Identifying And Quantifying The Benefits Of GEOSS

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Introduction

GEOSS, the Global Earth Observation System of Systems, is envisioned to be a global public infrastructure that generates comprehensive, near-real-time environmental data, information and analyses for a wide range of users. The general assumption regarding GEOSS is that the benefits to society by far outweigh the costs. However, this notion is being increasingly challenged, and it is becoming necessary to provide rational, quantified and persuasive arguments to justify investment of what are often public funds. In particular, the identification of benefits is crucial to ensure long term sustained GEOSS operations. To date, there have been few integrated assessments of the economic, social and environmental benefits of Global Earth Observation (EO). In an effort to address these issues, the European Commission has sponsored several projects (see Acknowledgements) to develop methodologies and analytical tools to assess the societal benefit areas (SBAs) of GEO in the domains of: Disasters, Health, Energy, Climate, Water, Weather, Ecosystems, Agriculture and Biodiversity. Thus it is the aim of this article to present several of these overarching methodologies as a contribution to the ongoing effort to improve GEOSS.

GEOSS Benefit Assessment

These efforts have resulted in a variety of tools and methodologies developed for GEOSS benefit assessment which address the various SBAs within GEOSS, along with GEOSS as a whole. Four overarching methods warrant further explanation here because of their cross-sectoral applicability (a decision tree is also presented to determine which method to use):

1) **Benefit chain concept**
2) **Bayesian decision theory**
3) **A real options framework**
4) **Systems dynamics modeling**

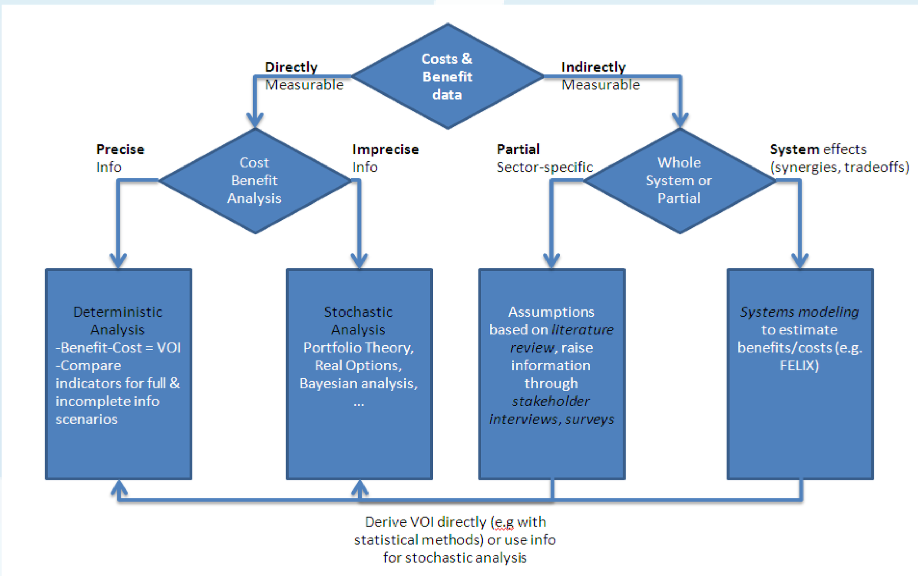

Fig. 1. Decision tree to determine which benefit assessment method to apply.

Benefit Chain Concept

The basic notion is that an incremental improvement in the observing system (including its data collection, interpretation and information sharing aspects) will result in an improvement in the quality of decisions based on that information. This will lead, in turn, to beneficial societal outcomes, which have a value. The 'benefit chain' concept describes how order-of-magnitude approaches and a qualitative understanding of the shape of the cost and benefit curves can help guide rational investment decisions in Earth Observation systems.

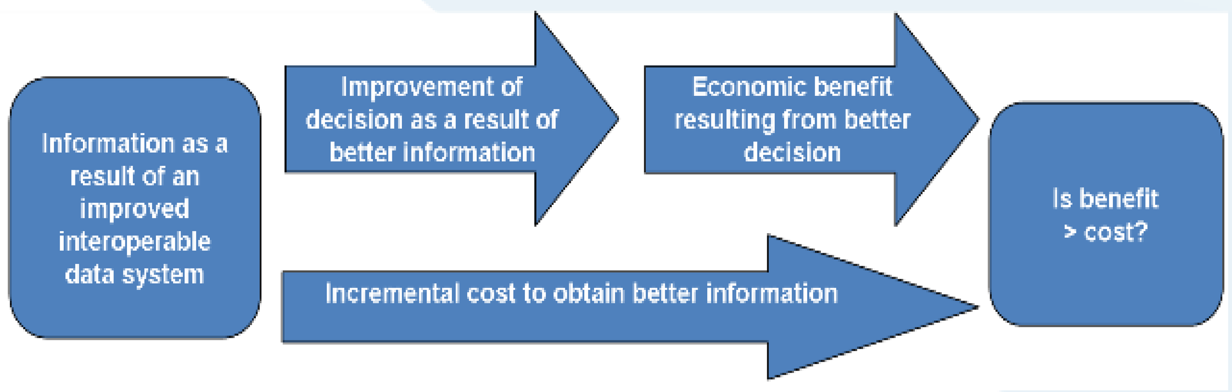

Fig. 2. Benefit Chain.

Bayesian decision theory

This method explicitly considers the extent to which decision-makers actually use Global Earth Observation for decision-making. The approach is particularly attractive as it links the value of information to the perceived accuracy of the information system.

Fig. 3: An algae bloom off the southern coast of England in 1999 as observed from satellite (Source: Wikipedia)

Using expert elicitation to assess decision-makers perceptions of the accuracy of the GEO-based algal bloom early warning system, the analysis indicated that the value (i.e. avoided damage) of an early warning system would be 74,000 €/week. Since the costs of establishing and maintaining such an early warning system amount to 50,000 €/week, investing in satellite observation for preventing potentially harmful algal blooms seems to be an economically efficient investment to make. Increasing the accuracy of the information system substantially increases the value of information – the value of perfect information, for example, being estimated at 370,000 €/week.

Real Options Framework

This approach takes into account investment irreversibility, uncertainty and the flexibility to react when new information arrives. Such a framework is proposed here, and applied to a satellite mission case study, considered to bring about new scientific information potentially leading to lower damage from natural disasters. Satellites are a key source of EO designed to obtain information for improved decision making. In terms of avoiding damages from natural disasters through, for example, better weather forecasts, early warning or better-informed rescue missions, the benefits are high, but also difficult to quantify.

Fig. 4: Satellite (Source: Dreamstime)

Key findings show that large volatility of the benefits from avoided damage or damage mitigation increases the option value, thus leading to postponement of the satellite mission. While rational to wait in the face of uncertainty, higher volatility also implies higher spikes in damages, representing high-impact disasters – hence it is important to ex ante assess the benefits that could be obtained through EO.

Systems Dynamics Modeling

In order to illustrate the propagation of GEO benefits across all nine SBAs and to capture the global perspective of such issues as greenhouse gas emissions or climate change, system dynamics modeling and simulation methodology was used to develop the FeliX (Full of Economic-Environment Linkages and Integration dX/dt) model. The FeliX model provides a systems perspective, where the underlying social, economic, and environmental components of the Earth system are interconnected and constitute a complex dynamic system. A change in one area results in changes in other areas. Being a dynamic model it captures change of certain phenomena or impact of certain policies over time. Constructed as such, the model allows for analysis of particular policies, actions and interventions in both the short and long term.

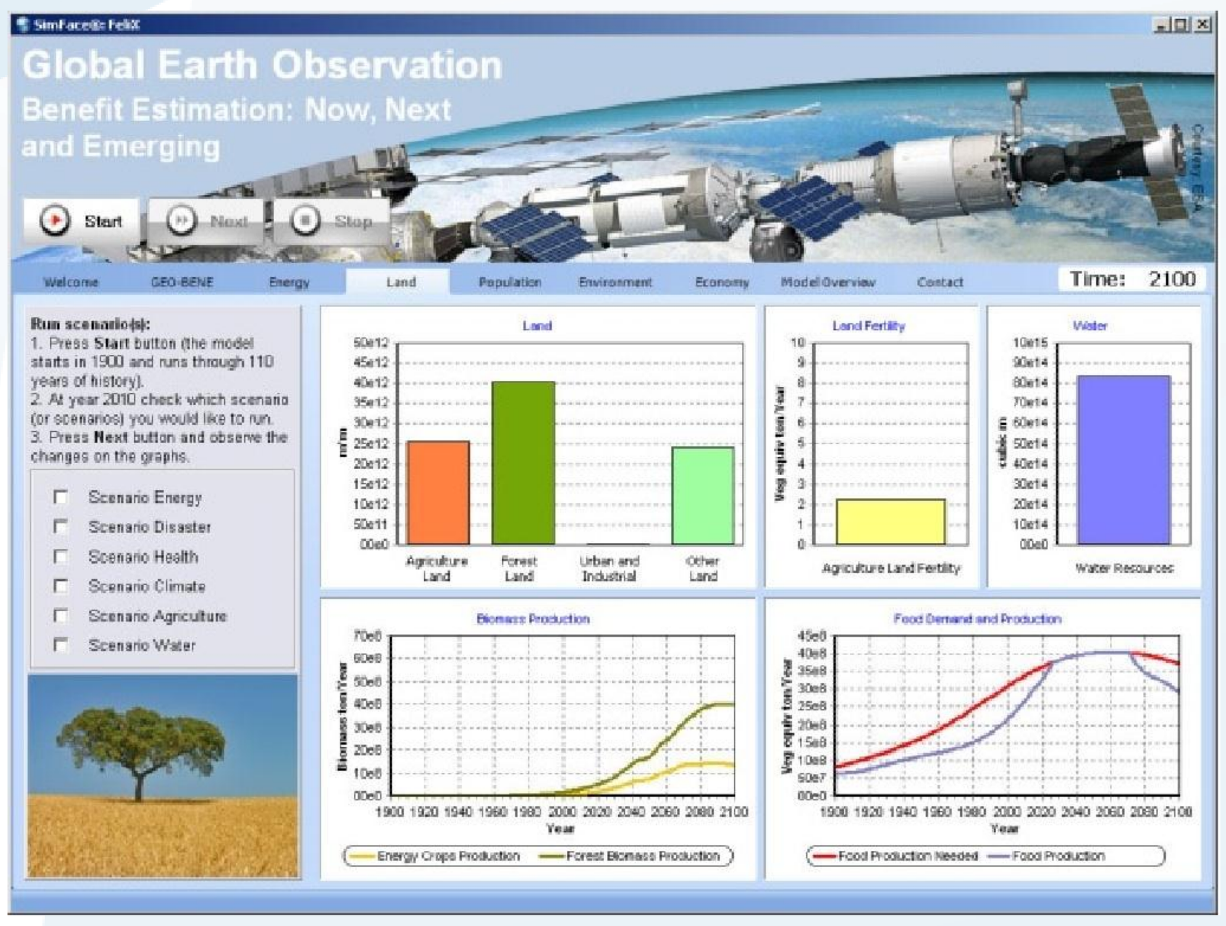

Fig. 5: FeliX model showing land responses to the business as usual scenario.

Conclusion

The economic importance of integrated assessment can be gauged by a recent survey of practitioners in Europe undertaking Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs). This survey indicates that the current barriers to the discovery, access, and use of the environmental and geographic data necessary to undertake EIAs and SEAs account for an added cost of € 150-200 million per annum in the EU alone, along with reports of lower quality, i.e. greater uncertainty on the environmental impacts of the projects proposed. The development of SDIs and of interoperable systems of systems in the GEOSS context can remove these barriers, and therefore provide significant economic benefits, in addition to the all-important increased understanding of the complex relationships between environmental processes and human agency. With the implementation of INSPIRE requiring the development of SDIs at multiple levels across Europe, and the development of GEOSS at the global level, it is important to develop a portfolio of studies providing evidence of the benefits of these investments.

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