
Resilience
Sustainability
Burkhad et al. 2012 Ecol Ind

- Land cover / land use
- Ecological integrity
  - Ecosystem structures & processes
- Supply
- Ecosystem services
  - Regulating services
  - Provisioning services
  - Cultural services
- Demand

- Human benefits
  - Social, economic & personal well-being
- Population, economy
Global biophysical & social drivers

Regional context
- Space scales
- Regional climate, landscapes, ecosystems, biota, etc.

Slower variables
- Soils, sediments, disturbance regime, functional types, etc.
- Animal behavior, soluble nutrients, fires, floods, etc.

Faster variables
- Ecosystem services
- Environmental impacts

Institutional response
- Human actors

Regional governance economy, etc.
- Property & use rights, wealth & infrastructure, cultural ties to land, etc.
- Community income, migration, access to resources, etc.

Carpenter et al 2009 PNAS
Integration
Bundles of ecosystem services

Raudsepp-Hearne et al 2010 PNAS
Conceptual understandings
Telecoupling
Power, equity and justice
Strengthening the science-policy interphase
Reyers et al. 2015 PNAS

Co-design case study

Knowledge brokers
- Set project objectives
- Establish transdisciplinary teams

Assessment team
- Co-develop SES conceptual model
- Co-develop future scenarios of SES
- Model and analyze SES futures

Implementers
- Co-design responses
- Plan post-project sustainability
- Collaborative implementation

Bridging agents

Knowledge co-production

Knowledge brokers

Collaborative planning

Reyers et al. 2015 PNAS
• KEY QUESTIONS
• KEY CHALLENGES
• THE ROLE FOR GEOBON
Observations
Fostering accessibility to tools and data
BON-in-a-Box

ToolKit for MAPPING and MONITORING BioDiversity and EcoSystem SERVICES

ENHANCED, HARMONISED, INTEROPERABLE BioDIVERSITY and EcoSYSTEM OBSERVATIONS

GLOBAL SCALE

REGIONAL

NATIONAL

Monitoring Methods

Data Management

Field Methods & Protocols

Essential Biodiversity Variables (EBV)

Essential Ecosystem Services Variables

"A Digital, Customized, Smart & Advanced Toolkit for Biodiversity and Ecosystem Observation"

Urbina, Egoh, Londono Gill et al
In prep WG6
Proofs of concept
Demand: access to sources of water for domestic uses

Reyers et al. 2014 CSIRO
Guidance
Essential ecosystem Service Variables

- Supply
- Institutions and governance
- Values Economic Socio-cultural
- Anthropogenic Contribution to supply
- Use
- Benefits/beneficiaries
- Demand
- Benefit

Balvanera et al. WG6
<table>
<thead>
<tr>
<th>Food-Energy-Water Nexus</th>
<th>DPSIR</th>
<th>Nature</th>
<th>Nature’s benefits</th>
<th>Quality of life</th>
<th>Institutions and Governance</th>
<th>Anthropogenic drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food security</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy security</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water security</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biodiversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecosystem services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health and HWB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livelihoods and subsistence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tradeoffs, Sustainability and transformation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The diagram illustrates the interactions between different aspects of the Food-Energy-Water Nexus and the Quality of Life and Governance. The DPSIR framework is used to analyze the relationships between Nature, Nature's benefits, Institutions and Governance, Anthropogenic assets, and Drivers.

### Food-Energy-Water Nexus

- **Food security**
- **Energy security**
- **Water security**

### Natural Assets

- **Biodiversity**
- **Ecosystem services**

### Health and HWB

- **Health and HWB**

### SDGs

- **Income**
- **Livelihoods and subsistence**

### Tradeoffs, Sustainability, and transformation

The diagram highlights the interdependencies and tradeoffs between these elements, emphasizing the need for comprehensive strategies to address sustainability and transformation challenges.
Facilitate strategic interconnections
Global Framework for Ecosystem services

Science-Policy Interphase

Ecosystem services

ESP

GEOBON

PECS

SGAs

Natural Capital

IPBES

Global
Global Framework for Ecosystem services

Guidance

Ecosystem services

ESP

PECS

GEOBO N

IPBES Global

SGAs

Natural Capital
Global Framework for Ecosystem services

Proofs of concept

Ecosystem services

ESP

GEOBON

PECS

IPBES Global

SGAs

Natural Capital

Balvanera, Geller et al. in prep WG6
IN SYNTHESIS
• Monitoring ecosystem services for policy design requires careful consideration
• There are important challenges to be faced
• GEOBON can play a key role
Working Group 6: Ecosystem Services

Working Group 6 is focused on developing protocols, proofs of concepts and an encompassing strategy to monitor ecosystem services at different spatial scales.