A Benefit Assessment of GEOSS: Results from the Geo-Bene project

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International Institute for Applied Systems Analysis (IIASA), Austria

With Contributions from Geo-Bene partners

UN/Austria/ESA Symposium
Graz 9/09/2008
Overview

• The Geo-bene project
• Review of current assessments – Public benefit assessment
• The benefit chain concept
• Example Uncertainties in Land Cover Information
• Example Banda Aceh/ Tsunami
• Example Algae Bloom in the North Sea
• Example Conservation planning
• Example food security in Africa
The world in 2030 will be a world of change:

- 7.5 billion people
- temperature increase > 1 degree
- little wilderness, new diseases....

... governments will be asking for information
... observations systems need 20 years to be designed, tested, implemented
... the time to start their design is now
... and we need to document today’s baseline of a world with only „small“ change
Objective of GEOBENE

... to develop methodologies (Ph1) and analytical tools (Ph2) to assess societal benefits of GEO and to perform benefit assessments (Ph3).
Review of (Cost) - Benefit Assessments

• Pricewaterhouse Coopers study (GMES) benefit assessment
• Environmental Protection Agency (USA)
• A number of studies which look at the benefit from an improved weather forecast
• M. Macaulay (2006) applies the VOI theory and methods to show how space-based Earth Observations can improve natural resource management
• Yesterdays presentation in RS for Agriculture: decision support system used to produce global crop yield estimates by the USDA's Office of Global Analysis/International Production Assessment Branch (IPA)
Global Earth Observation
Benefit Estimation: Now, Next and Emerging

COSTS

Earth System Models

Decisions

Earth Observation Systems

Actions

On-going feedback to optimize value and reduce gaps

Decision Support

BENEFITS

Societal Benefits

GEOBENE
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‘Shot-gun’ pathway

Total Benefit Assessment → Meta-analysis → Any other Source → Literature

‘Rifle’ pathway

GEO-BENE Cross SBA Accumulated Marginal Benefit Assessment

GEO-BENE Core Economic Models: FASOM, Energy, Disaster&Health

Benefit Chain Concept: GEO-BENE Individual Assessments

Aggregator
Table 10.1 GEOSS Ten-Year Implementation Plan: Relative Phasing and Maturity of Earth Observation Application

An initial synoptic description of the phasing of GEOSS implementation.

<table>
<thead>
<tr>
<th>Topics</th>
<th>Disaster</th>
<th>Health</th>
<th>Energy</th>
<th>Climate</th>
<th>Water</th>
<th>Weather</th>
<th>Ecosystems</th>
<th>Agriculture</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periods (years)</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>2</td>
<td>6</td>
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</tr>
</tbody>
</table>

**Observation:**

1 *In situ* and airborne

2 Space-based

3 Convergence of Obs.

4 Continuity

**Product:**

5 Key Products

6 Modeling/Assimilation

7 Synergy of Products

8 Quality Control

**Data Management:**

9 Accessibility

10 Data Exchange

11 Interoperability

12 User Involvement

13 R & D for Observation

14 Capacity Building

---

Legend:

- P Planning Phase
- I Implementation Phase
- O Operational Phase

*Most operational area: weather*
2nd most obvious areas: Water & Agriculture: still mostly in planning!!? (→ huge benefits …)

Table 10.1 GEOSS Ten-Year Implementation Plan: Relative Phasing and Maturity of Earth Observation Application

<table>
<thead>
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<tbody>
<tr>
<td>Observation:</td>
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<td>8 Quality Control</td>
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</table>

Legend: P Planning Phase, I Implementation Phase, O Operational Phase
The benefit chain  

An introduction to the benefit chain

1. Information as a result of an improved interoperable data systems
2. Improvement of decision as a result of better information
3. Incremental cost to obtain better information
4. Economic benefit resulting from better decision
5. Is benefit >> costs?
Improvement though higher spatial resolution

Increasing spatial resolution
Improvement though higher temporal resolution

16 days  1 day  15 minutes

Increasing temporal resolution
Improvement through better integration of Satellite EO and in-situ
Improvement through better and improved models (models informed by observations)

Climate Models early 1990s

Global coupled climate models in 2006

Global Models in 5-10 years

Comparison with current regional model (resolution 25 km)

Source: NCAR
<table>
<thead>
<tr>
<th>Improvement to be realised</th>
<th>Effect</th>
<th>Selected Examples</th>
<th>Importance within GEOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimisation of the overall observation strategy, avoiding unnecessary redundancy in EO missions and systems</td>
<td>Reduction of costs</td>
<td>Recent co-ordination between EUOMETSAT, CNES, NOAA, NASA and joint research announcement of the Ocean Surface topology science team (Eumetsat and CNES, 2007)</td>
<td>High</td>
</tr>
<tr>
<td>More frequent observation due to better co-ordination, e.g. by having constellations of satellites, wider swaths and automated in situ systems</td>
<td>Better temporal resolution, ability to resolve rapid or short-duration phenomena</td>
<td>The shortened revisit time that can be achieved by combining the optical-band observations by Modis (2x), MERIS and SeaWIFS</td>
<td>Medium</td>
</tr>
<tr>
<td>Better sensors (e.g. more bands, different technologies, greater sensitivity)</td>
<td>More types of observations available, greater accuracy</td>
<td>Case study on hyperspectral sensors</td>
<td>Medium</td>
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<td>More timely information delivery</td>
<td>Near-real time observations for issues that require quick response</td>
<td>The AFIS fire warning system integrates data from MSG and MODIS thermal sensors with weather data and sends a message to the cellphone of people in the fire path within minutes of fire detection</td>
<td>Medium</td>
</tr>
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<td>Better integration of satellite and in-situ EO measurements</td>
<td>Calibration and validation of satellite products, better interpolation of in situ measurements, synergistic hybrid products</td>
<td>EU fosters research in in-situ and satellite integration studies</td>
<td>High</td>
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<td>Identification and closing of observation or information gaps</td>
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Submit Shotgun Assessment
If you have any further questions please contact Stoffen (fritz@iiasa.ac.at) or Florian (kraxner@iiasa.ac.at)

Title of paper or study: *

Contact
Please enter your contact details

Institution:
The name of your institution

ContactName:
Whom to contact for this study (e.g. email)

Area:
Please choose the benefit area relevant

Comments:

E.g. any additional information

Where can the study be found?:

E.g. web link, institute, reference, email. Please upload this study as a pdf in the next section “file attachments”!
Example: Value of Land cover uncertainty reduction

- Biofuels – Food Security – Water - GHG – Ecosystem Trade-off
GLC-2000 agricultural land: 2 363 M ha
MODIS-2000 agricultural land: 1 937 M ha
Scenario to compute value of land availability uncertainty

GLOBIOM calculations
2030 estimated food and wood demand

+ Substitution of up to 10% of transport oil energy consumption according to IPCC/GGI A2r baseline scenario 2030 in each of the 11 regions by ethanol.

Variants

a) WITH additional land (explicit supply function)

b) WITOUT additional land

+ avoided deforestation
Ethanol Consumption

From 2005 to 2030 (in %)

- North America
- Western Europe
- Pacific OECD
- Central and Eastern Europe
- Former Soviet Union
- Planned Asia (China)
- South Asia
- Other Pacific Asia
- Middle East
- North Africa
- Latin America
- Caribbean
- Sub-Saharan Africa
- WORLD

Ethanol Consumption (in M toe)
Water Use

Irrigation Water Use (in km³ H₂O)

From 2005 to 2030 (in %)

No available land — Available land

www.geo-bene.eu © GEOBENE 2007
Greenhouse Gas Emissions (in million tonnes CO2)

From 2005 to 2030 (in %)

No available land  ---  Available land
III. Illustrative application

Ethanol Price (in USD/L)

From 2005 to 2030 (in %)

No available land  -  Available land
Land availability uncertainty is a USD 350 billion Gas bill Question in the scenario
Before
After
Specific Example: Field survey vs. aerial survey

<table>
<thead>
<tr>
<th></th>
<th>Terrestrial Mapping</th>
<th>Aerial Photogrammetry (Digital)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>100 USD/ha</td>
<td>12-14 USD/ha</td>
</tr>
<tr>
<td>Manpower</td>
<td>5 ha/day/team</td>
<td>50,000 ha/yr/company</td>
</tr>
<tr>
<td>Damaged Area</td>
<td>300,000 ha</td>
<td>300,000 ha</td>
</tr>
<tr>
<td>Time</td>
<td>1 team = 164 years</td>
<td>1 company = 6 years</td>
</tr>
<tr>
<td></td>
<td>1000 teams = 2 months</td>
<td>10 companies = 6 months</td>
</tr>
<tr>
<td>Total Cost</td>
<td>26.3 million USD</td>
<td>3.6 million USD</td>
</tr>
</tbody>
</table>

Source: K. Wikantika
Value of Geo-Information for deep sea fishing

Source: Sea Defense Consultants
Methodology: States and actions related to an Early Warning System for Tsunami detection and avoidance

States of nature:
- An undersea earthquake occurs & causes a Tsunami
- An undersea earthquake occurs but causes no Tsunami

Potential actions:
- Based on information from EWS, evacuate people.
- Based on information from EWS, take no action.

The methodology outlined above is described in detail in Hirshleifer and Riley (1979), Schimmelpfennig and Norton (2003) and Bouma et al., (submitted 2008). This technique is also applied in this study.
Pay-off Matrix (Java 2006)

<table>
<thead>
<tr>
<th></th>
<th>Evacuate</th>
<th>No Evacuation</th>
<th>Prior</th>
<th>Likelihood Evacuate</th>
<th>Likelihood No Evacuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsunami</td>
<td>50 Mil</td>
<td>138 Mil</td>
<td>.99</td>
<td>.9</td>
<td>.1</td>
</tr>
<tr>
<td>No Tsunami</td>
<td>5 Mil</td>
<td>0</td>
<td>.1</td>
<td>.75</td>
<td>.25</td>
</tr>
</tbody>
</table>

- Creating these for a variety of Tsunami Scenarios/regions
- Comparing then costs to a variety of proposed EWSs
Example: Added Value of remote sensing information for water quality in the North Sea Stakeholder survey

<table>
<thead>
<tr>
<th></th>
<th>Eutrophication</th>
<th>Excessive algal bloom</th>
<th>Sea water clarity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>With GEO</td>
<td>Present</td>
</tr>
<tr>
<td>Expectation of water</td>
<td>63%</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>quality being well</td>
<td>50-100%</td>
<td>80-100%</td>
<td>10-90%</td>
</tr>
<tr>
<td>monitored</td>
<td></td>
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</table>

Source: Bouma and Van der Woerd (2007)

**Investment Costs**: investment of the dutch government to launch the ENVISAT satellite is 2.5 million a year

**Benefits**: for water quality managament (including economic benefits to the fishing industry) in the North Sea can be up to 2.6 million a year
Benefit chain & conservation planning
An introduction to conservation planning

Things to conserve & how much of them to conserve

Things to avoid

Where to conserve
Case study 3: The benefit chain & conservation planning

Ecosystems

Landcover

Species

No GEOSS

GEOSS
Finer resolution species, ecosystem & land cover data

10% less land required

1.2 bill € 57 mill € pa.

200 mill €

Based on costs of land acquisition & management

Based on costs GEOSS type data

Fritz et al. *In Press*
Example Integration of socioeconomic with biophysical data, Food security in SSA

Projected changes in crop yield between 2000-2030
Overall projected changes in crop yield between 2000-2030
Global Earth Observation
Benefit Estimation: Now, Next and Emerging

Projected population per square km in the 2030s:

- 0 - 2
- 2 - 10
- 10 - 50
- 50 - 200
- > 200

Percent change of per capita GDP from the 1990s to the 2030s with respect to global average change of per capita GDP

www.geo-bene.eu © GEOBENE 2007
Global Earth Observation

Population

- Country Borders
- <5,000
- 5,000 - 10,000
- 10,000 - 20,000
- 20,000 - 50,000
- 50,000 - 100,000
- 100,000 - 150,000
- 150,000 - 300,000
- >300,000

- High degree of urbanisation
- Decrease in per capita calorie availability by 0 - 30%, lower capacity to import food in the future
- Decrease of per capita calorie availability by more than 30%, lower capacity to import food in the future
• Thank you!

For further questions
Steffen Fritz
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