→ GREEN GROWTH

Earth observation for international development projects

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Earth observation information provides a key contribution to the planning, implementation and monitoring of large international development projects. ESA has been collaborating with multilateral development banks since 2008 to demonstrate the value of such information to their investments taking place in developing countries.

ESA's current and planned technological capabilities place Europe at the forefront of Earth observation. In the next decade, ESA plans to launch more than 25 new Earth observation satellites, which will provide an enormous wealth of new data to be exploited by the scientific as well as operational user communities.

This includes launching the most ambitious operational Earth observation programme in the world: Global Monitoring for Environment and Security (or GMES/Copernicus, see **http://copernicus.eu**). This programme will combine data from the world's biggest fleet of Earth observation satellites and from thousands of *in situ* sensors to provide timely, reliable and operational information services covering land, marine and atmospheric environments and emergency response.

Preparations for adapting to this vast amount of information are in place in Europe for public sector users, but the data will be available globally. The potential for new applications with new user communities in the international development and private sectors is evident.

This year, ESA broadened the initial scope of working with the multilateral development banks. New initiatives have been started to demonstrate the benefits of Earth observation information for major international development projects with the major banks (World Bank, European Investment Bank, UN International Fund for Agricultural Development, Asian Development Bank and the European Bank for Reconstruction and Development).

These initiatives are being carried out through ESA programmes, together with the European and Canadian Earth observation services industry (mainly small companies) that are in a world-leading position in terms of diversity and maturity of products and services. ESA can therefore be a key partner to international development institutions seeking innovative solutions to address the sustainable development challenge.

Why 'green growth'?

Many areas of sustainable development are facing their defining moments. Today's urban population of about 3.6 billion people is projected to reach 5 billion by 2030, with more than 90% of the urban population growth expected to occur in the developing world. This increasing concentration of population and assets will intensify their exposure to natural disasters. In 2011 the world experienced the highest disaster losses ever recorded and this trend will continue, exacerbated by the effects of climate change and variability, which are likely to affect the poorest and most vulnerable communities.

Moreover, with global population rapidly rising, the world will need to feed 9 billion people by 2050, which will require a 50% increase in food production. At the same time, the World Bank estimates that by 2025, nearly two-thirds of countries will be water-stressed and 2.4 billion people will face absolute water scarcity, posing challenges to agricultural productivity and food security.

Other major global issues related to natural resources depletion, such as deforestation, soil degradation, desertification and loss of biodiversity, also reveal alarming trends. Deforestation and degradation of 2 billion hectares of forest landscapes affects not only Earth's environment and the balance of greenhouse gases (GHG), but also the livelihoods of 350 million people who live within or close to dense forests and depend on them for their subsistence and income.

Similarly, healthy biodiversity and economically productive oceans are essential for food security, jobs and the sustainable quality of life on Earth. An estimated 61% of the world's total Gross National Products (GNP) comes from areas within 100 km of the coastlines. The oceans as a whole provide 16% of the global population's animal

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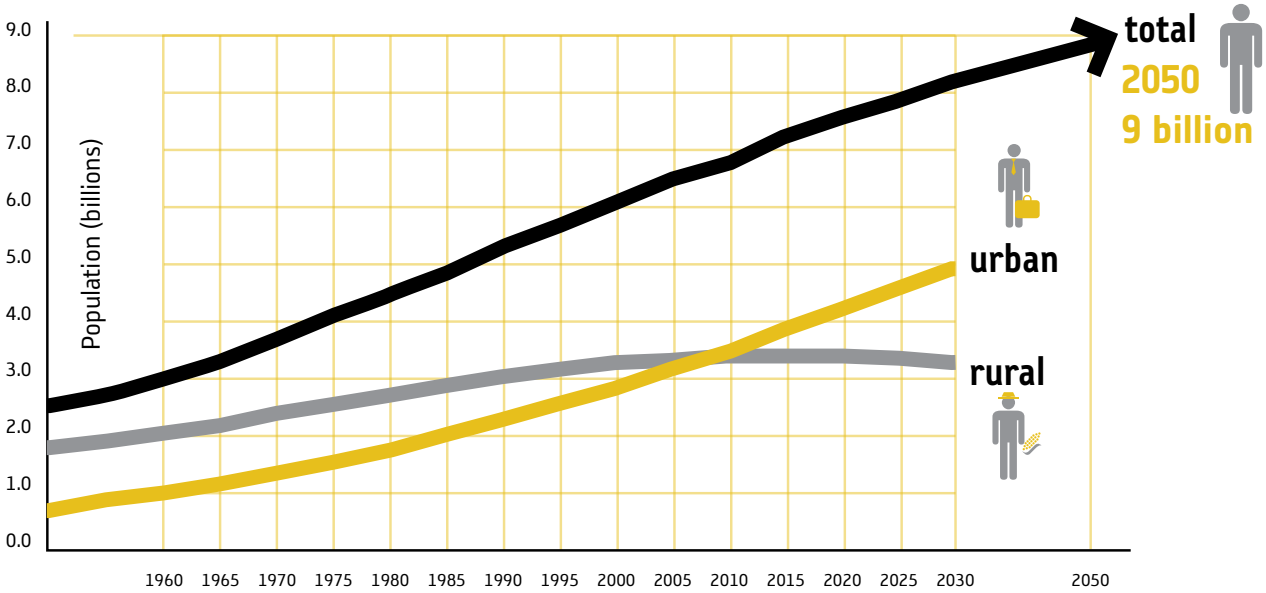
Today's urban population of 3.6 billion people is projected to reach 5 billion by 2030 (www.un.org)

Urban and rural population growth



← 2/3 of the all countries will be water-stressed meaning 2.4 billion people will face water scarcity

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protein intake. However, over-exploitation is undermining the socio-economic performance of these resources.

As much as 85% of the world's ocean fisheries are fully exploited, over-exploited or depleted. More than 60% of global coral reefs are under direct threat from land- and ocean-based activity. Taken together, they are creating an annual global economic loss of some $US 50 billion, not taking into account the disruptive effects of sea-level rise and other effects of climate change.

Counteracting all these challenges requires targeted, focused and result-driven development programmes. These are actively exploring practical paths of action to ensure that natural resources are used sustainably, while meeting the demands of growing global population, managing disruptive impacts of climate change and preparing for increased frequency and intensity of natural disasters. Many of these programmes are defined, developed, financed and/or led by the key multilateral development banks.

Given the major trends outlined above, there is increasing pressure (indeed necessity) that these major development programmes ensure economic growth in an environmentally sustainable manner, or put simply: 'green growth'.

In support of this, financial approaches are being developed to put an economic value on the environment. Examples include: the Natural Capital Project led by Stanford University and World Wildlife Fund (see **www.naturalcapitalproject.org**), and the Wealth Accounting and Valuation of Ecosystems Services (WAVES) initiative, recently launched by the World Bank itself (see **www.wavespartnership.org**).

Led by ESA and in cooperation with the major development banks, new knowledge products and services, innovative ideas (including the potential of the next-generation Earth observation tools) and techniques are being customised and tailored to help achieve the sustainable development objectives of specific development projects.

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Swordfish dead in tuna-fishing net. Swordfish are sometimes caught by accident (BJ Skerry/Nat. Geo./WWF)

Earth Observation in support of 'green growth'

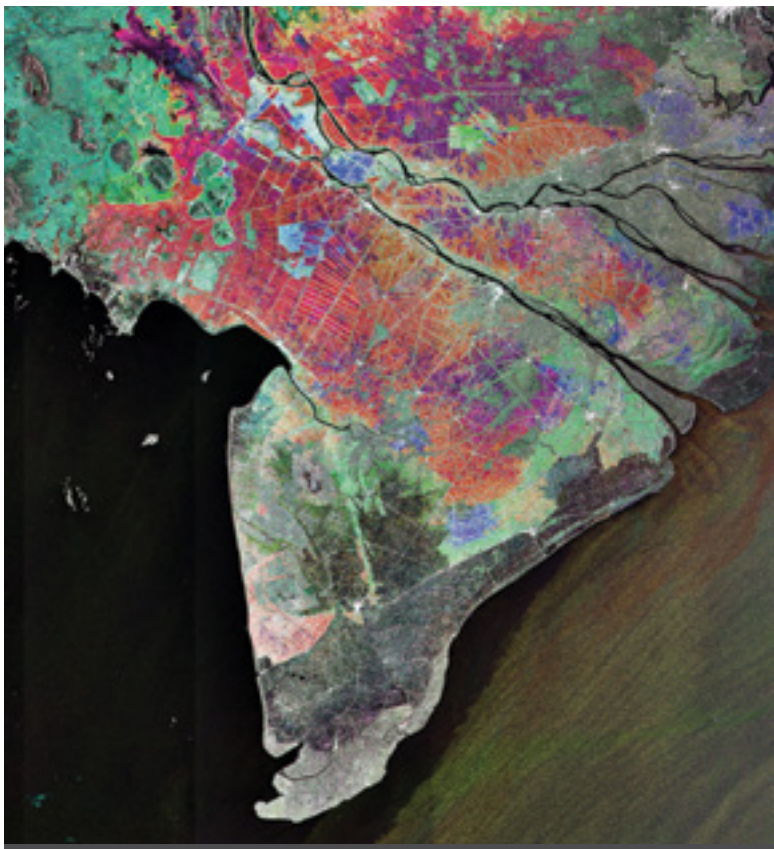
Earth observation by satellite can address a number of areas of environmental sustainable development, or green growth. It is a valuable source of information for management and protection of key ecosystems to counteract over-exploitation resources, desertification and land degradation, and to support sustainable agriculture and biodiversity conservation. In the same way, Earth observation capabilities extend to marine and coastal ecosystems to mitigate negative impact of both natural and human-induced changes on sensitive habitats.

Earth observation is also used extensively to support risk assessment, as well as crisis mapping including post-disaster recovery, rehabilitation and reconstruction. In addition, Earth observation is used for operational monitoring of urban development with comprehensive, accurate, up-to-date geographical information to understand how cities are evolving over time at local, regional and global levels.

ESA partners with main user communities to ensure that Earth observation services and products can be used to respond to sustainability needs and studies of the environment. The key ongoing activities are: TIGER, the initiative supporting African institutions in managing water resources; and the GLOB projects, delivering a range of global satellite information in support of international environmental treaties and conventions.

ESA is also a leading organisation within the Committee for Earth Observation Satellites (CEOS), where, along with other space agencies, it supports the Forest Carbon Tracking system and the Global Forest Observing Initiative. Within CEOS, ESA was a founding member of the International Charter 'Space and Major Disasters', which has provided over the last ten years rapid access to Earth observation data and information in support of aid relief from natural disasters to national and international disaster relief organisations worldwide.

The challenge now is to establish a stable connection between existing and upcoming European Earth observation capabilities and the leading institutional players in sustainable development to exploit synergies with funding programmes behind them. The existing partnerships with the multilateral development banks are a start to building a comprehensive approach toward this new user community, taking advantage of ESA's three decades' of experience in developing Earth observation-based applications.



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An Envisat radar image of the Mekong Delta In Vietnam, where such an enormous amount of rice is produced it makes Vietnam the world's third biggest rice exporter. Radar sensors are particularly suited for monitoring rice cultivation because they are able to detect waterlogged ground and penetrate the humid cloud coverage typical of Asian rice-cultivating regions

ESA and the multilateral development banks

The multilateral development banks provide support to developing countries to reduce poverty and stimulate economic growth. This involves dealing with the complex challenges of climate change, rapid urbanisation, threats to food security, natural resource depletion and the risk of natural disasters. The provision of accurate and consistent geospatial information is a key component and the world is looking at the development banks to bring the best available datasets to support strategic planning and to deliver quality solutions to the countries around the world.

Over the last couple of years, some of the banks have gained significant experience in utilising new technologies, including satellite Earth observation tools and other geospatial technologies in addressing a variety of development challenges. For example, the World Bank has developed partnerships with external organisations, including national space agencies (such as ESA, NASA, NOAA and JAXA), and private sector satellite operators and services providers to improve its access to the range of available Earth observation data, information services and knowledge products.

ESA began exploring this potential through three small-scale technical assistance demonstration projects for the World Bank in 2008. The trials demonstrated the use of Earth observation-based services to support climate change adaptation projects in Belize (coral reefs), Bangladesh (coastal dynamics) and North Africa (land subsidence).

The success of the early pilots resulted in the scaling up of the collaboration with the World Bank in 2010 to include 12 larger-scale activities and the launch of a joint 'Earth Observation for Development', or 'eoworld' initiative (see **www.worldbank.org/earthobservation**). The 12 activities were spread across the bank's sustainable development network and carried out in over 20 countries in Latin America, Africa, South and East Asia in the following thematic areas:

- climate change adaptation
- disaster risk management
- urban development
- water resources management
- coastal zone management
- marine environment management
- agriculture
- forestry

In parallel (and building on the experiences with the World Bank), ESA began further collaboration with more multilateral development banks. A further ten demonstration projects are being completed with the European Investment Bank, and eight demonstration projects have been started with UN International Fund for Agricultural Development. In addition, strong interest is being shown by Asian Development Bank and European Bank of Reconstruction and Development to initiate collaboration with ESA.

All these activities aim to demonstrate the value of Earth observation to support targeted international development programmes. The long-term objective is to promote the use of Earth observation as a standard reference technology and a component of 'best-practices' in the definition of future programmes, projects and other development initiatives, and to establish this technology as a standard tool in planning, implementation, monitoring and assessment of international development investments.

Practical examples of the application of Earth observation information include establishing baselines, results monitoring, impacts assessment and auditing, identifying 'hot spot' locations, and supporting dialogue with local partners by putting development issues in a spatial context.

Not only wetlands, but also rangelands, grasslands, forests, deserts and coastal areas – all our natural reserves – provide valuable assets to society in terms of measurable and accountable services.

The impact of Earth observation in development projects

The initial projects to demonstrate the utility of Earth observation information have confirmed that the availability of factual, evidence-based information is a unique tool. This is not only for practical management of ongoing international development activities, but also for transparency and raising awareness to develop an informed community of stakeholders and to engage them effectively in a dialogue on the common issues.

Many of the bank project managers highlighted their fundamental need for quality data and information to

Peru/Bolivia
Satellite monitoring of water quality and land cover of Lake Titicaca demonstrated that between 2003 and 2010 the size of the lake decreased by 7% and that important wetland and breeding ground for endemic species are facing unprecedented degradation.

Liberia
Earth observation-based forest mapping provided independent verification of contradictory reports concerning available forest resources and discovered that deforestation rates in the investigated areas had been kept to a minimum.

Jakarta
The problem of urban subsidence is particularly disturbing. Pumping of water from deep wells causes the land to sink by as much as 10 cm a year. Earth observation accurately and efficiently identified the subsidence problem in the metropolitan area, revealing trends with millimetre precision and on the level of single infrastructure elements.

Papua New Guinea
Satellite-based land-cover monitoring helped to involve local government, industry and civil society in setting a transparent baseline for the future biannual environmental audits.

↑ Examples of benefits obtained by integrating Earth observation information into specific World Bank projects

guide their decisions, especially in view of multimillion-dollar investments in new infrastructure, forest stocks, environmental conservation or water resources.

From the perspective of planning, this type of tested and validated geo-information with known accuracies and limitations was useful, particularly in cases where there was a need to upgrade the reliability of available datasets to mitigate the possibility of making poor decisions (based on inaccurate or out-of-date data that can be locked into a project in the early stages).

From the operations perspective, the use of Earth observation information for project implementation and evaluation was regarded as essential to managing a range of operational risks, as well as to strengthening of strategic relevance and technical quality of the proposed or ongoing projects.

These initial activities also helped identify the potential of further exploiting Earth observation information within new World Bank global programmes and partnerships (GPPs).

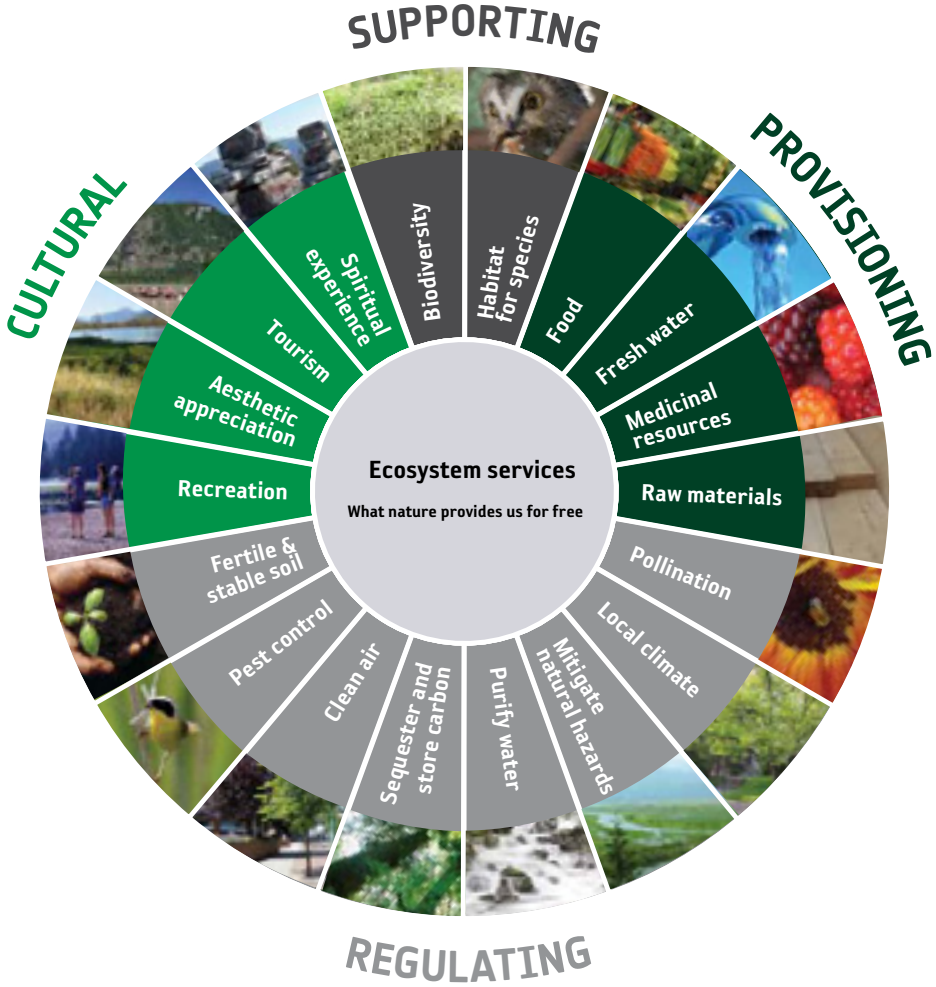
GPPs are important because they play a key role in creating and sharing of knowledge, and in mobilising financial and technical resources of a larger community of donor organisations, as well as public and private stakeholders, particularly on environmental issues. Discussions are in progress to explore the potential of Earth observation with the two new World Bank initiatives: the Global Partnership for Oceans (GPO), see **www.globalpartnershipforoceans.org**, and the Wealth Accounting and the Valuation of Ecosystem Services (WAVES), see **www.wavespartnership.org**.

Latest developments: ecosystems services

The value that nature brings to countries and societies is often taken for granted or not well understood. Consider a wetland on which a government plans to build a new department store. People who appreciate the natural beauty of this wetland want to preserve it. But how can these people argue against the clear numbers demonstrating economic growth and new jobs if this department store is erected?

The beauty of the wetland is often not enough to change government decisions, especially not in times of financial crisis. Government and policy makers need firm arguments and most often these must be supported by financial information. In order to secure protection of this wetland as well as its beauty, for example, its economic value to society must be quantified and communicated to decision-makers.

It is surprising to most people that the economic value brought to society by a wetland more often than not outweighs the economic gain of destroying it. A wetland provides clean water for drinking and agriculture, it refills groundwater stocks, it works as flood-prevention agent, it prevents erosion and damage from storms, as well as being



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An ecosystem service is defined as the benefit that people derive, either directly or indirectly, from a natural reserve. Earth observation can provide input to the valuations of ecosystem services by establishing baselines, monitoring the compliance of standards, spot checks of sustainable management practices and support environmental reporting (MetroVancouver)

a habitat for wildlife and a carbon store. Putting a price on all these values of a wetland may convince decision-makers to keep the land rather than developing it with building (see *'The economic value of the world's wetlands'* by L. Brander and K. Schuyt, 2010, available at TEEBweb.org).

Not only wetlands, but also rangelands, grasslands, forests, deserts and coastal areas – all our natural reserves – provide valuable assets to society in terms of measurable and accountable services. This is leading to a new concept of natural capital accounting or 'ecosystems service' (ES) assessments.

These financial approaches to quantifying the economic value of the environment were introduced in the Millennium Assessment report on Ecosystems, and further defined and globally mainstreamed through initiatives as the Economics of Ecosystems and Biodiversity (TEEB), the System of Environmental Economic Accounting (SEEA) by the UN Statistical Division and WAVES.

Working with the ecosystems service community

European traditions in environmental monitoring are very strong. The EU is a world leader in environmental and ecosystems monitoring through programmes and initiatives led by the Joint Research Commission and the European Environmental Agency. ESA's Earth Observation Directorate has been involved in environmental monitoring through climate variability and risk assessments, 'Reduced Emissions from Deforestation and Forest Degradation' (REDD) activities, coastal monitoring, global wetlands monitoring, biodiversity mapping, assessments of renewable energies, water management and certification of sustainable forest management.

As part of these European environmental traditions, ESA is increasing its activities in ecosystems service assessments. These will also support new global strategic safeguards for biodiversity and ecosystems, for example, Convention on Biological Diversity targets and the EU Biodiversity policy.

ESA is working with a consortium of experts from five specialist Earth observation service companies in Austria, UK and Sweden to understand needs and requirements of the ES community and improve the capacity to measure natural capital around the world. Two lines of activities have been initiated: demonstration of the benefits of Earth observation-based information for selected ES projects and users, and broader studies of how the Earth observation information can be used in ES assessments to expand this potential market.

The production and processing sectors are estimated to have negative environmental costs not accounted for on a global scale, in the order of $7.3 trillion or 13% of the global economy (2009). This includes air pollution, greenhouse gas emissions and bad land and water use. Coal power production is a sector where the estimated health costs and other damages exceed the production value of the sector.

- Example of economic value of sustainable use of nature resources and ecosystems services (TEEB for Business Coalition, P. Suhkdev, TEd Talk 2011 and E. Barbier, 2007)

These demonstration trials include forest studies in Vietnam, Indonesia and Peru, and coastal studies in Australia and Yucatan. The aim of these activities is to derive the economic value of specific ecosystems addressed in each area for a selected group of users whose natural resources are threatened by industrialisation and bad land-use management.

The market expansion studies target the whole ecosystems domain, including a wide range of users and stakeholders from European and UN organisations, international environmental convention secretariats, manufacturing companies, the private insurance sector, specialised NGOs and SMEs, environmental certification organisations, research institutions, industry-wide groups and the international development banks. Together with the WAVES team at the World Bank, ESA hosted a user workshop targeting US ecosystems stakeholders in May. Similarly the global law company Linklaters hosted a workshop with ESA targeting European ecosystems stakeholders in April 2013 in London.

The messages from these user consultation workshops were clear: there is a need for better geospatial data with higher spatial resolution, delivering accurate and validated information. There is a need for long-term consistency in delivery of these data, enabling capabilities for tracking changes in ecosystems services using the same datasets. There is a need for data sources that support not only local and regional studies, but also national accounting programmes.

The ES community have a long list of initial requirements: improved and specialised land use and land-cover mapping, forest inventories, crop yield for the provisioning ES services, improved models for flows of surface-water mapping, better nutrient and sediment retention models, sediment retention and soil retention for regulating services. In addition, there is strong interest in indirect proxies for population density for the cultural services and improved life cycle assessments, hazard/erosion and risk mapping for the supporting ES services. ■

For smallholders in Thailand, cutting down the mangrove forests may lead to short-term profits in shrimp farming. However, when all ecosystems services provided by the mangroves are accounted for, the economic gain to society is larger if the mangroves are kept rather than removed, because of their erosion and coastal storm protection ability. The incentive for governmental accounting of the value of nature is present

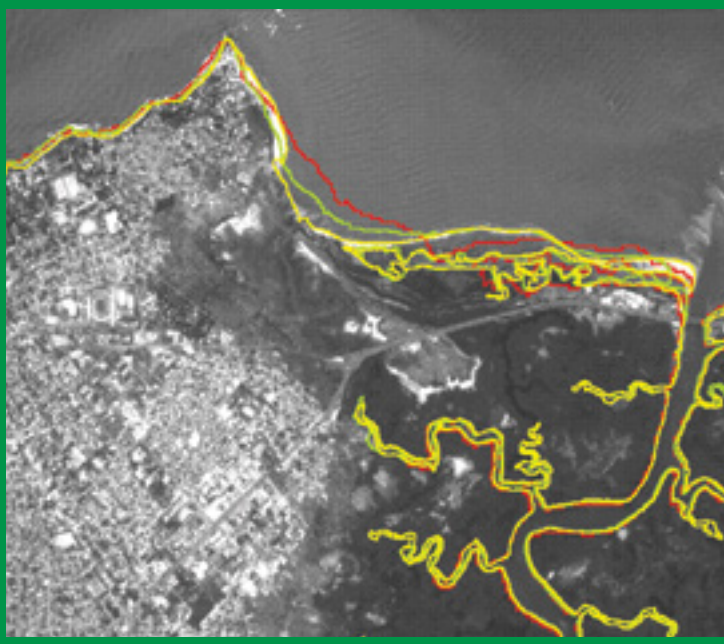
- Example of economic value of sustainable use of nature resources and ecosystems services (TEEB for Business Coalition, P. Suhkdev, TEd Talk 2011 and E. Barbier, 2007)

Case Study 1

→ MONITORING COASTLINE CHANGE IN WEST AFRICA FOR WORLD BANK

WHY	West Africa, countries are lacking long-term, harmonised records of the evolution of coastal environment. Historical satellite data analysis has allowed the assessment of long-term trends in coastal change and sea-level rise.
WHAT	Satellite coastline change maps, sea-level, currents and wind data
RESULTS	The ESA study carried out by Geoville confirmed that coastline is decreasing along the entire length of West Africa and that there is a need to support a range of preventive actions in collaboration with national governments. Coastline monitoring became an integral part of the bank-financed project focused on adaptation to climate change in São Tomé and Príncipe.
OUTLOOK	São Tomé and Príncipe is also experiencing illegal logging in the pristine rainforest covering most of the island. ESA is now working together with UN-IFAD in an activity to map changes and type of the forest.

← Remote Sensing Training course for government office employees, local World Bank and UN IFAD staff in São Tomé and Príncipe (Geoville)



↑ Coastline change of the city of Bakau, Gambia (Geoville)

2010
2000
1988

Case Study 2

→ AGRICULTURAL MAPPING IN GAMBIA FOR UN-IFAD

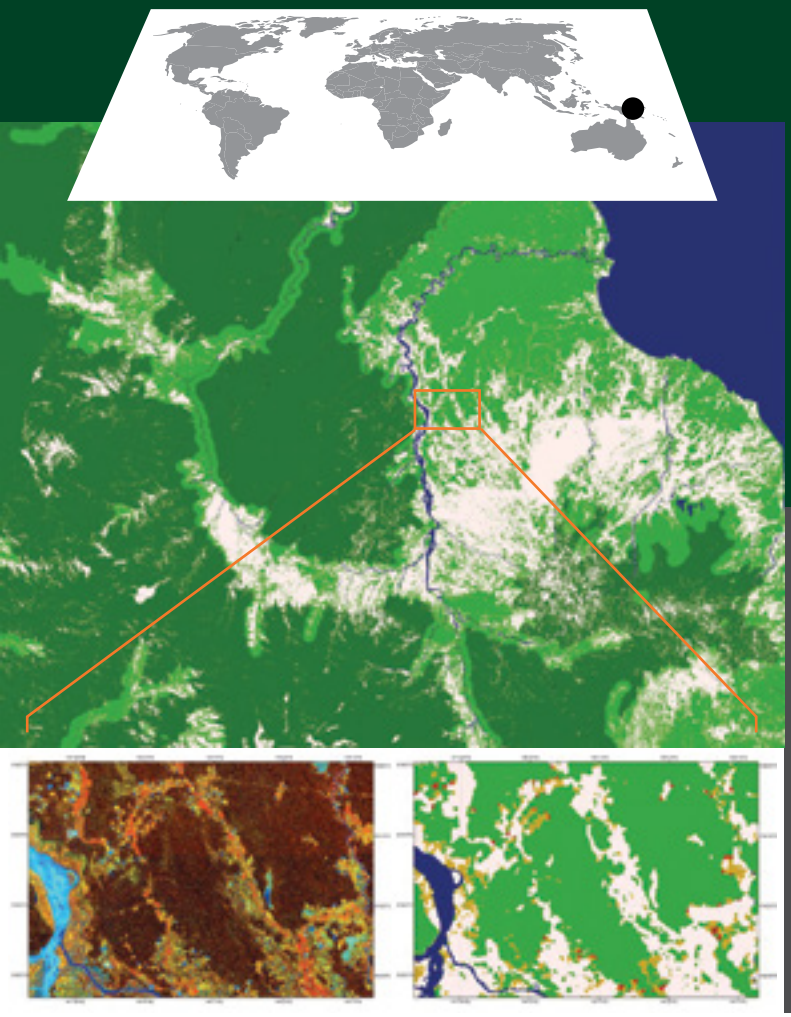
WHY	Gambia is 300 km by 50 km in size and heavily influenced by the Gambia river that crosses the country from east to west. It is one of the poorest countries in the world with soil erosion, land degradation, seawater salt intrusion, poor infrastructure and extreme poverty. UN-IFAD is working with the Gambian government on development projects that will focus on the poor rural population and their participation in local government and rural communities to implement strategies to improve agricultural production.
WHAT	ESA is working with the Swiss company Sarmap in mapping Gambia from space with radar. The aim of this is to establish baselines, understand current agricultural practices and document interannual changes.
RESULTS	Land-cover maps and maps of rice crop production patterns are in production.
OUTLOOK	Sarmap, ESA and UN-IFAD are also working with local communities. The local people are involved in collecting crop information for validation of the space-based maps. This will greatly enhance the accuracy of the maps as well as educate local people, a natural element of most bank development activities.

↗ A colour composite using both Envisat ASAR and ALOS PALSAR (yellow indicates permanent vegetation/settlements, blue shows changing land cover (agriculture) (Sarmap)

→ Gambia land-cover map from ALOS (Sarmap)

Case Study 3

→ ASSESSING THE IMPACT OF OIL PALM PRODUCTION IN PAPUA NEW GUINEA FOR WORLD BANK



WHY	Papua New Guinea face problems with unsustainable extraction practices in the palm oil and forestry section and growing industrialisation.
WHAT	Land cover and forest type mapping.
RESULTS	Earth observation services provided in Papua New Guinea documented that the World Bank-supported development of smallholder's plantations are compliant with oil palm sector sustainability criteria, such as the Roundtable on Sustainable Palm Oil, and do not result in negative effects on the environment.
OUTLOOK	The ESA project with SarVision demonstrated new opportunities for managing operational risks associated with palm oil production and other agricultural practices causing conflicts with existing natural habitats.

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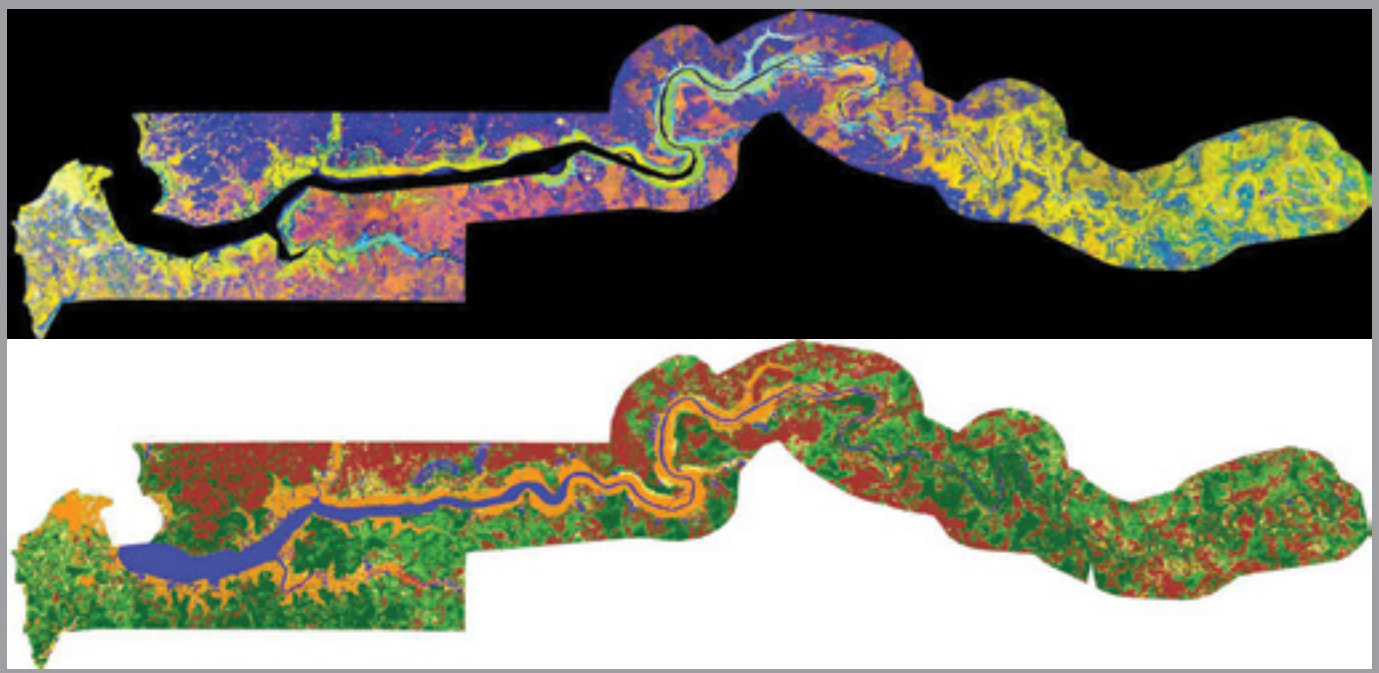
Small clearings for food gardens/subsistence agriculture in Oro. The RapidEye 5 m satellite image mosaic (left) shows recent small clearings in 2011 (blue spots), secondary forest (dark brown), smallholder oil palm (dark orange) and other land cover types. The forest cover change map product at 30 m resolution (right) shows deforestation of secondary forest during 2005–9 (orange), deforestation of secondary forest during 2009–11 (red), in addition to secondary forest (green), rivers (blue), and non-forest including oil palm (white) (SarVision, RapidEye)



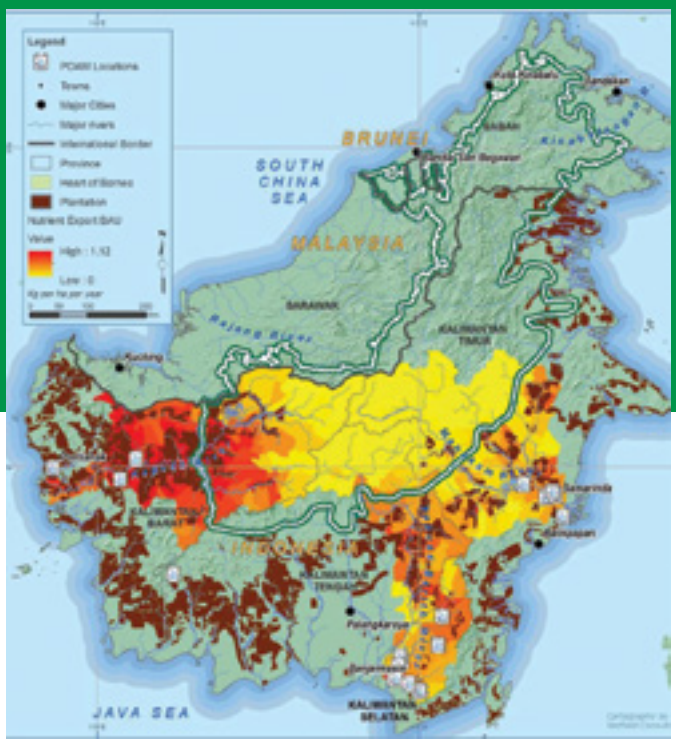
Case Study 4

→ EO FOR GREEN GROWTH ANALYSIS IN BORNEO FOR WWF

WHY	Borneo's tropical forests are among the most diverse and beautiful on the planet. Faced by threats from expansion in the palm oil extraction industry, forestry and mining and growing industrialisation, the governments of Indonesia, Malaysia and Brunei joined forces in assessing the economic value of the island's nature reserves in a large reporting activity: Heart of Borneo (www.heartofborneo.org). The main aim of the project was to assess business-as-usual scenarios against sustainable development scenarios taking ecosystems services into account.
WHAT	ESA worked with the World Wildlife Fund for ES assessments. Watershed functions, soil erosion, biodiversity and carbon stocks were carefully assessed using models and Earth observation data.
RESULTS	Services delivered for the World Wildlife Fund were key to the success of the Heart of Borneo project. Careful addressing of the value of all ecosystems was effective in changing policymaker views on land use in Borneo to include more sustainable practices.
OUTLOOK	ESA is launching more demonstration trials including forest studies in Vietnam, Indonesia and Peru, and coastal studies in Australia and Yucatan. The aim of these activities is to derive the economic value of the specific ecosystems addressed in each area for a selected group of users whose natural resources are threatened by industrialisation and bad land use management.

↑ Water yield and water supply intakes for Kalimantan, Indonesia, using land cover information, slope and elevation data from satellites

↓ Projected nitrogen export associated with business as usual for 2020, Kalimantan, Indonesia (Hatfield Consultants)



All these activities aim to demonstrate the value of Earth observation to support targeted international development programmes.

Case Study 5

→ ECOSYSTEMS CHARACTERISATION FOR EEA

Agricultural landscape of Łęczyca, Poland, classified with the purpose of finding small hedges, bio-corridors and natural fences for example that protect biodiversity (GISAT)

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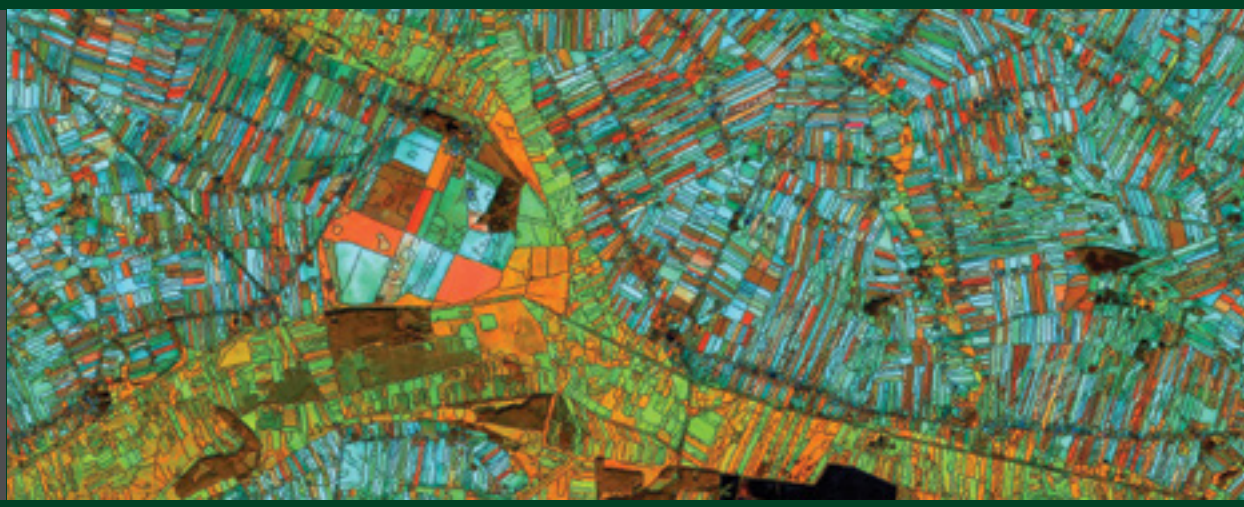

WHY	Small linear landscape features serve as natural habitats or bio-corridors and provide provisioning (genetic, wood), regulating (climate, soil erosion protection, water purification) and cultural (landscape character) ecosystem services.
WHAT	A ESA project carried out by Geoville and GISAT assessed the ability of Earth observation analysis techniques to support the European Environmental Agency (EEA) needs related to ecosystem mapping and assessment, land and ecosystem (capital) accounts, green infrastructures and regional environmental characterisation.
RESULTS	It is possible using high-resolution satellite data to map almost all linear features of relevance to the EEA.
OUTLOOK	EEA and ESA are looking into the possibility for expansion of the trials on a pan-European scale.

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Detailed mapping of high resolution land use and land cover is crucial to assess changes in ecosystems. This detailed satellite based map of building footprints and land cover types supports Water Resource Management and exposure mapping of urban infrastructure and agriculture along the Mekong River in Cambodia. (GeoVille for ESA/WorldBank; KARI (Korea Aerospace Research Institute)