A NEW EARTH OBSERVATION BASED GEOGRAPHIC ECOSYSTEM MONITORING AND ASSESSMENT SERVICE

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ABSTRACT

Earth observation based mapping of the physical and social landscape can improve the understanding of the economic and societal benefits arising from specific ecosystems. The European Space Agency (ESA) G-ECO-MON – Geographic Ecosystem Monitoring and Assessment Service project is intended to show that Earth Observation (EO) applications are neither costly nor complex and are globally accessible. Therefore they are ideally suited for ecosystem service monitoring and assessment. By supporting better understanding of ecosystem services, EO applications support the sustainable management of natural capital and the wider environment. EO can thus make an important contribution both to organisations and to the environment, as well as society at large.

1. BACKGROUND OF THE PROJECT

The ESA G-ECO-MON project extends the use of EO based information for multiple applications. These include environmental impact assessments, production management, supply chain management, ecosystem management, payment for ecosystem services (PES), natural wealth accounting, emergency management or public policy. To achieve the project goals, an assessment of the market for EO applications was carried out by an international project consortium combining world-class expertise in EO services customised for land, coastal and marine ecosystems together with in-depth knowledge on the needs of corporate, investor, NGO and governmental users. Therefore, a review of the requirements of other stakeholders - such as the developers of business, project and environmental management standards, environmental research community, and the verification community – was conducted. During the first phase of the project, the market structure and potential applications of EO products were assessed through individual interviews and workshops. In the second phase the project, it will demonstrated, through a series of case studies, how stakeholders can receive customised, best-practice EO services that meet their operational needs and conditions for ecosystem service assessment. These services will then be assessed in terms of their impact, benefits and utility. This two-phased project will also support the integration of EO based information into standardised models and evaluation protocols for ecosystem service measurement.

The market segments of interest were identified via dedicated user interviews and workshops that were held in Phase 1, resulting in several demonstration studies selected across a range of geographies, ecosystem services and biomes, aimed to encourage user uptake and application.

2. THE ROLE OF EARTH OBSERVATION FOR ECOSYSTEM SERVICE ASSESSMENT

2.1 Ecosystems and their services

An ecosystem is a complex set of relationships among the living resources, habitats and residents of an area acting as a functioning unit. Each ecosystem represents a community of living organisms (biotic components such as plants, animals and microbes) in conjunction with the non-living components of their environment (abiotic components such as air, water and soil), which are linked together through nutrient cycles and energy flows [1]. According to the UN Millennium Ecosystem Assessment (MA)[1], ecosystems provide ecosystem services - “the benefits people obtain from ecosystems.”

[1] The Millennium Ecosystem Assessment was called for by United Nations Secretary-General Kofi Annan in 2000 in a report to the General Assembly entitled *We the Peoples: The Role of the United Nations in the 21st Century*. Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for actions needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being.

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Human well-being and business depends on these services including freshwater, food, pollination, and climate regulation. Particular ecosystem services existing in a region will vary reflecting the ecosystems' characteristics (e.g., size, diversity of plants and animals within it).

Best practices in ecosystem services measurement require that the quantity and quality of service production and the flows of services among ecosystems and to people be considered. These services can exist at different scales: pollination occurs at a local level, freshwater is provided regionally, while global climate regulation occurs on a large scale. The delivery of such services to people and companies has direct implications for well-being and performance. "Ecosystem service assessments" is a term used to describe this research, measurement, analysis and reporting. The core methods were developed by the MA and have been adapted for the corporate sector [2] and numerous community and public applications [3].

People can alter ecosystem services provision principally through land use and land change, over consumption, pollution, climate change, and invasive species. Historically, increases in provision services, such as food, have come at the expense of regulating services such as soil quality maintenance and water regulation on which food production depends. Population and economic growth pressures require more provisioning services, without the historical loss of regulating, supporting and cultural services.

2.2 Ecosystem service assessment and valuation

One reason this challenge is still unmet is that many ecosystem services are not included in decision making. This failure is happening despite initiatives such as the MA and The Economics of Ecosystems and Biodiversity (TEEB) [5] that have concluded that there is adequate rationale for an economic approach to the management of ecosystems [6].
One of the best-known studies of the value of the world's ecosystem services and natural capital is a paper published in Nature in 1997 by Robert Costanza along with twelve co-authors. In this paper, a global 'minimum estimate' of US $33 trillion [7] was suggested, but there still are impediments to estimating ecosystem service values. While it would be, for example, useful to estimate the value of ecosystem services that are dispersed over a very broad public, it is precisely under these circumstances that it is most difficult to use the tools of economic value estimation ('the paradox of valuation').

Recently, a range of market mechanisms has been introduced to reflect the economic value of ecosystem services and to create incentives and pay residents or companies for better ecosystem stewardship and management.

These include corporate ecosystem valuation, national resource accounting, certification schemes, payments for ecosystem services schemes (i.e. provision of contracts between consumers and suppliers of services), biodiversity offset programs (i.e. compensation of losses by an economic development project through habitat restoration or creation elsewhere) and new standards for and environmental impact assessments, among other initiatives.

2.3 Nature valued from space

Geographic Information Systems (GIS) and Earth observation mappings of the physical and social landscape can greatly aid in the understanding of ecosystem benefits arising from specific ecosystems. Notably, the critical role of remote sensing and its applications for ecosystem service assessment have been highlighted in studies from Boyd & Wainger [8] and from DeFries & Pagiola [9]. Satellite data can provide the information needed to accurately assess the ecosystem conditions including land cover and land cover change mapping, habitat mapping for biodiversity, wetland mapping, land degradation assessments and measurements of land surface attribute as input to ecosystem models.

The MA recognizes remote sensing as a "new data set" and "assessment tool" providing globally consistent information making ecosystem service assessments more rigorous. In particular, the scope for wider use of EO based information services in ecosystem monitoring and ecosystem service assessment was highlighted in several synthesis reports within the MA.

With a new generation of powerful satellites in orbit (or being soon commissioned) and easier access to data through a number of commercial vendors, EO derived information is now increasingly being used to determine precise characterisations of the changes in boundaries and spatial heterogeneity of habitats and ecosystems. However, to date only a small number of NGOs have exploited these EO services. Several international development banks and state environmental agencies have expressed interest in better understanding of how EO based information can support ecosystem service assessment. While the capability to map habitat status and changes in habitats is relatively mature, the integration of such data into models to assess the capacity of an ecosystem to provide services and to track flows of these services remains at an early stage of development. At the same time, many organisations are working to incorporate ecosystem service assessments into their work and have requested a greater availability of EO based information services to support such analyses.

Even so, overall user uptake of EO based information by ES players remains limited in what is still an emerging sector. This initiative by ESA for a project to support the expansion of the user base for EO services for use in ecosystem services assessment is therefore timely.

3. UNDERSTANDING THE USER REQUIREMENTS

The project considered a number of specific market groups where ES assessment can play an important role (impact assessments, product / production management, payment for ES and public policy / ecosystem management).

The project identified a number of overarching needs. EO plays an important role in all of the following groups:

Assessing land-use and land-cover. The approach generally involves assigning an ES value to a given land cover class and is a key requirement in all market groups considered. Presently this type of data has been used for small geographic areas on specific ES. However, there is significant potential to scale this up and develop consistent classification methodology. Furthermore, higher spatial resolution, shorter temporal spacing, etc in improved land use/land cover maps were identified through the project stakeholder engagement as the single most useful update/improvement to existing EO applications for ES modelling.

Sustainable management of water. This includes deriving an understanding of rainfall, evapotranspiration, water withdrawals, soil moisture among other variables from remote sensing. These variables were identified as important areas for improving existing EO applications for ES modelling.

Delineating the full extent of ecosystem flows. System boundaries change to reflect the ES under consideration. The most obvious application involves mapping watersheds through digital elevation models (DEM). However, products derived from EO could also support mapping other boundaries or "sheds" (e.g. marine primary production, carbon stocks and commodity production).

Mapping beneficiaries or demand for ES. This includes information on the distribution, size, and locations of populations. It also involves mapping factors influencing their status such as infrastructure development and settlement distribution. This can be achieved through assessment of light patterns, road networks and other indicators. The EO data can then be integrated with socio-economic data sets, such as national census or surveys.

This project also considered a number of key factors influencing the use of EO for ES assessments, including:

Key drivers of ES assessments include emerging multilateral policies, national policies linked to environmental stewardship and climate change adaptation, mandated standards linked to access to finance, access to markets, risk management and spatial planning, CSR policies and public policy. In some cases, ES assessments are a mandated practice linked to international project development or trade. At a minimum, they are considered by many to represent best practices. However within the business community, the understanding of the linkage between their activities and ES is still emerging and many organisations have yet to conduct ES assessments.

Geospatial information and analysis forms a central component of ES assessments. For instance, geospatial data related to sustainable water management (e.g. watersheds, water use, water quality) is seen as one of the most universally required inputs into ES management. While there are many examples of customised analyses, ES models play a central role in determining what geospatial data is needed and how it has to be structured and delivered, often integrated with in situ information and other data sources. While the value of geospatial data is widely recognised, the value of EO is often not appreciated (except in the area of carbon assessment where the potential for EO is better understood).

Drivers of greater use of EO include:

- Increasing requirements of some organisations to move from considering ES at a site level to wider regional, watershed or landscape levels;
- The cost of collecting and maintaining adequate in situ data;
- An inconsistency in standards of collection or quality of in situ data;
- Errors and inaccuracies in using sample data and extrapolation;
- The need for independently derived and replicable data;
- The availability of free wall to wall EO data (at near real time and at resolutions better than 30m);
- The role of EO as a powerful communications tool (in combination with GIS platforms), supporting a drive to greater transparency and stakeholder engagement.

A key *success factor* identified is the need for standardised EO products for consistent interpretation across different sensors and systems (radar and optical). In many cases, while base layers should be standardised (e.g. at a high level such as defining forest and non-forest), products could be customised. While the value of EO is important for project implementation, it is important to keep products and process as simple as possible (especially given the complexity of the underlying technologies).

However it is noted that the market is not demand-led and there is a need to showcase EO. Developers need to identify key benefits and get actors together to share experience and information.

In the past, a key *barrier* to greater use and integration of EO within ES has been the lack of a user-friendly, inexpensive and/or open source GIS platforms to integrate EO data with ancillary data sets. In a number of sectors, there is a potential for significant increase in the use of GIS platforms. There are also instances where EO for ES assessment does not provide an appropriate solution. For example, in the tropics, ES activities are often at a small scale and located in areas with a high incidence of cloud cover. A final barrier is related to past experiences of users within the EO sector: technical service providers have in the past oversold the capabilities of the technology and, where this is the case, it will take time to re-establish confidence.

4. DEMONSTRATING THE EARTH OBSERVATION POTENTIAL

4.1 An EO portfolio for ecosystem assessments

The importance of EO for ecosystem assessment and valuation is increasingly recognised. Satellites enable a spatially explicit and temporarily accurate source of land cover, land use and changes to support broad assessments of global ecosystems at low cost compared to labour intensive and field surveys based on field sampling and extrapolation models. Planned very high resolution (better than 15m) constellation optical and radar satellites will provide high revisit times allowing not only current mapping, but also for regular and timely monitoring. EO products will therefore increasingly support the effective definition, measurement and assessment of ecosystem services (ES).

With the expansion of ES analysis, the opportunity for EO to become a standard source of spatial data has never been greater. This opportunity is reinforced by the recent emergence of open source GIS platforms and mobile technologies; demand for EO is also driven by the growth and acceptance of ES models requiring standardised quality geospatial data.

Based on the analysis of user requirements, an initial EO product portfolio was elaborated for land, marine and coastal applications that will be further refined for the users obtaining EO data in a dedicated demonstration study.

4.2 Demonstration projects

The field of ecosystem services assessment embraces a broad set of actors and stakeholders, comprising financial institutions, development banks, environmental protection agencies, NGOs, trade associations, international initiatives or private sector operators. It is therefore of utmost importance for the sustainability of the expansion of EO services into this market, to involve from the very beginning of the project a user group that represents the broad information requirements for different ecosystem types (land, marine, coastal). In Phase 2 of the project, several demonstration studies around the globe will be carried out that highlight the effectiveness of EO applications and promote good practices. A public open call for application was issued in summer 2013 and due to the overwhelming response, more than the five initially planned demonstration studies will be carried out. The final demonstration projects will be selected with view to their market group, the geographic distribution and technical feasibility. The project progress and details on the demonstration studies can be followed on the website www.space4ecosystems.com, a future platform to support EO based geographic ecosystem assessment and monitoring.

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