Satellite Environmental Information and Development Aid: An Analysis of Longer-Term Prospects

Commissioned by the European Space Agency

Caribou Space | esa

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Introduction

Introduction

This report is an analysis of the longer-term prospects for expanding the use of satellite-based environmental information in Development Aid operations and activities.

The report has been commissioned by the European Space Agency (ESA), which is an intergovernmental organisation of 22-member states with a mission to 'shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world' (see **www.esa.int**).

The intended audience is; the European National Development Aid Agencies, International Financial Institutions (IFIs) and National Space Agencies.

The report consists of the following:

- An Executive Summary of the key points,
- Background information to set the context, summarise the current status of ESA's and other space agencies initiatives in promoting the use of satellite environmental information for Sustainable Development,
- An actual example of a similar high-technology sector being fully integrated into Development Aid operations & financing; a case study on mobile telecommunications,
- A brief summary of the current changes taking place in both Sustainable Development and satellite environmental information,
- A description of the benefits of satellite environmental information for Development Aid,
- The longer-term strategic vision, including the barriers to be addressed in achieving this vision and a description of the primary activities to be carried out,
- Initial options on how these activities might be financed and an identification of some issues related to their implementation.

In addition, the report contains supplementary information in several Annexes in support of the main arguments, as follows:

- An Annex of the export market opportunity in developing countries for the European EO information services sector,
- An Annex of the benefits of satellite environmental information specifically for Environmental Safeguard Systems (ESS),
- An Annex of other ESA initiatives in relation to the Sustainable Development Goals (SDGs) and the implementation of some Global Environmental Conventions.

Whilst there are benefits arising from other aspects of space capabilities to the field of Development Aid (e.g. satellite communications (SatComms), global navigation satellite system (GNSS), space weather/ meteorology), this report does not analyse these aspects. It focuses entirely on the capabilities offered by satellites in delivering a wide range of information for the monitoring of the Earth's environment in the context of Sustainable Development.

Executive Summary

Executive Summary

This report is an analysis of the longer-term prospects for expanding the use of satellite-based environmental information in Development Aid operations and activities, commissioned by the European Space Agency (ESA). The main findings are:

— *Satellite Environmental Information in the Context of Sustainable Development*

- Satellite environmental information is global, comprehensive, accurate, repeatable and timely,
- Satellites can produce a wide range of key environmental information that is of significant value to Sustainable Development,
- Substantial initiatives are in progress to demonstrate the value of satellite environmental information for Sustainable Development within Europe (ESA, UK Space Agency, Netherlands Space Office, DG-DEVCO) and outside Europe (NASA, JAXA, CEOS, GEO).
- Work to date has focused on engaging the International Financial Institutions (e.g. World Bank, ADB, IFAD) and user organisations in developing countries. Dialogue with the European National Development Aid Agencies is beginning at European level,
- It is widely recognised that there is significant potential for the large-scale use of satellite capabilities in the field of Development Aid.

— *An Example of Integrating High Technology into Development Aid: Mobile Telecommunications*

- The mobile industry successfully integrated mobile technology within Development Aid,
- The GSMA's Mobile for Development department was influential in this evolution and was provided with over £50 million of funding from 10 National Development Aid Agencies and Private Foundations,
- This took ~10 years to achieve the change in behaviour required in both the aid and mobile sectors,
- GSMA had to convince these donors of the 'case for mobile in development' by communicating impact and cost-effectiveness of mobile technology in development,
- GSMA is the mobile industry trade association and not an obvious host for a development initiative. However, the technical understanding, relationships to industry and governments, and ability to collaborate across industry all located in one organisation were recognised as unique and valuable capabilities by donors themselves.

— *Sustainable Development in Evolution*

- The UN 2030 Agenda and the Sustainable Development Goals (SDGs) provide a globally agreed set of development priorities and targets to 2030,
- Accurate, global and timely data is critical to tracking progress towards the achievement of the SDG targets and indicators,
- Development Aid is provided for the economic development and welfare of developing countries and the majority is classed as Official Development Assistance (ODA),
- There is increasing emphasis on addressing environmental issues in developing countries in the National Development Aid Agencies and International Finance Institutions.

— *Step-change in Satellite Environmental Information*

- Europe's Copernicus programme is a game-changer in providing unprecedented volumes of free satellite environmental data,

- ESA and the European Commission have invested over €250 million over the past decade for the research & development of a wide variety of satellite environmental information products and services, with the European EO information services sector now having world-leading capabilities,
- These combined capabilities (Copernicus space system, the European EO information services sector) are currently in place and are ready to be leveraged further for the environmental issues facing international Development Aid,
- Space 4.0 is a new era happening now in which there is the increased number of diverse space actors around the world, including the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction. It represents new opportunities for the use of space technologies.

— *Benefits of Satellite Environmental Information for the Development Aid Sector*

- The primary benefits that satellite environmental information brings to the Development Aid sector can be categorised in four areas of activities:
  - Increased efficiency of existing operations and activities, leading to increased impact,
  - Improved policy definition and planning of future activities,
  - New and extended capabilities,
  - Improved transparency, responsibility and accountability.
- Most existing examples of benefits are associated with the first category (1), but there are a growing number in the other three categories (2,3,4),
- As a starting point, a 1-2% investment in procurement and use of satellite environmental information in development will lead to increased efficiencies for Development Aid operations and activities (some quantitative results are emerging for on-going projects), with probably more benefit achieved if fully incorporated into policy-making and planning,
- The benefits of satellite environmental information are real, manifest, growing in number, but the value-proposition (benefits vs. cost) of the use needs to be further consolidated, convincingly argued and presented. There is an opportunity to do this via the OECD Space Forum.

— *Evidence of Uptake of Satellite Environmental Information in Development Aid*

- European National Development Aid Agencies and IFIs are increasing their interest and usage of satellite environmental information through the use of their own resources,
- The World Bank is the IFI that has the highest value of projects with specific financial amounts for satellite imagery and services,
- The majority of IFI projects including satellite imagery and services are located in Asia and Africa,
- If satellite environmental information were systematically used in all IFI development projects at the level of 1-2% of the project financial resources, this may represent a significant economic volume of ~€200–300 million per year for this source of information.

— *Strategic Vision and Activities*

- The strategic vision is to 'transfer and mainstream satellite environmental information into Development Aid operations, activities & financing',
- The barriers to achieving this vision include lack of awareness, acceptance and adoption in the Development Aid community (IFIs, National Development Aid Agencies, Private Foundations and Client States),
- Overcoming these barriers will require a sustained programme of effort and resources; therefore, a dedicated programme of work be initiated by ESA is proposed, referred to as 'Space for International Development Aid' (Space4IDA),
- This programme is designed from the outset to achieve sustainable transfer and systematic use of satellite environmental information, and should be implemented in partnership with the Development Aid stakeholders,
- The three suggested primary activities are:
  - Activity 1: Risk-Reduction Developments
  - Activity 2: Capacity Building for IFIs, National Development Aid Agencies, Private Foundations and Client States
  - Activity 3: Skills/Knowledge Transfer to Developing Countries

— *Options for Programme Financing*

- The overall envelope for the integration and of satellite environmental information into Development Aid is proposed on the order of €120–200 million and for a timescale of 2020–25, with the bulk of the financing (€100-150 million) coming from Development Aid financing, and a small R&D component from ESA Member States (€20–50 million),
- Two options are foreseen for handling the Development Aid financing as follows;
  - Option 1 is for ESA to receive the Development Aid directly and implement Space4IDA activities as a single ESA programme with the Development Aid community,
  - Option 2 is for one or more IFIs to set up a Trust Fund for receipt of Development Aid and implement Space4IDA activities in a joint programme of work between ESA and Development Aid community,
- Both options have advantages and disadvantages for consideration.

— *Implementation Topics*

- Space for International Development Aid (Space4IDA) will ensure long term sustainability and reduce dependence on Development Aid in the future by focusing heavily on capacity building and skills/knowledge transfer activities,
- Compliance to ODA requirements will be managed by either the IFIs or ESA depending on the selected programmatic structure,
- The Space4IDA programme will require a robust monitoring and evaluation (results reporting) framework to measure and communicate progress against its primary and secondary aims,
- The Space4IDA programme will generate a reference portfolio of results, lessons and best practice that can be shared across the Development Aid Community. Communications activities will ensure that these organisations learn from the programme, and each other, to replicate best practice.

— *Conclusions*

The Development Aid community, by nature of the development activities carried out (many of which are large-scale infrastructure projects), have an evident and manifest need for coherent, consistent, accurate and varied environmental information (both current & historical).

There is a growing public & political pressure to demonstrate that the development investments being made for economic growth are also environmentally sustainable (i.e. 'Green Growth'). Achieving the target of Green Growth requires a detailed understanding of the state of the Earth's environment; what is happening now, where has it come from, and what is going to be the likely evolution in the future.

It is in this context, that satellite environmental information plays a key role. The international Development Aid sector represents an opportunity to realise the full value (scientific, societal, economic) of the world-leading space missions and satellite environmental information expertise already available in Europe.

These factors—in combination with the step-change in satellite environmental information, the huge developments in computing and data science, and proven benefits for Development Aid—highlight that now is the time for the space industry to accelerate the achievement of the 2030 Agenda on Sustainable Development.

Background

Background: Satellite Environmental Information in the Context of Sustainable Development

Key Points

- Satellite environmental information is global, comprehensive, accurate, repeatable and timely,
- Satellites can produce a wide range of key environmental information that is of significant value to Sustainable Development,
- Substantial initiatives are in progress to demonstrate the value of satellite environmental information for Sustainable Development within Europe (ESA, UK Space Agency, Netherlands Space Office, DG-DEVCO) and outside Europe (NASA, JAXA, CEOS, GEO),
- Work to date has focused on engaging the IFIs (e.g. World Bank, ADB, IFAD) and user organisations in developing countries. Dialogue with the European National Development Aid Agencies is beginning at European level,
- It is widely recognised that there is significant potential for the large-scale use of satellite capabilities in the field of Development Aid.

This chapter provides a brief overview of the role of satellite environmental information in Sustainable Development and a summary of some of the main initiatives being carried out by space agencies within Europe and beyond.

'Earth observation (EO) is the gathering of information about the physical, chemical, and biological systems of the planet via remote-sensing technologies'[1], and in this report the term is used interchangeably with the term 'satellite environmental information'. EO satellites carry a wide range of instruments for land, ocean and atmospheric monitoring. As of 2016 there were over 400 EO satellites in orbit, and at least 400 more are expected to be launched by 2025[2], providing a profusion of satellite environmental information at varying spectral[3], temporal[4] and spatial[5] resolution.

Satellite environmental information is global, comprehensive, accurate, repeatable and timely. Satellites provide consistent, repeatable, objective data that can be processed by software to extract insight and information that can be used for decision-making and planning. Satellites are a non-intrusive technology, and sometimes the only feasible method of collecting information especially for very remote or difficult to access regions (e.g. conflict areas) without the need for ground teams and ground infrastructure.

The basic assertion is that satellites can produce a wide range of key (sometimes unique) environmental information that is of significant value (i.e. delivers measurable benefit) to many of the challenges involved in the broader domain of Sustainable Development. These include: dealing with the complex issues of climate change, rapid urbanisation, threats to food security, natural resources depletion (including water and forests), and the risk of natural disasters (including the increasing frequency and severity of extreme weather events).

Addressing these challenges requires a detailed understanding of the state of the Earth's environment; what is happening now, where has it come from, and what is going to be the likely evolution in the future. It is in this context, that information about the environment from Earth Observation (EO) satellites

1 Wikipedia. 'Earth Observation'. https://en.wikipedia.org/wiki/Earth_observation. Accessed July 2018.

2 UK Parliament. 'Environmental Earth Observation'. https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0566. Accessed August 2018.

3 Spectral resolution refers to the number of colours or discrete spectral samples that are recorded for each image pixel. Typically, the presence of more spectral wavebands increases the ability of the imagery to discriminate between different features e.g. land cover.

4 Temporal resolution is related to the repeat frequency with which a satellite system can acquire images of the same location.

5 Spatial resolution refers to the pixel size of an image. The higher the spatial resolution, the greater the ability to identify and 'see' more detail in an image.

can play a key role.

Specific examples of the types of satellites environmental information and the associated benefits in achieving Sustainable Development are given later in section 7. This chapter summarises some of the main initiatives in demonstrating the use of satellite environmental information that have been carried out so far.

ESA Initiatives

Within the Directorate of Earth Observation Programmes (EOP), since around 2010 ESA has sought to demonstrate the benefits (both quantitative & qualitative) that satellite-based (or Earth Observation; EO) environmental information can deliver for the specific case of Development Aid projects and operations. Many of these projects are large infrastructure investments, financed through loans that come with several reporting obligations of their impact (environmental, social, financial).

As a European organisation, ESA has focused on the promotion of European EO capabilities. Europe is in a world-leading position in terms of EO capabilities, which includes both space assets (ESA, EU Copernicus, EUMETSAT, and National missions), and the downstream EO information services sector (companies and institutional suppliers).

The primary focus of ESA in terms of users (as agreed with ESA Member States through the Earth Observation Programme Board – PB-EO) was to address the IFIs, or Multi-Lateral Development Banks (IFIs/MDBs) and their Client States. As such, the European National Development Aid Agencies have not been involved as yet in any significant manner in ESA activities.

This EOP initiative and the associated activities are branded as **Earth Observation for Sustainable Development** (EO4SD). The main achievements (to date) of the EO4SD initiative are given below.

EO4SD Phase-0 (2010 to 2015, €8 million): This initial phase (Phase-0) of EO4SD identified, defined and completed some 65+ small-scale demonstrations of the use of EO in the implementation of a wide range of Development Aid projects. These were implemented with the World Bank[6], Asian Development Bank (ADB)[7], the International Fund for Agricultural Development (IFAD)[8], and the European Investment Bank (EIB)[9]. The scope was to provide limited-scale, initial examples of satellite environmental information that best highlighted European EO capability.

The broader geo-information requirements for each specific project were identified and agreed in discussions between ESA and the projects Technical Team Leaders (TTLs), and then used as a basis to solicit proposals from the European specialised information service companies (normally ex-university SMEs) to produce & deliver the customised information to the IFI teams and users in the Client States. The very best proposals were then selected by ESA (in open competition) for implementation.

ESA's involvement and contribution was both technical (translating the broad geo-information requirements into technical specifications of what satellites can deliver), and also financial (in covering the cost of producing the required information, which was typically of the order of €100K for each small-scale demonstration).

The users of this satellite environmental information (both the IFI teams and the Client States) undertook to provide feedback as to the impact and benefits delivered by this technology in the context of the individual projects. Examples of these benefits are further described in section 7 of this report. The full results of all 65+ demonstrations can be found at **http://www.vae.esa.int/page_documents.php**.

The main purpose of this initial Phase-0 was to raise awareness of the unique capabilities of a very wide range of satellite environmental information within Sustainable Development. In this respect, these initial experiences have raised interest within the IFIs to explore a longer-term, more strategic approach to the integration of satellite environmental information in their activities. It has also led to an initial level of procurement of satellite environmental information by the World Bank, ADB, IFAD and the Global Environment Facility (GEF) using their own financial resources.

As examples of this longer-term interest, both the World Bank (in Dec 2015) and ADB (in Nov 2016) have signed strategic, 5-year Memorandums of Intent (MoIs) with ESA to collaborate more closely in ten

6 Climate and disaster resilience, maritime/fishing, water and sanitation, land-use, urban planning, and health.

7 Rural development, urban development, climate and disaster resilience, transportation and renewable energy.

8 Land use, agriculture and forestry.

9 Agriculture, land management and water resources management.

priority thematic areas: Urban Development, Marine Resources & Coastal Environment, Agriculture & Rural Development, Disaster Risk Reduction, Water Resources Management, Forest Management, Energy & Extractives, Ecosystems Services, Fragile & Conflict States, and Climate Resilience & Proofing.
These MoIs have formed the basis of the subsequent period of EO4SD activity (Phase-1) as described below.

EO4SD Phase-1 (2016–2023, €25 million): The Phase-1 work scales-up the level of activity by carrying out larger, regional demonstrations in 2-3 key regions around the world (one in Americas, Africa, Asia/Pacific), and 2-3 countries in each region.

The overall objective is to start the integration of satellite information products & services, as 'best-practice' environmental information, in the planning and implementation of the development projects, programmes and activities of the IFIs, together with their respective Client States.

These larger demonstrations are targeted to each of the nine thematic development domains identified in the MoIs with World Bank & ADB and are being driven by the requirements of World Bank flagship programmes and projects in these domains.

As part of these MoIs, and in order to facilitate the ESA collaboration, both World Bank and ADB agreed to host a resident technical expert from ESA at their HQs in Washington DC and Manila.

An important element of this new phase of activity is the increased resources available for building technical capacity within the government agencies of the countries involved (Client States), such that the environmental information derived from satellites can be effectively used in the local operations with a view to their long-term, sustainable usage.

Each of the activities are being carried over out a three-year period by leading consortiums from the European EO information services sector (selected by open competition), via contracts each of €2–2.5 million, under the technical management of ESA, and executed in a series of separate batches as follows:

- 2016–19: Agriculture and Rural Development, Urban Development, Water Resources Management,
- 2018–20: Disaster Risk Reduction, Fragile & Conflict States, Climate Resilience & Proofing, Marine Resources & Coastal Environment,
- 2020–23: Forest Management, Ecosystems Services.

To give an indication of the scale & scope of these demonstrations, the geographic coverage of the first batch of on-going activities in Agriculture, Urban & Water as per Figure 1.

The main outputs of this phase of work will be a set of detailed information to give complete, clear and convincing answers to the following questions:

- What satellite environmental information is most needed and how can it be used in Development Aid

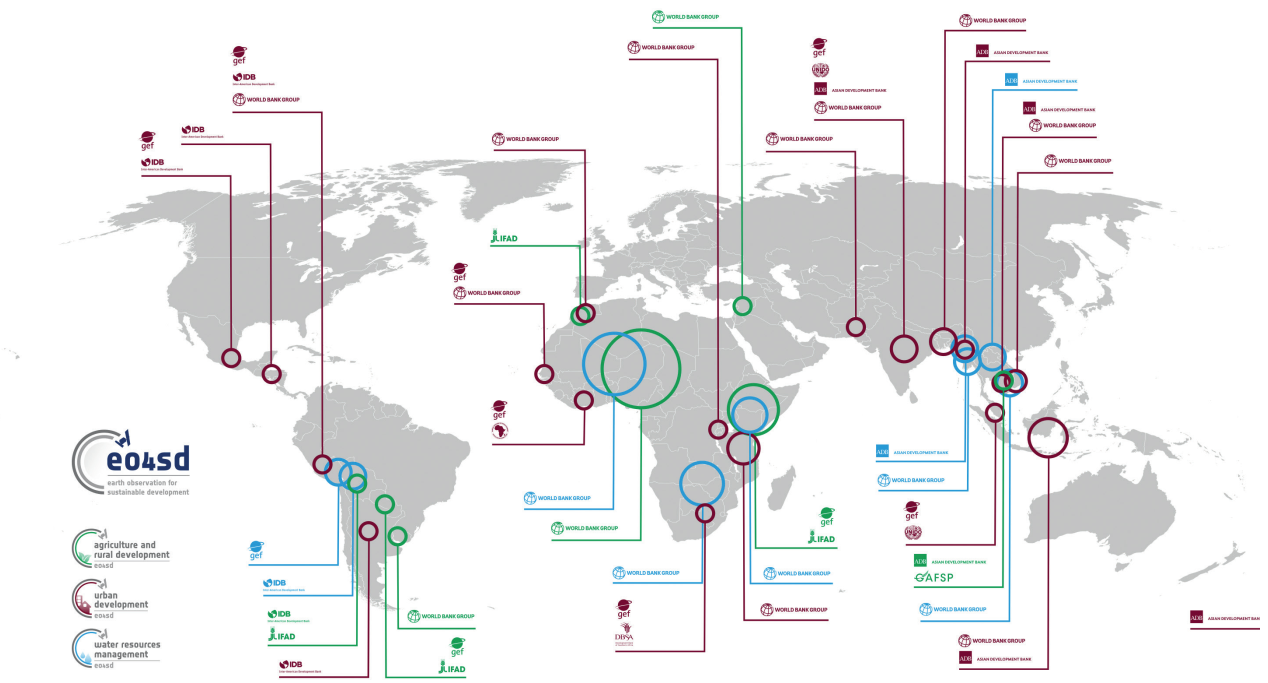


FIGURE 1: Geographic Distributions for the Areas of Interest (AOIs) Addressed in the On-going ESA Activities in Urban Development, Water Resources Management, and Agriculture & Rural Development

activities and working practices?

- What benefits does this information deliver to the Development Aid stakeholders (e.g. IFIs and their Client States), and do these benefits justify the costs?
- How can the use of this satellite environmental information be established on a long-term, sustainable basis?

As such, this information is being used in shaping the future activities required (and described later in this document) for the long-term sustainable use of satellite environmental information to support international Development Aid.

Other Space Agency Initiatives

Over the last decade, a number of National Space Agencies have started initiatives to demonstrate the capabilities and use of satellite environmental information in Sustainable Development with varied stakeholders. These include the IFIs, National Development Aid Agencies, and a range of local government organisations in the developing countries as aid recipients. A few examples of the key initiatives are given below.

— *Within Europe*

UK Space Agency's International Partnership Programme (IPP) is a £152 million programme (2016-2021) that uses the UK space sector's research and innovation strengths to deliver a sustainable, economic or societal benefit to under-developed nations and developing economies. There are currently 33 projects addressing deforestation and land-use, agriculture, climate & disaster resilience, maritime/fishing, education, health and also, urban, infrastructure & industry.

The projects are in partnership with 112 government ministries, research institutes/academia, NGOs and private sector across 30 countries, and are delivered by 122 organisations from the space industry leading to growth opportunities for the UK space sector.

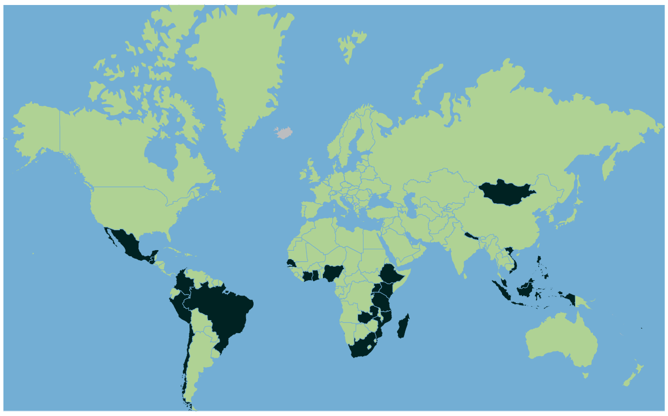


FIGURE 2: IPP Project Locations

Netherlands Space Office Geo-data for Agriculture and Water (G4AW) Programme, is commissioned by the Dutch Ministry of Foreign Affairs with €100 million ODA funding. The G4AW Facility (2013 to 2020) has 17 projects, in 10 countries reaching 5-10 million farmers, with services that aim to increase income, boost agricultural productivity and/or improve climate resilience.

G4AW supports over 120 partners representing government ministries, private sector firms, academic institutions and non-governmental organisations (NGOs) from the Netherlands, the country of implementation and other countries. The projects support smallholder farmers with pests and disease warning, water use and drought warning, fertiliser advice, weather information and crop monitoring and weather-indexed insurance, across 10 crops including rice, coffee and potatoes.

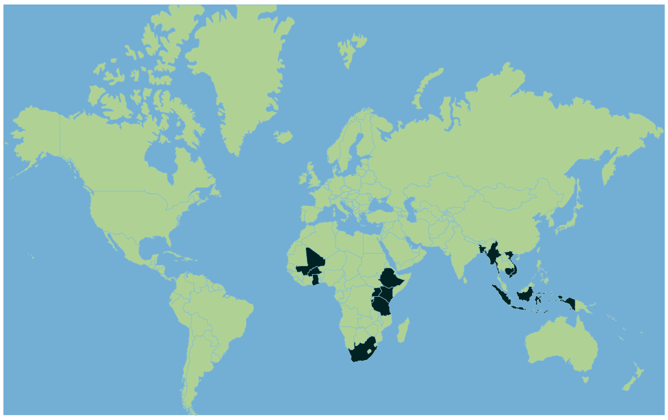


FIGURE 3: G4AW Project Locations[10]

Global Monitoring of the Environment & Security (GMES) and Africa Support Programme is a €30 million joint programme, started in 2017 and co-financed by the European Commission (DG-DEVCO) and the African Union Commission. It follows from the launch of GMES & Africa process in Lisbon, Portugal, on 7th December 2007 during the 2nd

10 Netherlands Space Office G4AW. 'G4AW projects'. https://G4AW.spaceoffice.nl/en/projects/G4AW-projects. Accessed August 2018.

EU-Africa Summit, and builds on previous EO programmes implemented in Africa since 2001.

FIGURE 4: GMES Newsletter

It will use and adapt the Copernicus Programme data and services to the African context. GMES & Africa's first phase consists of two main services; a natural & water resources service, and marine and coastal service, with components to address the global needs to manage the environment, mitigate climate change and ensure civil security. It is to enable the implementation of the African Space Policy and Strategy, formulated to harness the continent's capabilities in utilising space science and technology for economic growth and Sustainable Development.

In the implementation agreement, the African Union Commission (AUC) is the 'delegated authority' responsible for the management of the programme, through the Human Resource, Science and Technology (HRST) Department. ESA participates to the GMES & Africa Support Programme Policy Coordination and Advisory Committee (PCAC). The GMES & Africa programme is aimed at improving African policy-makers', planners', scientists', business and private sector and citizens' capacities to design, implement, and monitor national, regional and continental policies and to promote sustainable management of natural resources through the use of EO data and derived information. GMES & Africa introduced several key innovations: for the first time, with the inclusion of the North African countries, the programme is pan-African. It engages the African private sector and national and regional academia. In May 2018, the African Union Commission (AUC) officially awarded grants to thirteen successful consortia of institutions that will serve as Regional Implementing Centres for implementation of activities.

Outside Europe

Japan Aerospace Exploration Agency (JAXA) collaboration with ADB to implement a number of projects applying space technology and GIS since the 1990s.[11] In July 2010, ADB finalised a letter of intent with JAXA on disaster management, climate change mitigation and adaptation, forest monitoring, and water resource management using space technologies, mainly those involving remote sensing. The collaboration field was expanded to include agriculture and urban development in 2012.

NASA partnered with USAID on the SERVIR programme which 'Connects space to village' by helping developing countries use information provided by EO satellites and geospatial technologies to manage climate risks and land use. SERVIR has activities in more than 45 countries and counting, has already developed over 70 custom tools, collaborated with over 250 institutions, and trained more than 3,000 individuals, improving the capacity to develop local solutions.[12]

CEOS & GEO Initiatives

The Committee of Earth Observing Satellites (CEOS) established in 1984 consists of 32 Member Agencies (mainly National Space Agencies) and 28 Associate Member Agencies (varied technical, scientific & user organisations). The primary mission of CEOS is to ensure international coordination of civil space-based EO programmes and promote exchange of data to optimise societal benefit and inform decision making for securing a prosperous and sustainable future for humankind.
CEOS has a number of formal working groups and ad-hoc technical teams and initiatives addressing a wide range of EO domains; some of the most relevant to Sustainable Development are listed below.

The Global Forest Observations Initiative (GFOI) is implemented with GEO and national governments in support of REDD+ national forest monitoring systems. It aims to foster the sustained availability of observations for national forest monitoring systems, support governments that are establishing national systems (by providing a platform for coordinating observations, providing assistance and guidance on

11 ADB. 'Space Technology and Geographic Information Systems Applications in ADB Projects'. https://www.adb.org/sites/default/files/publication/148901/space-technology-and-gis-applications-adb-projects.pdf. Accessed August 2018.

12 NASA. 'SERVIR Overview'. https://www.nasa.gov/mission_pages/servir/overview.html. Accessed August 2018.

utilising observations, developing accepted methods and protocols, and promoting ongoing research and development), and work with national governments that report into international forest assessments, such as the national greenhouse gas inventories reporting to the UN Framework Convention on Climate Change (UNFCCC) using methods of the Intergovernmental Panel on Climate Change (IPCC).

The Africa Regional Data Cube (ARDC) is a new tool that harnesses the latest EO and satellite technology to help Kenya, Senegal, Sierra Leone, Ghana, and Tanzania address food security as well as issues relating to agriculture, deforestation, and water access. The Data Cube was developed by CEOS in partnership with the Group on Earth Observations, Amazon Web Services, Strathmore University in Kenya, Office of the Deputy President - Kenya, and the Global Partnership for Sustainable Development Data.[13]

The ARDC is based on Open Data Cube infrastructure, which seeks to increase the value and impact of global EO satellite data by providing an open and freely accessible exploitation. The Open Data Cube initiative is led by Australia's CSIRO, CEOS, USGS, Analytical Mechanics Associates, and the UK Satellite Applications Catapult.[14]

Committee on Earth Observation Satellites' (CEOS) Strategic Implementation Team (SIT), have in 2017 in the area of Development Aid, discussed the possibility of a coordinated, inter space agency approach toward the IFIs. The findings were summarised in a 1-page Statement on 'EO and Overseas Development Aid', endorsed at the 31st CEOS Plenary in October 2017 by all heads of the Member Agencies, in which the CEOS agencies underline their joint commitment to develop a coherent strategy and approach to promote and expand the use of EO in the domain of Development Aid (see: **http://ceos.org/meetings/31st-ceos-plenary/**).

CEOS have produced a 2018 Special Edition of the EO Handbook, 'Satellite Earth Observations in Support of the Sustainable Development Goals'. This is the 3rd thematic EO Handbook (preceded by the EO Handbooks on Disaster Risk Reduction and Climate). The 100-page Handbook promotes and showcases the contribution of Earth Observations to the realisation of the 2030 Agenda on Sustainable Development, its goals and targets, and to the SDG Global Indicator Framework, and was coordinated by ESA on behalf of the CEOS Ad Hoc Team on Sustainable Development Goals (SDGs).

Group on Earth Observations (GEO) is an intergovernmental organisation (more than 100 national governments and in excess of 100 Participating Organisations) working to improve the availability, access and use of EO for the benefit of society. GEO works to actively improve and coordinate global EO systems and promote broad, open data sharing. GEO's global priorities include supporting the UN 2030 Agenda for Sustainable Development, the Paris Climate Agreement, and the Sendai Framework for Disaster Risk Reduction.

In March 2017, GEO published a new report 'EO in support of the 2030 Sustainable Development Agenda' which highlights case studies of how EO responds to Sustainable Development, whether for health, disaster risk reduction or environmental protection.

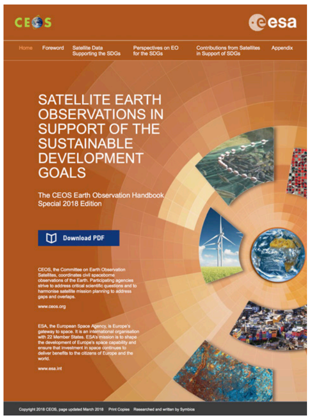


FIGURE 5: CEOS Publication

FIGURE 6: GEOS Publication

— *Recent Wider Discussion with European National Development Aid Agencies*

Several European National Development Aid Agencies are also actively investigating the use of satellite environmental information to support their operational activities; examples include the Agence Française de Développement (AFD) in France, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in Germany, the Department for International Development (DFID) in UK, the Swedish International Development Cooperation Agency (SIDA) and the Swiss Agency for Development and Cooperation (SDC).

13 Global Partnership for Sustainable Development Data. 'Africa Regional Data Cube'. http://www.data4sdgs.org/initiatives/africa-regional-data-cube. Accessed August 2018.

14 Open Data Cube. 'Partner Projects'. https://www.opendatacube.org/projects. Accessed August 2018.

In mid-2017, ESA was approached separately by both AFD and GIZ who were interested to learn more about the experiences that ESA had had with the IFIs on the use of satellite environmental information. After a few initial exchanges and recognising the growing interest in the Development Aid community, ESA took the initiative to widen the discussion with those interested European National Development Aid Agencies, together with representatives from the National Space Agencies/government departments, the OECD and DG-DEVCO.

A first exploratory meeting with European National Development Aid Agencies was organised and hosted at ESA's centre for Earth Observation, ESRIN located in Frascati, Rome (Italy) on 16th January 2018. More than 20 participants from various organisations attended (i.e. National and EU Development Aid Agencies, National Space Agencies, Embassies), with representation from United Kingdom, Germany, France, Italy, Netherlands, Sweden, Norway, Switzerland and Luxembourg.

The purpose of that meeting was to open dialogue at European level, to take stock of the current opportunities, share information and experiences, and collectively identify the key issues and actions needed to grow the use of satellite environmental information in the Development Aid sector, in the longer-term.

Good, first suggestions were provided by all participants in the open discussion sessions regarding the possible scope and content of any future ESA activities, including what should and should not be addressed. Detailed further information in this respect is available at '**ESA Opening a Dialogue with National Aid Agencies**' and '**Satellite Environmental Information in support of Development Aid Activities in European Aid Agencies**'.

To summarise, this first meeting concluded with the following main outcomes and next steps:

- It was confirmed through the material presented that there is significant potential for the wide-scale use of satellite capabilities in the field of Development Aid,
- In the **shorter-term,** ESA are now initiating new actions to develop an interactive web-based environment where Development Aid actors can access introductory satellite environmental information guides, data sets, analysis & visualisation tools, and perhaps hosted processing. The content will be customised to the language and practices of the Development Aid domain. ESA are finalising the requirements in discussions with some interested National Development Aid Agencies to shape those developments that should begin in early 2019,
- In the **longer-term**, ESA will continue to develop proposals for future activities, considering the suggestions and comments, both in this initial meeting and in future dialogue with the Development Aid community.
- In this respect, ESA is organising a wider, structured consultation on the use of satellites in Development Aid at a European-level workshop involving more Member States and actors to be held at ESRIN, and now scheduled for 11th and 12th September 2018, to which this document is commissioned as input for discussion

Integrating High Technology into Development Aid

An Example of Integrating High Technology into Development Aid: Mobile Telecommunications

Key Points

- The mobile industry successfully integrated mobile technology within Development Aid,
- The GSMA's Mobile for Development department was influential in this evolution and was provided with over £50 million of funding from 10 National Development Aid Agencies and Private Foundations,
- This took over ~10 years to achieve the change in behaviour required in both the aid and mobile sectors,
- GSMA had to convince these donors of the 'case for mobile in development' by communicating impact and cost-effectiveness of mobile technology in development,
- GSMA is the mobile industry trade association and not an obvious host for a development initiative. However, the technical understanding, relationships to industry and governments, and ability to collaborate across industry all located in one organisation were recognised as unique and valuable capabilities by the donors themselves.

This chapter provides a case study of how the mobile telecoms industry successfully integrated mobile telecoms technology into Development Aid. It provides an overview of the important role of GSMA Mobile for Development within this evolution, the leadership team of which are now Caribou Space. It is an analogous initiative to EO4SD's ambitions to integrate satellite technology into Development Aid efforts and there are many parallels and implications for EO4SD.

History

Developing countries launched basic mobile networks for voice and SMS in the 1990s. Awareness of the social impact of mobile was limited and most of the Development Aid community did not have investments in the mobile industry. In the developing world, by 2005 there were 825 million subscribers,[15] compared to ~4 billion today,[16] and the lowest cost handset was US$100.

GSMA, the global mobile industry association, identified that affordable mobile technology was the main barrier to its use in the developing world. GSMA's low-cost handset competition in 2007 drove the cost per handset from US$100 to less than US$30. The winner, Motorola, provided GSMA with some of the proceeds from the millions of handset sales to establish the Mobile for Development department (M4D).[17] M4D is now a ~90FTE dedicated team,[18] working with the mobile industry, development community and governments, to drive innovation in financial services, health, agriculture, digital identity, energy, water, sanitation, disaster resilience and gender equality, across 49 countries impacting 30 million people.

As mobile technology became widespread in developing countries, and awareness of the positive impact of mobile increased, the donors provided GSMA additional funding. GSMA setup the GSMA Foundation[19] to simplify the receipt of Development Aid and to ensure adequate governance, financial, legal & operational processes, and robust M&E. The department leveraged GSMA's institutional budget with over £50 million of donor funding since 2008, from International Finance Corporation (World Bank Group), UK DFID, USAID, Australian Aid

15 Will Croft (Caribou Digital, previously GSMA Intelligence). Personal Communication. July 2018.
16 GSMA Intelligence.
17 GSMA. 'Mobile for Development'. https://www.gsma.com/mobilefordevelopment/. Accessed January 2018.
18 GSMA. 'Meet the Mobile for Development Team'. https://www.gsma.com/mobilefordevelopment/meet-the-team/. Accessed January 2018.
19 GSMA. 'GSMA Foundation'. https://www.gsma.com/aboutus/foundation/. Accessed July 2018.

(DFAT), Norway's NORAD, Bill and Melinda Gates Foundation, Rockefeller Foundation, MasterCard Foundation, Omidyar Network, and Cherie Blair Foundation.

Today

Mobile phones are the most popular and widespread personal technology on the planet, with 5.1 billion mobile subscribers globally and 4 billion in the developing world.[20]

1,400 mobile operators have launched 4,400 networks globally with most countries having many competing mobile operators. Many developing world mobile operators were launched or acquired by European 'group' companies. Mobile operators now have extensive development activities such as the Vodafone Foundation,[21] Orange for Development,[22] Telefonica[23] and Telecom Italia.[24] Operators have allowed start-ups to build on top of their networks, thus becoming a technology platform on top of which a plethora of entrepreneurs can innovate and launch new services.

The Development Aid community have staffed teams responsible for embedding mobile technology in their programmes, such as DFID's Emerging Policy, Innovation and Capability department[25], USAID's Global Development Lab[26] and Australian Aid's innovationXchange.[27] Donors co-funded the launch of new organisations focused on mobile technology including Digital Impact Alliance[28] and the Alliance for Affordable Internet.[29]

Donors have integrated mobile technology into their development projects to make them more effective, so improving their internal processes and practices, and improving transparency and accountability, as exemplified by DFID's Digital Strategy 2018 to 2020.[30]

The mobile industry has used the technology to address development challenges in adjacent sectors such as access to financial services. In 2007 there were only seven mobile money services but by 2016 there were 277 with ~690 million registered accounts.[31] Digital entrepreneurship ecosystems including Silicon Cape[32] (Cape Town) and Silicon Savannah[33] (Nairobi), have emerged with local start-ups launching mobile websites and applications addressing local needs, supported by a plethora of financiers including donors, social investors, venture capital, private equity and banks.

ICT education in schools and universities has improved digital skills, and 'technology incubators/hubs', like iHub in Nairobi,[34] support peer learning. These technology incubators provide training curriculums, networking, mentors and community – there are over 1,000 in Asia and Africa.[35] Mobile technology became easier to use through software environments, platforms, tools and cloud hosting, allowing persons with a wider range of expertise to develop solutions to local challenges.

Over the course of ~10 years, mobile technology went from being expensive and rare in developing countries, to being prolific and globally integrated into Development Aid.

20 GSMA Intelligence. https://www.gsmaintelligence.com/. Accessed July 2018.
21 Vodafone. 'Vodafone Foundation'. http://www.vodafone.com/content/foundation.html. Accessed July 2018.
22 Orange. 'Orange for development'. https://www.orange.com/en/Footer/Thematic-features/2014/for-open-innovation-with-a-big-societal-impact/open-innovation/Orange-for-development. Accessed July 2018.
23 Telefonica. 'The Sustainable Development Goals'. https://www.telefonica.com/en/web/responsible-business/sdg. Accessed July 2018.
24 Telecom Italia. '2016 Sustainability Report'. http://csv2016.telecomitalia.com/en#we-think. Accessed July 2018.
25 DFID. 'Operational plan 2011-2016 Emerging Policy, Innovation, Capability (EPIC)'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/389493/Operational_Plan_Emerging_Policy_Innovation_Capability.pdf. Accessed July 2018.
26 USAID. 'About The US Global Development Lab'. https://www.usaid.gov/GlobalDevLab/about. Accessed July 2018.
27 Australian Aid. 'Innovation XChange'. https://ixc.dfat.gov.au/. Accessed July 2018.
28 DIAL. https://digitalimpactalliance.org/. Accessed July 2018.
29 Alliance for Affordable Internet. http://a4ai.org/. Accessed July 2018.
30 DFID. 'DFID Digital Strategy 2018 to 2020: Doing Development in a Digital World'. https://www.gov.uk/government/publications/dfid-digital-strategy-2018-to-2020-doing-development-in-a-digital-world. Accessed July 2018.
31 GSMA. '2017 State of the Industry Report on Mobile Money'. https://www.gsma.com/mobilefordevelopment/sotir/. Accessed January 2018.
32 Silicon Cape Initiative. https://www.siliconcape.com/. Accessed July 2018.
33 TechCrunch. 'The Rise Of Silicon Savannah And Africa's Tech Movement'. https://techcrunch.com/2015/07/23/the-rise-of-silicon-savannah-and-africas-tech-movement/. Accessed July 2018.
34 iHub. 'Hello, We are iHub'. https://ihub.co.ke/. Accessed January 2018.
35 GSMA. '1000 Tech Hubs are Powering Ecosystems in Asia Pacific and Africa'. https://www.gsma.com/mobilefordevelopment/programme/ecosystem-accelerator/1000-tech-hubs-are-powering-ecosystems-in-asia-pacific-and-africa/. Accessed July 2018.

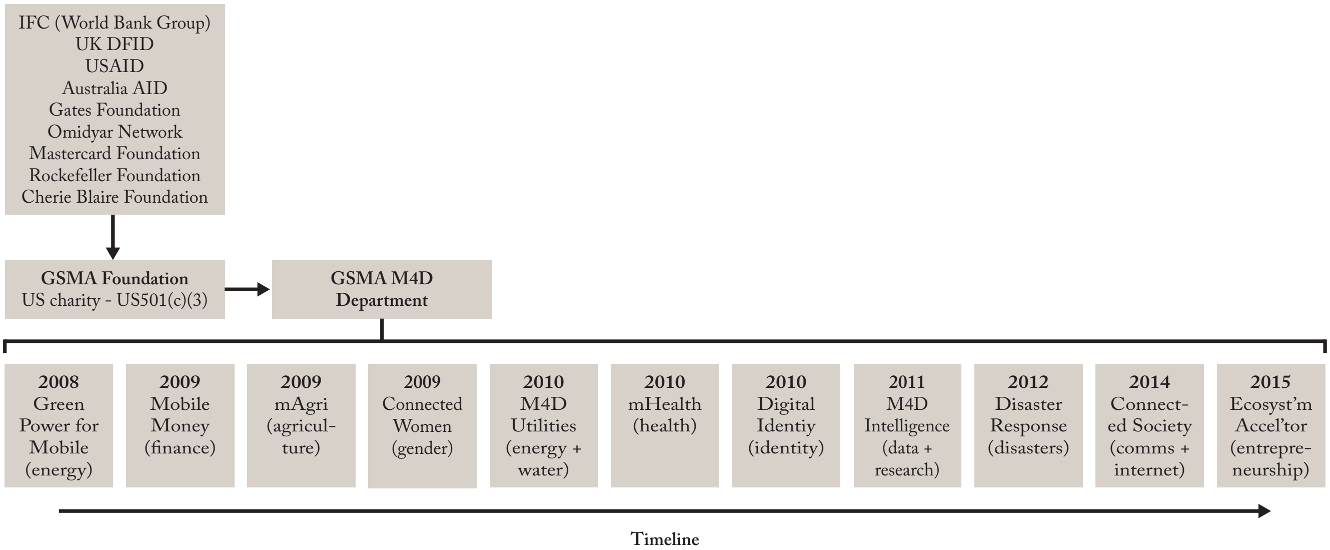


FIGURE 7: GSMA Mobile for Development Programmes and Donors

Parallels and Implications for EO4SD

- Shifting the behaviour of both the Development Aid and mobile sector to utilise mobile technology for development benefits took over 10 years significant and resources. ESA is in a similar scenario seeking to integrate satellite environmental information into Sustainable Development.
- GSMA represents many of the world's largest companies and is not an obvious host for a major initiative focused on development. However, the deep technical understanding of the technology, the relationships to industry members and governments, and the ability to steer cross-industry collaboration were identified as unique capabilities by the donors. ESA is in a similar scenario as the organisation that represents the European space sector.
- GSMA significantly leveraged the institutional budget with substantial funding from a range of donors including IFIs, National Development Aid Agencies and Private Foundations. ESA should utilise Member State ESA subscriptions to ensure a stable foundation for EO4SD against which Development Aid can be leveraged.
- Initially GSMA M4D had to convince donors of the 'case for mobile in development' by measuring and communicating the impact and cost-effectiveness of mobile to address development challenges. The same awareness building is required for donors on the benefits of satellite environmental information.

As a cautionary note the mobile industry is different to the space industry, so whilst this case study is informative, it is not directly analogous. Satellite environmental information is currently complex technology to use compared to mobile, the total scale of the industry is smaller at US$260 billion global satellite industry revenue[36] versus US$1.05 trillion mobile operator revenues.[37]

Satellite environmental information has advantages though, as there is less country level regulation than the mobile sector, and by nature there is global uniform coverage.

36 Satellite Industry Association. http://www.infoespacial.com/archivo/files/SIA-SSIR-2017_full-1.pdf. Accessed July 2018.
37 GSMA. 'The Mobile Economy 2018'. https://www.gsma.com/mobileeconomy/wp-content/uploads/2018/02/The-Mobile-Economy-Global-2018.pdf. Accessed July 2018.

Sustainable Development in Evolution

Sustainable Development in Evolution

Key Points

- The UN 2030 Agenda and the Sustainable Development Goals (SDGs) provide a globally agreed set of development priorities and targets to 2030,
- Accurate, global and timely data is critical to tracking progress towards the achievement of the SDG targets and indicators,
- Development Aid is provided for the economic development and welfare of developing countries and the majority is classed as Official Development Assistance (ODA),
- There is increasing emphasis on addressing environmental issues in developing countries in National Development Aid Agencies and IFIs.

This chapter introduces the background and evolution of Sustainable Development and the role of Development Aid.

Sustainable Development

Sustainable Development is 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'.[38] This definition and the modern concept of Sustainable Development is derived mostly from the landmark report in 1987, 'Our Common Future' by the Brundtland Commission (formerly World Commission on Environment and Development).[39]

The concept of Sustainable Development formed the basis of the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992.[40] The summit was attended by 178 governments and marked the first international attempt to draw up action plans and strategies for moving towards a more sustainable pattern of development.

In a similar vein, the OECD definition of Green Growth is, 'fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.'[41] There are now 46 countries adhering to the OECD 'Declaration of Green Growth'[42] and an OECD-published Green Growth Strategy which sets out a vision for economic recovery alongside environmentally and socially sustainable economic growth.'[43]

2030 Agenda on Sustainable Development

The international community recently engaged in an ambitious universal agenda on Sustainable Development with the aim to end poverty, promote prosperity and people's well-being, whilst protecting the environment.

'Climate change presents the single biggest threat to development, and its widespread, unprecedented impacts disproportionately burden the poorest and most vulnerable.'[44] The Paris Agreement on Climate Change, which came into force in 2016, has a central aim to strengthen the global response to the threat of climate change by keeping a global temperature

38 World Commission on Environment and Development: Our Common Future'. http://www.un-documents.net/our-common-future.pdf. Accessed July 2018.

39 Same as above.

40 United Nations. 'United Nations Conference on Environment and Development (UNCED), Earth Summit'. https://sustainabledevelopment.un.org/milestones/unced. Accessed August 2018.

41 OECD. 'Green Growth'. http://www.oecd.org/greengrowth/. Accessed August 2018.

42 OECD. 'Declaration on Green Growth'. http://www.oecd.org/env/44077822.pdf. Accessed August 2018.

43 OECD. 'Towards Green Growth'. http://www.oecd.org/greengrowth/towards-green-growth-9789264111318-en.htm. Accessed August 2018.

44 United Nations. 'Progress of Goal 13 in 2016'.

rise this century well below 2 degrees Celsius.[45] A secondary effect of climate change is mass migration to neighbouring states and beyond[46]—a prominent issue on the European political scene.

The 2030 Agenda on Sustainable Development ratified by the UN General Assembly in September 2015 is a new, transformative and integrated development agenda that will drive the global agenda on Sustainable Development for the next 15 years. A comprehensive governance process is in place within the UN framework to guide implementation of the 2030 SD Agenda, including the High-level Political Forum, the UN Statistical Commission, the UN initiative on Global Geospatial Information Management (UN-GGIM), and many UN specialised agencies allocated as custodians of individual SDGs.

In total 17 Sustainable Development Goals (SDGs) and 169 SDG Targets have been adopted by the world leaders, which later were translated into 232 SDG Indicators that collectively provide a management tool for countries to implement development strategies and report on progress toward the SDG Targets.

'A robust monitoring mechanism for the implementation of the SDGs requires a solid framework of indicators, and consequently good and reliable statistical data, to measure, monitor and report progress, inform policy and ensure accountability of all stakeholders.'[47] The 2030 Agenda for Sustainable Development clearly stressed the importance of Geospatial Information and Earth Observations to inform the SDG Targets and Indicators. An effective monitoring of the SDG Indicators and reporting of the progresses towards the SDG Targets require the use of multiple types of data that go well beyond the traditional socio-economical data that countries have been exploiting to assess their development policies.

Accurate, global and timely data is critical to tracking progress towards the achievement of the SDGs. Hence the importance to integrate data coming from new technologies such as EO in order to produce high-quality and timely information, with more detail and at higher frequencies and with the ability to disaggregate development indicators.

EO, together with modern data processing and analytics, offer unprecedented opportunities to make a quantum leap in the capacities of countries to efficiently track all facets of Sustainable Development. Organisations such as Global Partnership for Sustainable Development Data have been established 'to help stakeholders across countries and sectors fully harness the data revolution for sustainable development, using this new knowledge to improve lives and protect the planet.'[48] Satellite environmental information is global, comprehensive, accurate, repeatable and timely, and therefore is a critical source of data to monitor progress to the SDGs.

The UN Division for Sustainable Development Goals acts as the Secretariat for the SDGs, supported by the UN Statistics Division (UNSD) which is the decision-making body for coordinating international statistical activities. National government agencies and statistical offices report to the UN on progress in achievement of the SDGs. ESA is assisting Member States and developing countries to integrate satellite environmental information into their national development policies and reporting processes in relation to their engagement on the 2030 agenda through a dedicated series of research and development projects (see Annex C).

Development Aid

To support economic, environmental, social, and political development of developing countries, and achievement of the UN SDGs, governments and other agencies provide Development Aid.[49]

Official Development Assistance (ODA), is defined by the OECD's Development Assistance Committee (DAC) as being focused on 'economic development and welfare of developing countries'[50] and 'concessional in character'.[51] ODA accounts for approximately 40-45% of total net flows to DAC countries and totalled US$144 billion in 2017.[52] 65-75% of ODA is spent

45 UNFCC. 'The Paris Agreement'. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. August 2018.

46 UNFCC. 'Climate Change Is A Key Driver of Migration and Food Insecurity'. https://unfccc.int/news/climate-change-is-a-key-driver-of-migration-and-food-insecurity. Accessed August 2018.

47 United Nations. 'Sustainable Development Goals'. https://unstats.un.org/sdgs/. Accessed August 2018.

48 Global Partnership for Sustainable Development Data. 'About the Global Partnership for Sustainable Development Data'. http://www.data4sdgs.org/about-gpsdd. Accessed August 2018.

49 Or development cooperation (also development assistance, technical assistance, international aid, overseas aid, official development assistance (ODA), or foreign aid).

50 OECD. 'DAC List of ODA Recipients'. https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/DAC_List_ODA_Recipients2018to2020_flows_En.pdf. Accessed July 2018.

51 OECD. 'Official development assistance – definition and coverage'. http://www.oecd.org/dac/stats/officialdevelopmentassistancedefinitionandcoverage.htm. Accessed July 2018.

52 OECD. 'DAC Members Net Official Development Assistance in 2016'. Accessed July 2018.

bilaterally[53] by individual national governments with the remainder channelled through the multilateral institutions such as the UN, the World Bank and the Regional Development Banks.

The Development Aid community includes:

National Development Aid Agencies, for example UK DFID, German GIZ, France AFD, as the government departments responsible for administering ODA. Their budgets range from 0.11% of Gross National Income (GNI) for Hungary, to 1.01% for Sweden, with 0.7% as the UN target.[54]

International Financial Institutions (IFIs) including the World Bank and the International Finance Corporation (IFC) were first established after World War II to assist in the reconstruction of Europe. Now a large number of IFIs provide financing and professional advice for the purpose of development in the form of long-term concessional loans and grants to low and middle-income countries each year.[55] There is increasing focus by the IFIs in defining future strategies that assist in poverty reduction and economic growth but also address key environmental issues such as tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability (see ADB Strategy 2030, and World Bank's 'A Measured Approach to Ending Poverty and Boosting Shared Prosperity: Concepts, Data, and the Twin Goals').[56]

Private Foundations, which are philanthropic organisations with increasingly significant sources of funding in international development. They include the Bill and Melinda Gates Foundation, MasterCard Foundation, Rockefeller Foundation and Omidyar Network. They provide US$7.96 billion per year, equivalent to 5% of what is spent via ODA,[57] and are major players in specific sectors such as health.

53 OECD. 'Statistics on resource flows to developing countries – Table 4 Bilateral ODA provided by 29 governments in 2016'. http://www.oecd.org/dac/stats/statisticsonresourceflowstodevelopingcountries.htm. Accessed July 2018.

54 Compare your country. 'Official Development Assistance 2017 – Preliminary Data'. http://www2.compareyourcountry.org/oda?cr=oecd&lg=en/. Accessed July 2018.

55 OECD. 'DAC total net official development assistance flows to multilateral organisations'. https://doi.org/10.1787/dev-v2017-1-table5-en. Accessed July 2018.

56 World Bank. 'A Measured Approach to Ending Poverty and Boosting Shared Prosperity'. https://openknowledge.worldbank.org/bitstream/handle/10986/20384/9781464803611.pdf?sequence=1. Accessed August 2018.

57 OECD. 'Private Philanthropy for Development'. http://www.oecd.org/development/private-philanthropy-for-development-9789264085190-en.htm. Accessed July 2018.

Step-change in Satellite Environmental Information

Step-change in Satellite Environmental Information

Key Points

- Europe's Copernicus programme is a game-changer in providing an unprecedented volumes of free satellite environmental data,
- ESA and the European Commission have invested over €250 million over the past decade for the research & development of a wide variety of satellite environmental information products and services, with the European EO information services sector now having world-leading capabilities,
- These combined capabilities (Copernicus space system, the European EO information services sector) are currently in place and are ready to be leveraged further for the environmental issues facing international Development Aid,
- Space 4.0 is a new era happening now in which there is the increased number of diverse space actors around the world, including the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction. It represents new opportunities for the use of space technologies.

This chapter introduces how the EO sector is evolving, providing a new wealth of satellite environmental information, that will be a game-changer for Sustainable Development.

Many significant developments and changes are taking place in EO that are bringing this technology from scientific use, to a level where it can be used as an operational source of environmental information in a wide range of (non-specialist) domains. In addition, political, public and scientific interest is growing to make better environmental decision-making through the use of EO to address the grand societal challenges that the world is increasingly facing, as manifest through initiatives such as the Group on Earth Observations (GEO).

Europe's Copernicus programme[58] is the most comprehensive EO programme globally and is a game-changer in providing an unprecedented volume of satellite environmental information data. ESA is responsible for coordinating the Copernicus space component and is developing the fleet of Sentinel satellites. The Copernicus data policy is that of 'free, full and open' meaning that all Sentinel data is available freely to anyone.

To give an indication of the huge changes that are coming in term of data availability of satellite environmental data, the forecast volume of Sentinel missions' data is given in Figure 8 and compared against all the other Earth Observation missions that ESA is handling.

Copernicus data is available to the public via Sentinel Open Access Data Hub, which has 112,000 users, who have download over 42PB of data across five million downloads.[59]

Recently, ESA has launched the Copernicus Data and Information Access Services (DIAS)[60], which will provide a 'one-stop shop on the cloud' for easy access to all Sentinel, as well as third party, data and processing tools and resources'.[61] The DIAS provides a unified system through which these vast amounts of data are fed into a range of thematic information services designed to benefit the environment, the way

58 Copernicus is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU Agencies and Mercator Océan.

59 ESA, Dr. Josef Aschbacher. ESA Earth Observation Programme.

60 Copernicus. 'The upcoming Copernicus Data and Information Access Services (DIAS)'. http://copernicus.eu/news/upcoming-copernicus-data-and-information-access-services-dias. Accessed August 2018.

61 Space News. 'ESA tasks Airbus with streamlining Copernicus data access'. http://spacenews.com/esa-tasks-airbus-with-streamlining-copernicus-data-access/. Accessed July 2018.

we live, humanitarian needs and to support effective policy-making for a more sustainable future.

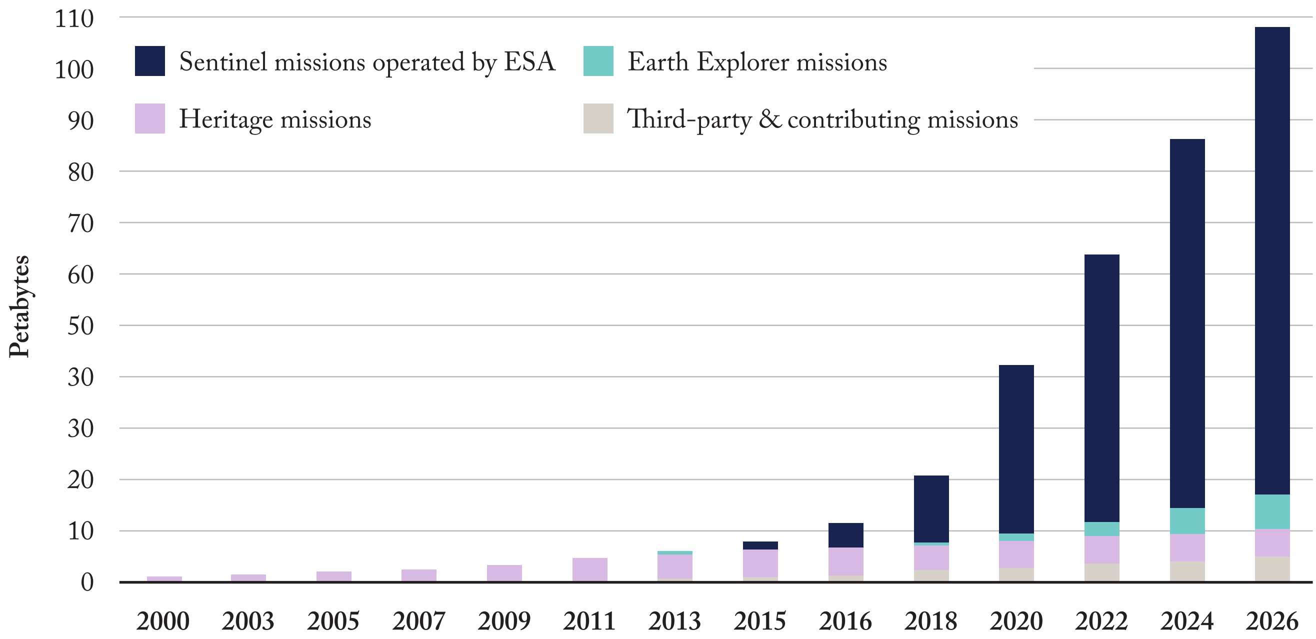


FIGURE 8: Projected Volume of Data Available from ESA's EO Data Archive (Petabytes)

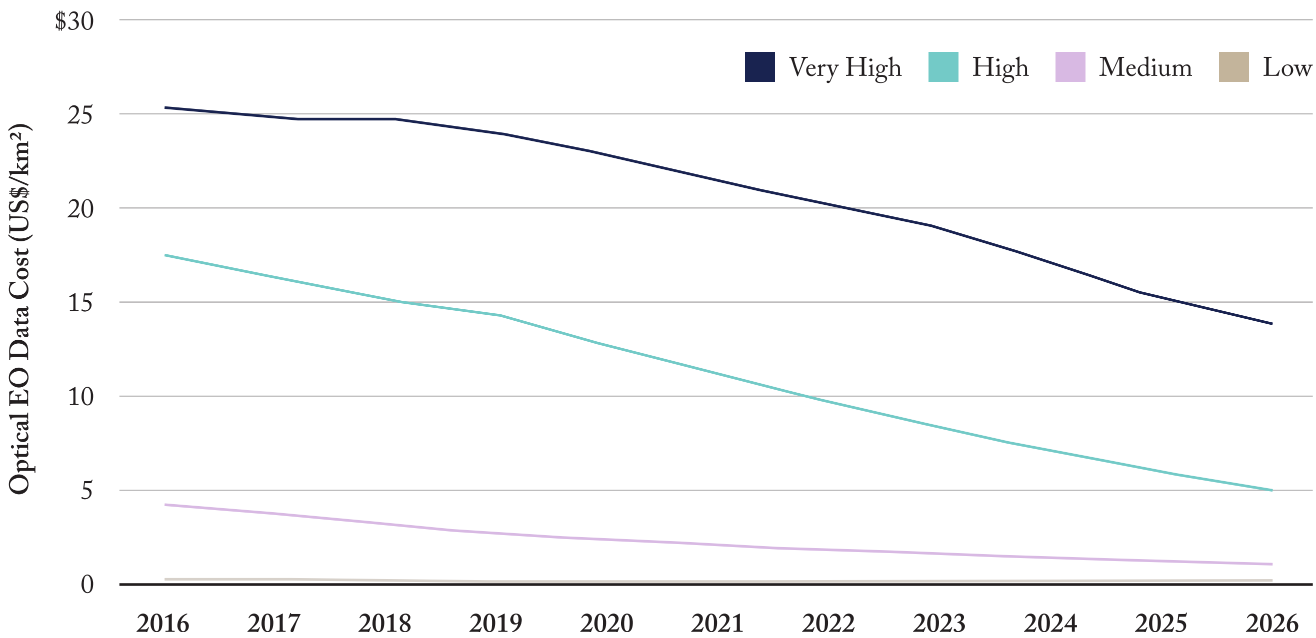


FIGURE 9: Optical EO Data Cost at Various Resolutions (US$/km²)

A wide variety of development challenges can be addressed using Copernicus' data - in UK Space Agency's International Partnership Programme (IPP), 21 of 25 EO projects use Copernicus as a source of satellite environmental information.

In addition to the Sentinels, there are a wide range of very high resolution (<0.5m) and high resolution (<1m) satellite missions that are developed and operated either nationally (e.g. France Pleaides, Italy CosmoSkyMed, Germany TerraSAR-X) or commercially (e.g. DigitalGlobe). The data is not free from most of these high resolution systems and comes at cost. However, also the trend is for these data costs to reduce in time as per Figure 9.

To turn the data into information products that allow informed decision-making, processing of the data is required by specialist companies or organisations (the European EO information services sector). Over the last decade ESA and the European Commission have also invested in the order of €250 million of R&D funding through their own programmes to ensure that the wide variety of satellite environment information products and services derived from processing this basic data are robust and accurate.

These developments were for the purpose of putting in place the capabilities to produce satellite information products and services for the benefit of European government organisations (e.g. Environment Ministries, Forestry Departments, Agriculture and Water Agencies, Civil Protection, etc) to operate in accordance with environmental policies & legislation. The European EO information services sector (companies, government institutes, universities) has grown to be in a world-leading position in terms of technical capability through these investments.

However, note that these combined investments and capabilities (Copernicus space system, the European EO information services sector) are currently in place and are ready to be leveraged further for the environmental issues facing international development

Space 4.0

The first era of space, 'Space 1.0', can be considered to be the early study of astronomy (and even astrology). The next era, 'Space 2.0', came about with spacefaring nations engaging in a space race that led to the Apollo moon-landings. The third era, 'Space 3.0', with the conception of the International Space Station, showed that we understood and valued space as the next frontier for cooperation and exploitation.

Space 4.0 represents the evolution of the space sector into a new era, characterised by a new playing field including the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction.[62] Space launches now cost 11 times less than 5 years ago and satellites can cost 100 times less[63], and therefore the costs of commercial data are falling in the Space 4.0 era.

From a wider perspective, systemic changes in how science is organised (Open Science), how business is conducted (digital economy), and how society is responding to global challenges (climate, water, food, security) are re-defining the boundary conditions for the use of space technologies.

Key trends currently impacting satellite environmental information include: exponential growth in availability of EO data; the impact of big data, cloud processing, machine learning; the entrance of Google and Amazon into the field; the multiplication of national initiatives in EO, the emergence of venture-capital funded micro-satellite EO constellations in the US (e.g. Planet, etc); and the expanding use of drones for civil and security applications. Advances in on-board technologies are constantly improving spatial resolution and measurement accuracies. Much more frequent observations are being delivered with satellite constellations and geostationary platforms.

To meet the challenges and to proactively develop the different aspects of Space 4.0 in this rapidly changing context, the European space sector can become globally competitive only by fully integrating into society and economy.

In this context, the Development Aid sector represents an opportunity to realise the full value (scientific, societal, economic) of the space missions and investments already available.

62 ESA. 'What is Space 4.0?'. https://www.esa.int/About_Us/Ministerial_Council_2016/What_is_space_4.0. Accessed July 2018.

63 Goldman Sachs. 'Emerging Theme Radar'. http://www.goldmansachs.com/our-thinking/pages/macroeconomic-insights-folder/what-if-i-told-you/report.pdf. Accessed July 2018.

Benefits of Satellite Environmental Information

Benefits of Satellite Environmental Information for the Development Aid Sector

Key Points

- The primary benefits that satellite environmental information brings to the Development Aid sector can be categorised in four areas of activities:
  1. Increased efficiency of existing operations and activities, leading to increased impact,
  2. Improved policy definition and planning of future activities,
  3. New and extended capabilities,
  4. Improved transparency, responsibility and accountability.
- Most existing examples of benefits are associated with the first category (1), but there are a growing number in the other three categories (2,3,4),
- As a starting point, a 1-2% investment in procurement and use of satellite environmental information in development will lead to increased efficiencies for Development Aid operations and activities (some quantitative results are emerging for on-going projects), with probably more benefit achieved if fully incorporated into policy-making and planning,
- The benefits of satellite environmental information are real, manifest, growing in number, but the value-proposition (benefits vs. cost) of the use needs to be further consolidated, convincingly argued and presented. There is an opportunity to do this via the OECD Space Forum.

This chapter provides some examples of the primary benefits of satellite environmental information within the context of Development Aid for each of the four main benefits identified (operations, planning, new capabilities, accountability). The chapter concludes with observations on the scale of benefits that are possible through the use of satellite environmental information.

Europe is leading the way in using satellite environmental information within National Development Aid Agencies' existing operations and activities. Pioneering programmes like ESA Earth Observation for Sustainable Development (EO4SD, €33 million), UK Space Agency's International Partnership Programme (IPP, £152 million)[64] and Netherlands Space Office Geo-data for Agriculture and Water (G4AW, ~€100 million)[65] and have collectively completed over 100 development projects focused on the use of satellite environmental information in over 50 countries.

Most of the work carried out to date has been oriented to support specific projects, therefore most of the current examples of the benefits associated with the use of satellite environmental information are in the first category identified above, i.e. increased efficiency of existing operations and activities, leading to increased impact.

Nevertheless, examples of the benefits of satellite environmental information in all the four areas defined above are drawn from these programmes (ESA, UK, Netherlands) and presented below.

64 GOV.UK. 'International Partnership Programme'. https://www.gov.uk/government/collections/international-partnership-programme. Accessed July 2018.

65 Netherlands Space Office. 'Space for Food Security Geodata for Agriculture & Water G4AW'. http://eo4sd.esa.int/files/2018/01/ESRIN-G4AW-16-01-2018.pdf. Accessed July 2018.

1. Benefits of Increased Efficiencies of Existing Operations and Activities

— *European Space Agency: Earth Observation for Sustainable Development (EO4SD)*

See: EO4SD.esa.int/

It is recalled from chapter 3 that EO4SD activities have been carried out in two phases; EO4SD Phase-0 (2010 to 2015, €8 million) of 65+ small-scale demonstrations covering a very wide range of satellite environmental information product types, followed by EO4SD Phase-1 (2016-2023, €25 million) which scales-up the level of activity by carrying out larger, regional demonstrations in 2-3 key regions around the world in nine specific thematic information/development domains.

The EO products and information services were delivered by specialist providers in the European EO information services sector, under contract, and the technical management of ESA via an open competitive procurement process.
It is not in the scope of this report to detail the types of environmental information that satellites can provide, these are to be found in the supporting documents at **http://www.vae.esa.int/page_documents.php**.

However, to add substance to the discussion below regarding the benefits of this information, one concrete example is given here. This example is in support to the Kolkata Environmental Improvement Investment Program, implemented by the Asian Development Bank (ADB). This focuses on water supply and sewerage to the municipality, with the main stakeholder being the Kolkata Municipal Corporation (KMC), including also the Kolkata Metropolitan Development Authority (KMDA) representing 19 municipalities, and various state-level administrations.

In line with the Millennium Development Goals followed by India, in June 2015 the government launched three major urban development initiatives, handled by the Ministry of Urban Development (MoUD), in addition to several other programs such as the National Urban Information System (NUIS) initiated in October 2014. In this context, the KMC leads different projects for improving land use management and urban planning in a sustainable manner.

In Figure 10, on the left is the Land Use and Land Cover (LULC) product for Kolkata. The classification is based on the European Commission's Urban Atlas nomenclature. For the core urban area, it used very high resolution (0.5m) Pleiades-1A/1B satellite imagery from the period 7–15th February 2017. The peri-urban areas were classified using Sentinel-2A (10 m resolution) data, acquired on 16th March 2017, also shown as the background image. On the right is a detail of the informal settlements class, delineated via visual interpretation, based mainly on attributes of compactness, patch size and building density.

According to Neeta Pokhrel, Senior Urban Development Specialist working in the Kolkata programme, the EO4SD-Urban products can be very helpful for the KMC and other stakeholders for in-depth analysis of the city, both as mapping products and derived geo-statistical indicators. They can contribute to land use planning (e.g. with precise mapping of informal settlements), better handling of disaster management, and supplementing climate resilience assessments.

In addition to this specific example, the overall benefit & impact of all of the first demonstrations have been assessed and summarised by World Bank, ADB and IFAD in the following statements:

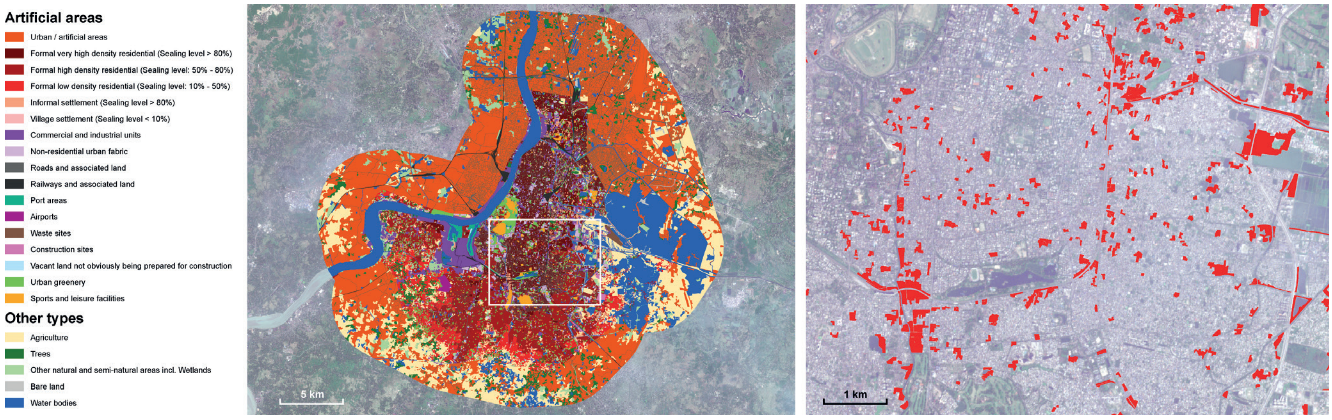


FIGURE 10: Kolkata, India: Left - Land Use and Land Cover (LULC), Right - informal settlements
(Pléiades data © CNES (2017), distributed by Airbus DS. Contains modified Copernicus Sentinel data (2017).

World Bank[66]**:** In partnership with the World Bank, 15 projects were completed between 2011-13, and an additional 18 projects between 2014-17, using the European EO information services sector via an open procurement process. These projects were across Central and Latin America, Africa, Asia and Pacific. They covered a wide range of development sectors including climate and disaster resilience, maritime/fishing, water and sanitation, land-use, urban planning and health.

> *"Earth Observation provides the development community with an unbiased, consistent and timely perspective that can inform data-driven decision making. Geospatial data and analytics are increasingly considered key elements for making development policy and have proven to be effective in supporting the planning, implementation, monitoring and evaluation of Sustainable Development projects. It therefore helps us to achieve our core mission at the World Bank to eliminate extreme poverty and boost shared prosperity, and to better serve our clients. The well-established partnership with the European Space Agency is illustrating the value of EO-derived services for World Bank operations."*

—**Laura Tuck**, Vice President, Sustainable Development, World Bank

Asian Development Bank (ADB)[67]**:** ESA and ADB partnered on the initiativeEarth Observation for a Transforming Asia and Pacific (EOTAP), to promote and demonstrate satellite EO in support of ADB's investments in its developing member countries (DMCs). EOTAP supported twelve projects, carried out from 2014-16. The projects were small-scale demonstrations of EO-based information products that addressed the specific needs of individual ADB projects, involving a wide range of ADB staff, programmes and initiatives, geographic regions and organisations in the concerned DMCs.

> *"Satellites provide spatially explicit, consistent and comparable city-level observations. These observations have significantly reduced the uncertainty about the evolution of cities, creating the opportunity for better planning of infrastructure investments and services. The on-going collaboration with ESA is helping ADB to explore the value of Earth Observation-based maps and applying them in designing our lending projects."*

—**Vijay Padmanabhan**, Director of the Urban Development and Water Division in ADB's Southeast Asia Department and Chief of the ADB Urban Sector Group

International Fund for Agricultural Development (IFAD)[68]**:** ESA began collaborations in 2008 with a strategic player in the domain of agriculture; IFAD. Initially, three small-scale activities focussed on Madagascar, but these laid the ground for five more substantial demonstration projects that began in 2010. IFAD found particular use in accessing and operationalising open-source data from ESA satellites (such as Sentinel 2) for project baseline assessments and impact monitoring in agriculture projects. IFAD are striving to build the EO capacity of IFAD staff, project teams and the government counterparts that they work with.

> *"EO services bring a powerful analytical tool to the development context. They make you see the hidden and complex dynamics between the bio-physical and the socio-economic components of the livelihood systems; they make you reach better targeting and they make you see the difference you bring in the ground and in the lives of people"'*

—**Naoufel Telahigue**, Country Program Manager, IFAD – Near East, North Africa, Europe and Central Asia Division)

The current **EO4SD Phase-1** activities (2016-2023) will be delivering an extensive portfolio of detailed user-related documentation in each of the nine specific thematic information / development domains. This information will be key input in order to start longer-term transfer and integration of satellite environmental information in these domains.

66 ESA. 'Earth Observation For Sustainable Development – Partnership Report | September 2016'. http://esamultimedia.esa.int/multimedia/publications/ESA_WB_Partnership_Report_2016/. Accessed August 2018.

67 ESA. 'Earth Observation For A Transforming Asia And Pacific'. http://esamultimedia.esa.int/multimedia/publications/EOTAP/. Accessed August 2018.

68 ESA. 'Earth Observation Support For The International Fund For Agricultural Development Final Report | August 2014'. http://esamultimedia.esa.int/multimedia/publications/IFAD/. Accessed August 2018.

UK Space Agency: International Partnership Programme (IPP)

See: gov.uk/government/collections/international-partnership-programme, and spacefordevelopment.org/about/

Through IPP projects, over 1,200 people in developing countries have increased their capability to use space solutions via training and capacity building, including through the sponsorship of bachelor's degrees and PhDs.

The projects are delivered by ~120 organisations from the space industry leading to growth opportunities for the UK space sector. Caribou Space and London Economics will be jointly publishing a report quantifying the UK economic benefit, in terms of measurable UK income, Gross Value Added (GVA) and jobs from IPP, in 2019.

Through Caribou Space, IPP has implemented a rigorous Monitoring & Evaluation (M&E) function to measure and communicate its development impact, based on UK Treasury[69], UK DFID[70], UK Space Agency[71], and OECD DAC best practice.[72]
IPP will share knowledge through a communications workstream to highlight the additionality that space solutions have over terrestrial systems to address development challenges.

IPP is conducting in depth economic evaluations of the cost-effectiveness of space solutions to address development challenges. All 33 consortiums are completing cost-effectiveness analysis (CEA), to assess whether and where space solutions are cost-effective at addressing development challenges compared to existing non-space alternatives that have the same development impact. A summary of this analysis will be published in the first half of 2019.

IPP has published a report **Space for Agriculture in Developing Countries**, extracting findings from the six agriculture projects in three Latin American and five African countries. The findings of forecast development impacts include:

- Increasing agricultural productivity by 3-5% yield for 5,000 farmers in 10 countries. One project is aiming to double yields & incomes for 25,000 smallholders,
- Improving the accuracy of early warning systems and affordability of insurance making thousands of farmers more resilient to the effects of climate change. Aiming for 5-25% increase in insurance penetration and a 10% decrease in premiums,
- Improving efficiency and reducing losses from pests, disease, drought and floods through real time risk information and advice,
- Improving management of natural resources by bringing one million hectares of land under sustainable management.

Advanced Coffee Crop Optimisation for Rural Development (ACCORD)

Coffee is a global commodity with growing demand globally, with revenues directly benefitting farmers in developing countries. ACCORD provides farmers with access to timely, geo-targeted advice through a simple mobile application. This combines satellite imagery with ground observations, and a custom high-resolution localised weather forecast model. The impacts will be:

- Yield will double over a three-year period,
- 25% improved coffee quality (cupping score),
- Farmer income will double over a three-year period.

IPP has also published **Space for Disaster Resilience in Developing Countries**, extracting findings from the 10 disaster resilience projects. The findings of forecast development impacts include:

- Improving the understanding of disaster risk and accuracy of disaster predictions through tools for government decision makers to assess how disasters will impact populations and infrastructure, therefore reducing economic losses, numbers of people killed and affected,[73]
- Strengthening government's planning of disaster response through near real-time situational analysis to allow government ministries, NGOs and private sector to better coordinate response plans, therefore reducing economic losses, numbers of people killed and affected,[74]

69 HM Treasury. 'The Magenta Book: Guidance for evaluation'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/220542/magenta_book_combined.pdf. Accessed July 2018.

70 DFID. 'DFID Evaluation Strategy 2014-2019'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/380435/Evaluation-Strategy-June2014a.pdf. Accessed July 2018.

71 UK Space Agency. 'Evaluation strategy: August 2015'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/456513/Evaluation_Strategy_August_2015_FINALv2.pdf. Accessed July 2018.

72 OECD. 'Evaluation of development programmes'. http://www.oecd.org/dac/evaluation/. Accessed July 2018.

73 Most projects are aiming for modest improvements in the GDP and human costs of disasters. Overarching targets have not been set as it is not appropriate to set targets on the human and economic costs of disasters.

74 Same as above.

- Enhancing preparedness for effective response through improved emergency communications to supplement damaged mobile networks, therefore restoring basic communications services, reducing the number of people impacted, and the severity of the effect of disasters.

Modelling Exposure Through Earth Observation Routines (METEOR)

The world will see the construction of one billion new dwellings by 2050 and this growth may lead to rapid increase in disaster risk. METEOR takes a step-change in the application of EO exposure data to allow quantitative assessment of disaster risk exposure, leading to better-informed disaster risk management decisions. The impacts will be:

- To substantially increase the availability of robust disaster risk information for all 48 least developed countries,
- To strengthen the resilience and adaptive capacity to natural disasters of Nepal and Tanzania,
- A network of stakeholders better placed to act as leaders of diaster risk management in their geographic region.

— *Netherlands Space Office: Geo-data for Agriculture and Water (G4AW)*

See: G4AW.spaceoffice.nl/en/

G4AW projects use satellite environmental information to support smallholder farmers with pests and disease warning, water use and drought warning, fertiliser advice, weather information and crop monitoring and weather-indexed insurance, across 10 crops including rice, coffee and potatoes.[75]

Across G4AW, all projects are expected to report an increase in yield and income for farmers by 2020. Early results are positive: a test within the Rain for Africa (R4A) project providing information services to grape farmers highlights a 10-20% saving on pesticide costs. More efficient use of inputs leads to cost savings, improved yields and increased incomes. A mid-term review carried out in 2016 identified a number of lessons, including:[76]

- Having a clear focus in terms of the products and services offered is important,
- Partnering with local, strong and active organisations increases the chance of success,
- Smallholders are often not the paying clients, which makes it difficult to measure outcomes,
- The whole value chain from research to commercialisation should be considered to achieve project sustainability,
- Key performance indicators used with the G4AW do not easily capture outcomes related to the sustainable use of resources, impact on climate or gender-disaggregated outcomes.

G4AW Project: The Geodata for Innovation Agriculture Credit Insurance Schemes (GIACIS)

A satellite-based information system to provide agricultural index insurance, in Ethiopia, with no or limited need for field inspections.

A pilot for 2,000 farmers within this project delivered such promising initial results that the Ethiopian government has stepped in to expand the scheme to reach over 1.6 million farmers over three years.

75 Netherlands Space Office G4AW. 'A Business Case for Opening New Markets using Satellite Data for Smallholder Farmers and Pastoralists in Developing Countries'. https://G4AW.spaceoffice.nl/files/files/G4AW/publications/2016%20G4AW%20Publication%20Lessons%20learned%20report%20-%20Opening%20new%20markets%20for%20smallholders%20LR%2020161209.pdf. Accessed July 2018.

76 Same as above.

2. Benefits of Improved Policy Definition and Planning of Future Activities

The UN Sustainable Development Goals (SDGs) and 169 SDG Targets to be achieved by 2030, provide a globally endorsed set of priorities for Sustainable Development, as detailed in section 5 Sustainable Development in Evolution. Guided by these priorities IFIs and National Development Aid Agencies develop institutional level strategies that define how and where they will focus their Development Aid, for example World Bank's *An Overview of the World Bank Group Strategy*[77], ADB's *Strategy 2030*[78] and *UK Aid Strategy*.[79] Satellite environmental information is global, comprehensive, accurate, repeatable and timely, and therefore is a critical source of data to monitor progress to the SDGs.

As an example of the contribution that space information can bring, the UK Space Agency International Partnership Programme (IPP) will have positive direct impact on the lives of seven million people, addressing 10 UN SDGs as per Figure 11 below.

At an individual country level, local governments, IFIs and National Development Aid Agencies require detailed, up to date, environmental information for policy and planning of future activities. Satellite environmental information can be used to identify, measure and track trends over large regions over long timescales, for example, in agriculture, land use, urbanisation, climate change, and the mapping of human settlements in relation to natural hazards.

IFIs and National Development Aid Agencies develop country level diagnostics and strategies to identify the most significant problems that hinder development as well as the main opportunities to create change. They commonly publish these strategies as per the World Bank[80] and DFID for Bangladesh[81] & Kenya.[82] They prepare and implement specific programmes within a given country, with a view to achieving poverty-alleviation or economic development objectives. During the programme design and appraisal process, satellite environmental information can be used to substantiate the severity of the development challenge helping to appraise between a range options for development programmes.

1 NO POVERTY

Build resilience to disasters by:
- Reducing the number of deaths, missing persons and persons affected by disasters
- Reducing direct economic loss in relation to GDP
- Using knowledge derived from IPP projects to create or strengthen at least 12 national and local diaster risk reduction strategies

2 ZERO HUNGER

Reduce hunger and achieve food security by:
- Contributing to a 3–5% increase in agricultural productivity
- Improving agricultural ROI, crop yields and reduce crop losses
- Improving incomes for 30,000 smallholders
- Bringing 1 million hectares of agricultural land under sustainable management (EO based) practices

3 GOOD HEALTH AND WELL-BEING

Ensure healthy lives and well-being by:
- Increasing the nunmber of live births assisted by a trained professional by 20%
- Reducing the incidences of (potentially) deadly diseases

4 QUALITY EDUCATION

Ensure that all girls and boys have a quality education by:
- Increasing by 15,000 the number of youths with ICT skills
- Increasing to 20% of students reporting the use of ICT for their learning
- Ensuring that 60% of students report the integration of ICT in the classroom

7 AFFORDABLE AND CLEAN ENERGY

Ensure access to energy for all by:
- Increasing by 3% the amount and proportion of renewable energy generated in SIDS

8 DECENT WORK AND ECONOMIC GROWTH

Promote safe and secure working environments in small boat communities by:
- Reducing the annual number of small boat deaths by 10%
- Increasing the number of people working in safe employment

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Improve the management of hazardous material and chemical waste by:
- Reducing the risk of mine tailings contaminating water and soil

14 LIFE BELOW WATER

Conserve marine environments and promote legal, sustainable fisheries by deterring overfishing, illegal, unprotected and unregulated fishing (IUU) by:
- Increasing by at least 2,000 the number of households benefiting from enhanced fisheries practices (e.g. VMS)
- Increasing the average income of small and medium sized fishing boats

15 LIFE ON LAND

Protect terrestrial ecosystems by:
- Reducing average deforestation rates by 5%
- Avoiding 100,000 hectares of deforestation per year

17 PARTNERSHIPS FOR THE GOALS

Strengthen domestic tax collection by:
- Improving domestic tax collection by £32 million in relevant IPP countries

FIGURE 11: IPP's Forecast Impacts on UN SDGs

77 World Bank. 'An Overview of the World Bank Group Strategy'. https://openknowledge.worldbank.org/bitstream/handle/10986/16093/32813_ebook.pdf?sequence=5. Accessed August 2018.

78 ADB. 'STRATEGY 2030'. https://www.adb.org/sites/default/files/institutional-document/435391/strategy-2030-main-document.pdf. Accessed August 2018.

79 HM Treasury, Department for International Development. 'UK aid: tackling global challenges in the national interest'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478834/ODA_strategy_final_web_0905.pdf. Accessed August 2018.

80 World Bank. 'Country Strategies'. http://www.worldbank.org/en/projects-operations/country-strategies. Accessed August 2018.

81 DFID. 'DFID Bangladesh'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/723116/Bangladesh-July-2018.pdf. Accessed August 2018.

82 DFID. 'DFID Kenya'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/723198/Kenya-July-2018.pdf. Accessed August 2018.

A closer look at National Development Aid Agencies country-level strategies highlights a number of concrete examples of programmes that would have been facilitated by the use of satellite environmental information. In recent years, DFID Mozambique has launched a number of programmes to improve smallholder farmers' livelihoods, as well as initiatives to support the government to improve land tenure security to incentivise rural investment into the country. The use of satellite environmental information could have supported analysis of current land use in Mozambique, reducing the need for extensive and costly on-the-ground surveying. EO data could also support programme managers to conduct a more in-depth assessment of potential social and economic risks arising from drought, flooding and other climatic events within the areas concerned.

A recent DFID review details 24 programmes[83] focused on strengthening land rights and/or improving land governance. These programmes would have benefited from the increased visibility from satellite environmental information of what land is currently used for, its value, and any risks to its use e.g. risk of natural disasters.

3. Benefits of New and Extended Capabilities

Satellite environmental information can provide information that either extends or creates entirely new analysis capabilities that allow IFIs and National Development Aid Agencies to begin to tackle a whole range of development challenges and issues that were not previously possible to address. Two examples are given below.

— *Data Analytic Approaches in Climate Information Services Supporting Implementation of the UNFCCC Paris Agreement*

The Paris Agreement of the UNFCCC Conference of the Parties (COP-21) saw important decisions taken by Parties to the Convention (that are national governments[84]) with significant implied commitments and related economic and social dis-benefits to their countries.

However, much of the Paris Agreement, and the primary interest of many nations, regions and cities, lies in their capacity to adapt to unavoidable change and in how best to define their strategies for doing so. This involves not only knowledge of changes in physical climate and local projections, but also of a range of factors which are less well defined and that cannot be integrated as part of a physical model; e.g. socio-economic factors, demography, health statistics and other 'soft' physical characteristics of the local region.

It is also likely that Parties will require, in due course, evidence as to the effects of climate change on their policies and, indeed, of the effects of their decisions and actions at COP-21 in effecting improvements to adaptation outcomes. There is an identified lack of appropriate indicators or information services available for policymakers to allow them to draw inferences as to the effects of their decisions in the Paris Agreement.

To address these requirements, climate information services will require new approaches to define the prior probabilities of potential outcomes, including social and political factors, dependent on the predicted change in baseline climate conditions. Data analytics offers a promising approach to the definition of these complex dependencies, based on historical data of multivariate change and societal response. This requires knowledge not only of the likely trend of future physical parameters of climate, but also of the behaviours of individuals, society and groups of varying size from cities to nations, involving complex interactions of social, health, economic, political and other factors.

Here, satellite environmental information can provide key input to understanding the potential relationships between previously un-modelled (and not obvious) dependencies between physical climate change and social outcomes. Many currently unknown relationships are likely to be discovered, with some already being identified, such as the connections between fire and drought events in central Africa and the El Nino effect in the Pacific Ocean.

— *Monitoring of States or Regions Subject to Fragility, Conflict & Violence (FCV)*

Satellite environmental information enables agencies to monitor activities in fragile and conflict-affected settings without the need for large numbers of personnel on the ground. In the aftermath of conflict or a natural disaster, imagery can be used to

83 LEGEND. '2016 DFID land portfolio overview'. https://www.odi.org/sites/odi.org.uk/files/resource-documents/11716.pdf. Accessed July 2018.

84 UNFCCC. 'List of Parties to the Convention'. https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states. Accessed August 2018.

ascertain the extent of the damage to buildings and communities, and to estimate the location of any possible survivors so that agencies can direct their resources to the highest priority settings. Satellite environmental information can also be used to track the activities of armed groups so that organisations can work to minimise – or at least plan a response for - any casualties from a conflict situation. ESA also promoted the use of EO in support of detection and clearance of landmines.[85, 86, 87]

In refugee settings, satellite environmental information can also be used to monitor mass forced movements of people. In Bangladesh, those involved in the Rohingya humanitarian crisis are currently banned from using drones[88] for better surveillance of the settlement area. The use of satellite imagery could likely provide agencies with a low-cost, open source of data to monitor the spread of settlements and land use in the surrounding area.

4. Benefits of Improved Transparency, Responsibility and Accountability

Satellite environmental information can improve the transparency, responsibility and accountability of IFIs and National Development Aid Agencies by enhancing M&E capabilities. High-resolution imagery can be used to demonstrate progress made with implementation activities and can greatly reduce the cost of M&E. The ability to use this imagery to estimate changes in crop yields, levels of forestation or water levels can avoid the need for expensive ground surveys and greatly reduce the budget required for rigorous impact evaluations. 'Real-time' data feeds of implementation activities can also act as 'feedback loops' for programme managers, enabling them to tweak programme activities or reallocate resources in order to maximise the impact and cost-effectiveness of the project.

One particular example is use in Environmental Safeguards Systems (ESS), where development activity is accompanied by environmental policy and procedures to screen proposed projects; and to assess the impacts and performance of projects when implemented. The global, comprehensive, accurate, repeatable and timely nature of satellite environmental information support ESS at all stages of a Development Aid project lifecycle including planning, implementation and M&E. See Annex B for details.

85 ESA. 'Hope For Detecting Landmines'. https://www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/HOPE_for_detecting_landmines. Accessed July 2018.

86 ESA. 'Midas - Mine & Ied Detection Augmented By Satellite'. https://business.esa.int/projects/midas. Accessed July 2018.

87 ESA. 'SAFEDEM - Space Assets For Enhanced Demining'. https://business.esa.int/projects/safedem. Accessed July 2018.

88 UAV Systems. 'Bangladesh Drone Laws'. https://www.uavsystemsinternational.com/drone-laws-by-country/bangladesh-drone-laws/. Accessed July 2018.

Conclusions: Benefits vs Costs

In the closing remarks to this chapter on the benefits, it is to be noted that satellite environmental information is a non-intrusive technology, and sometimes the only feasible method of collecting information especially for very remote or difficult to access regions (e.g. conflict areas).

Furthermore, many Client State developing countries, are lacking even the most basic, consistent mapping information, and hence satellite environmental information could deliver significant benefit in the form of up-to-date mapping of natural resources across whole countries and regions.

In summary, the benefits of using satellite environmental information are real, manifest, can be quantified, and are beginning to be fully documented through existing work in progress for the development aid sector.

— *But, do these benefits justify the costs of procuring and using satellite environmental information?*

From the previous chapter it is recalled that although the Sentinel data is available free of charge, the actionable information and insights derived from this data (and suitable for use in the context of Development Aid operations) comes at cost. The scales of these costs are well known through the R&D developments that have taken place over the last two decades.

In first discussions with the IFIs, a reasonable starting point for the level of financial resources that could be available to use innovative technologies within the framework of development projects has been proposed as 0.1% of project resources during preparation followed by 1-2% (max) of project resources during implementation. For a €100 million development project, such levels of resources would open the possibility of feasible and meaningful levels of satellite environmental information to be procured and used (but varying, depending on the specific product type).

— *What kinds of savings could such an investment lead to?*

There are a growing number of quantitative results emerging, with some substantial efficiencies being achieved for on-going for Development Aid operations and activities. There would probably be a greater level of efficiencies achieved if satellite environmental information was fully incorporated into policy-making and planning. However, the value-proposition (benefits vs. costs) of the use of satellite environmental information needs to be further consolidated, convincingly argued and presented. There could be a good opportunity for future work to be done in collaboration with the OECD Space Forum.[89]

89 OECD. 'OECD Space Forum'. http://www.oecd.org/futures/oecdspaceforum.htm. Accessed August 2018.

Evidence of Uptake

Evidence of Uptake of Satellite Environmental Information in Development Aid

Key Points

- European National Development Aid Agencies and IFIs are increasing their interest and usage of satellite environmental information through the use of their own resources,
- The World Bank is the IFI that has the highest value of projects with specific financial amounts for satellite imagery and services,
- The majority of IFI projects including satellite imagery and services are located in Asia and Africa,
- If satellite environmental information were systematically used in all IFI development projects at the level of 1-2% of the project financial resources, this may represent a significant economic volume of ~€200–300 million per year for this source of information.

This chapter highlights the increasing interest and usage of satellite environmental information within National Development Aid Agencies and IFIs projects and activities.

National Development Aid Agencies

In the first meeting held at ESA in January 2018 with European National Development Aid Agencies, both GIZ and AFD presented an overview of how satellite environmental information is currently being used in some of their development activities (the presentations can be found at **http://EO4SD.esa.int/2018/01/23/esa-opening-a-dialogue-with-european-national-aid-agencies/**).

In Germany, GIZ has over 30 projects spread across three continents[90] using satellite environment information in the areas of vegetation and forest, land use, agriculture and water projects. In late 2017, GIZ signed a cooperation agreement with the German Aerospace Centre (DLR), and also founded the Forum on Earth Observation at GIZ.[91]

In France, AFD has a number of multi-million euro projects focused on forest/land use and ocean/fishery monitoring and being implemented in Central/West Africa and Asia.[92] AFD also participate in a French working group on 'Space Hydrology' led by the French space agency, CNES.

The UK has the UK Space Agency International Partnership Programme with £152 million of ODA funding.

In the Netherlands, the Dutch Ministry of Foreign Affairs have commissioned the Netherlands Space Office (NSO) to execute the €100 million G4AW programme, focusing on water and agriculture projects in Africa and Asia to improve food security in developing countries by using satellite data.

Sweden's SIDA has a handful of projects using EO but seem to have a growing interest in building this capacity within their organisations.

Outside of Europe, NASA's SEVRIR has a partnership with USAID.[93]

90 GIZ. 'Current experiences in the use of satellite information in development aid activities from Germany'. http://eo4sd.esa.int/files/2018/01/GIZ-Presentation-ESA-WS-16.1.2018.pdf. Accessed July 2018.

91 Same as above.

92 AFD. 'Current experiences in the use of satellite information in development aid activities'. http://eo4sd.esa.int/files/2018/01/AFD-presentation-at-ESA-Esrin-16-01-2018.pdf. Accessed June 2018.

93 NASA. 'SERVIR Global'. https://www.servirglobal.net/. Accessed July 2018.

International Financial Institutions

ESA's EO4SD has partnered with the World Bank, EIB, ADB and IFAD since 2010. In this context, ESA have contracted a specialised, independent consultant to do a regular, monthly analysis of the procurement and development project notices published by the main IFIs on a daily basis.

The purpose of this analysis was:

- *Firstly* to identify any individual projects that made explicit reference to the use of satellite environmental information in their implementation,
- *Secondly* to identify a broader range of development projects where satellite information is not explicitly referenced, but (from the project description) there would be strong prospects for its use in the project implementation.

This analysis has itself been synthesised for the last 30-month period (November 2015 until July 2018) to produce a time series showing the evolution (at 3 monthly interval) of:

- The number of projects with an explicit use of satellite environmental information (which could be satellite imagery & analytics/information services, Geographic Information Systems (GIS), technical consultancy/expertise and equipment),
- The volume of financial resources identified within these projects for the satellite-related components.

There are a growing number of projects with a satellite information component, as seen in Figure 12. The majority of these projects are located in Asia and Africa, with 179 and 122 projects respectively, as shown in Figure 13.[94]

The World Bank is the IFI that has the highest value of specific financial amounts for satellite environmental imagery and services in projects, with US$43.1 million between November 2015 to July 2018, compared to US$4.18 million for ADB, as shown in Figure 14[95] (however, pro-rata it is expected to be larger as the total volume of Development Aid handled annually by World Bank is roughly 5 times greater than that of ADB).

FIGURE 12: IFI Projects from November 2015 to July 2018 With Specific Financial Amounts for Satellite Imagery & Services (No. Projects Per Quarter)

94 Same as above.
95 Robin Roach - ABD International. Personal Communication August 2018.

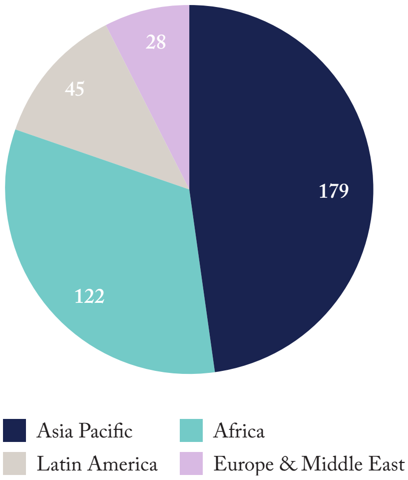


FIGURE 13: Geographic distribution of IFI Projects with Specific Financial Amounts for Satellite Imagery & Services from November 2015 to July 2018 (Cumulative No. of Projects)

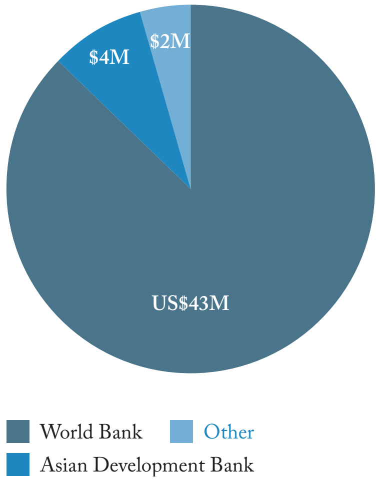


FIGURE 14: Value of Specific Financial Amounts for Satellite Imagery & Services in IFI Projects from November 2015 to July 2018 (Cumulative Total US$)

In addition to this project-based information, it is also worth noting that there are an increasing number of strategic planning and policy technical reports in which satellite technology is now being referred to. A few recent examples include:

- Asian Development Bank - Strategy 2030, which now incorporates High-Level Technology (July 2018)[96],
- Joint Report on Multilateral Development Bank's Climate Finance 2017 (June 2018)[97],
- Asian Development Bank - Partnering for Development: Donor Report 2017 (May 2018)[98],
- Climate Investment Fund - Board Paper on Long Term Admin Costs & Funding Options (March 2018)[99],
- World Bank - The Changing Wealth of Nations 2018: Building a Sustainable Future (Jan 2018)[100],
- Global Environment Facility - Tackling the Drivers of Global Environmental Degradation through Integrated Approach Pilot Programs (Jan 2018)[101],
- Asian Development Bank - Work Program & Budget Framework, 2018-2020 (Dec 2017)[102],
- World Bank - The Innovation Paradox (Oct 2016).[103]

Although the absolute values are relatively modest (see Figure 14) and reflect the fact that satellite technology is still in the early stages of being used in development, the trends in this information (the numbers of development projects and strategic reports) indicate the increasing interest of leading IFIs in the value of satellite environmental information for Development Aid operations and strategic activities.

This leads to the question of what the potential economic size of the financial resources could be associated with satellite environmental information, if this technology was used on a larger, more systematic basis in the Development Aid sector.

To answer this, ESA conducted an analysis at the end of 2015 of the actual planned projects in the pipeline for 2013-15, to be financed by the World Bank, the Inter-American Development Bank, the African Development Bank, and the Asian Development Bank, and identified all those with strong potential for the use of satellite environmental information in their implementation.

96 ADB. 'Strategy 2030'. https://www.adb.org/sites/default/files/institutional-document/435391/strategy-2030-main-document.pdf. Accessed August 2018.

97 Multiple Multilateral Development Banks. '2017 Joint Report on Multilateral Development Bank's Climate Finance'. https://reliefweb.int/sites/reliefweb.int/files/resources/2017-joint-report-on-mdbs-climate-finance.pdf. Accessed August 2018.

98 ADB. 'Partnering for Development: Donor Report 2017'. https://www.adb.org/documents/partnering-development-donor-report-2017. Accessed August 2018.

99 Climate Investment Funds. 'Long-term SCF Administrative Costs and Funding Options'. https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/scf_tfc_ic.1_2_intersessional_paper_options_to_fund_long_term_scf_administrative_costs_feb._23_2018_posted.pdf. Accessed August 2018.

100 World Bank. 'The Changing Wealth of Nations 2018: Building a Sustainable Future'. https://openknowledge.worldbank.org/handle/10986/29001. Accessed August 2018.

101 Global Environment Facility. 'Tackling the Drivers of Global Environmental Degradation through Integrated Approach Pilot Programs'. https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.C.51.Inf_.03_IAPs.pdf. Accessed August 2018.

102 ADB. 'Work Program and Budget Framework, 2018–2020'. https://www.adb.org/documents/work-program-and-budget-framework-2018-2020. Accessed August 2018.

103 World Bank. 'The Innovation Paradox'. https://openknowledge.worldbank.org/bitstream/handle/10986/28341/9781464811609.pdf. Accessed August 2018.

It then applied a 'what-if' scenario that satellite environmental information is planned-in and used in IFI project preparation and implementation on a systematic basis for all those projects identified with a simple rule of methodology for estimating the financial resources as follows: 0.1% of project resources during the preparation phase, and 1-2% of project resources during the project implementation phase. This may represent a significant economic volume of ~€200–300 million per year for this source of information.[104]

These orders of magnitude are consistent (even conservative) with some of the current observed use of satellite environmental information in the project implementation phase.

This methodology leads to first estimates for the potential economic size for EO-based information in support of all these projects as shown in Table 1.

Satellite environmental information in support of IFI projects	Value per year (€ million)
In support of the project preparation	40–50
In support of the project implementation	140–280

TABLE 1: Estimates for the Potential Economic Size for EO-based Information[105]

An analysis of the geographic location of these IFI projects (project planning pipeline for 2013-15) also shows that the majority of activities are taking place in South Asia and East Asia & Pacific, given below in Figure 15.

These considerations are preliminary, not comprehensive and will be subject to the (complex) procurement policies and regulations of each IFI and developing country. In addition, there are an increasing number of sources of free or very low-cost information becoming available that may be attractive even if not fully suited to the specific needs of projects.

Finally, this scenario is based on far-reaching and ambitious assumptions; i.e. that satellite environmental information is planned in and used in the project preparation and implementation on a systematic basis for all activities of relevance. Nevertheless, they indicate that if such a systematic, 'best-practice' approach was to be adopted, then the size of economic activity associated with the use of satellite environmental information could be significant (of the order of €200–300 million per annum) for just the following IFIs: World Bank, the Inter-American Development Bank, the African Development Bank, and the Asian Development Bank.

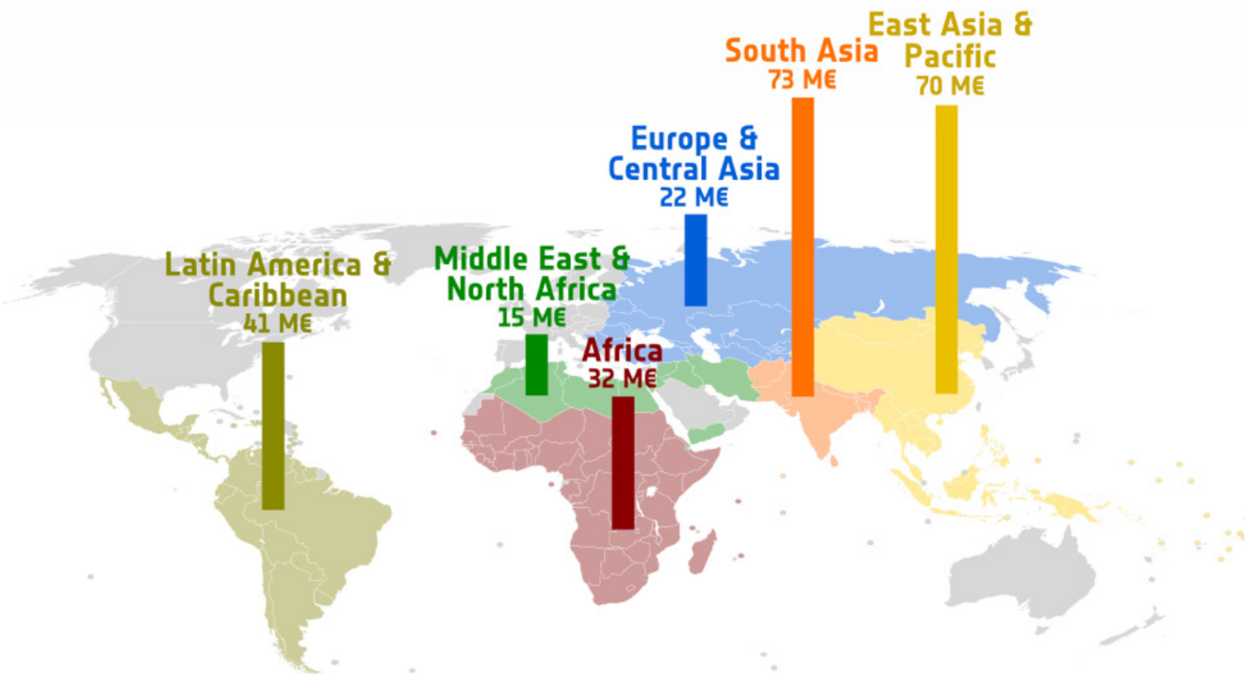


FIGURE 15: A Breakdown of the Geographic Distribution of Potential Economic Size for Satellite Environmental Information in Support of Planned IFI Projects in the Pipeline for 2013-15, to be Financed by the World Bank, the Inter-American Development Bank, the African Development Bank, and the Asian Development Bank

104 Analysis by ESA and Robin Roach (ABD International).
105 Same as above.

Strategic Vision & Activities

Strategic Vision and Activities

Key Points

- The strategic vision is to 'transfer and mainstream satellite environmental information into Development Aid operations, activities & financing',
- The barriers to achieving this vision include lack of awareness, acceptance and adoption in the Development Aid community (IFIs, National Development Aid Agencies, Private Foundations and Client States),
- Overcoming these barriers will require a sustained programme of effort and resources; therefore, a dedicated programme of work be initiated by ESA is proposed, referred to as 'Space for International Development Aid' (Space4IDA),
- This programme is designed from the outset to achieve sustainable transfer and systematic use of satellite environmental information, and should be implemented in partnership with the Development Aid stakeholders,
- The three suggested primary activities are:
  - Activity 1: Risk-Reduction Developments
  - Activity 2: Capacity Building for IFIs, National Development Aid Agencies, Private Foundations and Client States
  - Activity 3: Skills/Knowledge Transfer to Developing Countries

This chapter proposes a long-term, strategic vision for the role of satellite environmental information in Development Aid. It identifies barriers / obstacles to achieving this vision (based on current experiences) and proposes a dedicated, longer-term program concept of 'Space for International Development Aid – Space4IDA' to address these barriers and achieve the strategic vision. The chapter concludes with a discussion on the rationale for this approach and a first description of the potential content / activities.

Strategic Vision

The Development Aid community, by nature of the development activities carried out (many of which are large-scale infrastructure projects), have an evident and manifest need for coherent, consistent, accurate and varied environmental information (both current & historical). There is a growing public & political pressure to demonstrate that the development investments being made for economic growth are also environmentally sustainable (i.e. 'Green Growth'). Achieving the target of Green Growth requires a detailed understanding of the state of the Earth's environment; what is happening now, where has it come from, and what is going to be the likely evolution in the future. It is in this context, that satellite environmental information plays a key role.

Therefore, the long-term, strategic vision that is proposed and that will drive future activities to be implemented is proposed as:

> *"Transfer and mainstream environmental information from satellites into Development Aid operations, activities & financing"*

Here, 'mainstream' is to be understood as the systematic use of satellite-based information as a source of environmental information, planned and provisioned in the financial resources and operational working practices for all phases and activities of all international development projects; as per Figure 16.

This will involve understanding the role and contribution that satellite environmental information can play in some of the key documents defining the various stages of project implementation; notably the Project Concept Note (PCN), the Project Appraisal Document (PAD), the Implementation Status and Results report (ISR), and the Implementation Completion and Results report (ICR), or their equivalents in other Development Aid stakeholders.

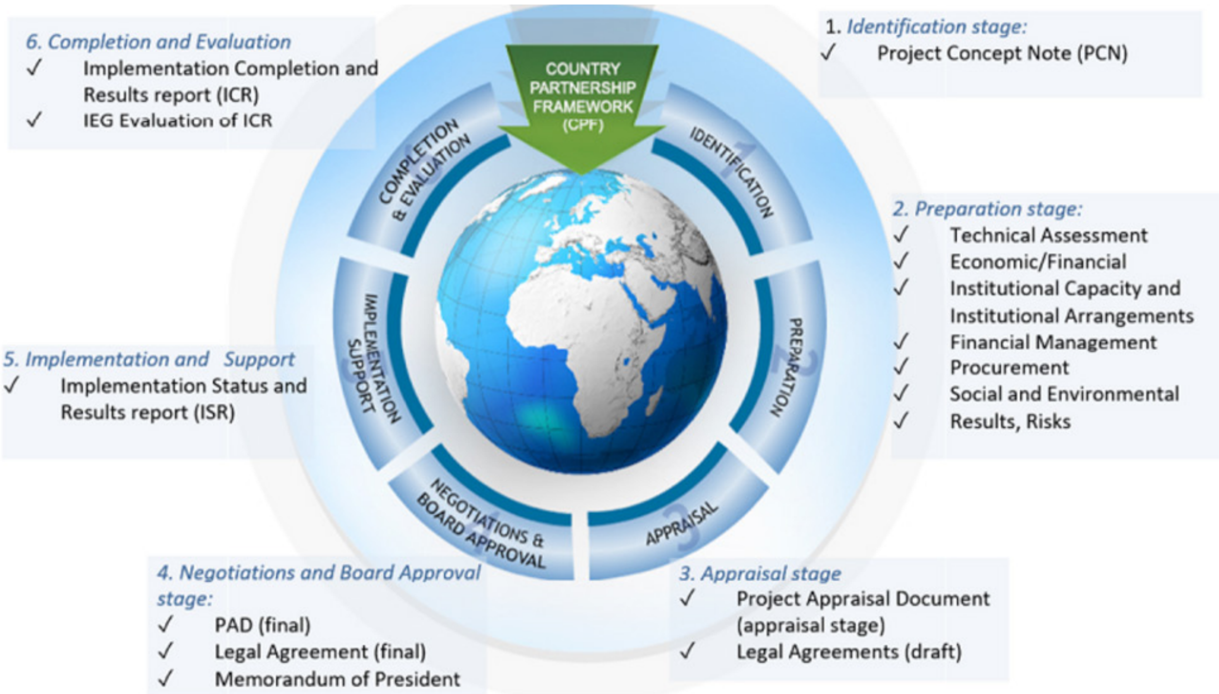


FIGURE 16: World Bank Project Cycle

It is also relevant in this context to also understand and work within the consultative process between the IFI e.g. World Bank and the Client State (borrower). This is strategically defined in the CPF **Country Partnership Framework**, which in turn is informed by a SCD **Systematic Country Diagnostic**. It is particularly relevant to assess the potential for a geospatial perspective early on, i.e. in the SCD phase, which is where an organisation such as ESA can provide access to independent and authoritative technical expertise and assistance.

It is acknowledged that this is an ambitious and far-reaching vision as it will require change (for improvement) and evolution in all aspects of the functioning of Development Aid; e.g. technical assistance, loan operations, policy formulation, planning and analysis. Given the complexity of the international Development Aid system and community, it is normal to anticipate that such fundamental changes such as adopting a new technology and way of working will require time and dedicated effort.

Therefore, '**Space for International Development Aid**', or Space4IDA, is proposed as a specific programme of work to be initiated by ESA, and this concept is referred to in this document. This is proposed due to the time and dedicated effort that will be required and the budgetary resources and timescales are discussed in the following chapter.

Such a programme of work would be built on the significant experiences and outcomes of previous activities both in ESA (EO4SD) and in other National Space Agencies (notably UK Space Agency, Netherlands Space Office, NASA, JAXA).

In particular, the current regional demonstrations in EO4SD are designed specifically to generate and deliver an extensive portfolio of detailed documentation in order to start longer-term transfer and integration of satellite environmental information in each of the nine specific thematic information/development domains; i.e. Strategic Plan, Client State and Stakeholder Capabilities Assessment, Stakeholder Engagement and Capacity Building Plan, Communications Package, Capacity Building Support Package, Service Delivery Operations Assessment, Service Delivery Utility and Impact Review, Stakeholder Engagement Review, EO Service Mainstreaming Roadmap.

In addition, the first meeting held at ESA in January 2018 with European National Development Aid Agencies identified pragmatic and valuable guidance on what and how longer-term activity to promote the wider use of satellite environmental information in development should be conducted. Some of these key recommendations include:

- The critical importance of capacity-building with Development Aid stakeholders,
- Involve the end-user from the very start in the co-design in the definition and planning of activities,
- Have the user commit to invest something into the activity (e.g. in-situ data, manpower and effort, co-financing),

- Build activities that are compatible and 'fit-in' to existing processes within the country; e.g. Land-use planning processes, National Adaptation Programmes of Action (NAPAs), Nationally Appropriate Mitigation Actions (NAMAs), and existing geospatial data infrastructures,
- From a technology viewpoint, cloud-based solutions are of great interest to many Developing Countries where computing infrastructure can be scarce.

The summary report of this first meeting (including all of the detailed recommendations) can be found at (http://EO4SD.esa.int/2018/01/23/esa-opening-a-dialogue-with-european-national-aid-agencies/). All recommendations would be fully taken on-board into scoping any activities to be carried out in a Space4IDA programme concept.

Barriers to Achieving the Strategic Vision

Based on the collective experience of previous activities, the main barriers to expanding the wider use of satellite environmental information in development can be specified as:

- **Awareness:** a lack of understanding in the Development Aid community and Client States of *what* environmental information this (complex) satellite technology can deliver, and a lack of a clearly argued *value proposition* for the use of satellite environmental information in Development Aid, i.e. that the benefits justify the costs incurred in using this technology.
- **Acceptance:** a lack of experience in the Development Aid community and Client States of *how* satellite information can be practically used in development activities, and an absence of an *authoritative 'champion'* for this technology from the Development Aid community.
- **Adoption:** a lack of capability and expertise to *operationally produce and deliver* satellite environmental information using local resources in developing countries and provide the follow-on *user consultancy and support*.

These barriers will be used to identify the activities to be carried out later in this chapter, but before this, it is appropriate to understand the basic rationale of why a programme concept such as Space4IDA should be required.

Rationale

— *Why this Space4IDA Programme?*

There are a growing number of initiatives directed towards the use of space technology and information for Sustainable Development (as summarised see Section 3), but Space4IDA is currently the only programme concept directed entirely to the specific needs of Development Aid operations, with the objective of achieving sustainable transfer and systematic use of satellite environmental information in the working practices and finances of this sector from the outset.

Development Aid is carried out on a geographic and economic scale that could provide resources for the inclusion of satellite environmental information technology, and has requirements on global, regional and local scales. Many of the Client States in which are recipients of Development Aid, are precisely those countries where there are ever-increasing changes taking place in the environment, as a result of both natural processes and also human activities. In addition, they are also those countries that often lack accurate and up-to-date information on the state of the natural resources. Furthermore, this programmatic concept provides a longer-term, stable framework that is needed for the Development Aid community stakeholders (IFIs, National Development Aid Agencies, Private Foundations and Client States) to engage strategically and start the process to progressively integrate and adopt this new technology.

The Space4IDA programme concept is also uniquely focused on promoting the world-leading European Earth Observation (EO) capabilities now becoming available, both in terms of space missions (ESA, EU, EUMETSAT, European national missions) and the highly-skilled, specialist capabilities of the European EO information services sector (industry, SME's, universities, government agencies/organisations).

As a secondary objective, the Space4IDA programme implementation would lead to growth in revenues for the European EO information services sector in developing countries. The developing world markets represent a growth opportunity for the European space sector. The developing world population is ~5 of 7.5 billion globally and will account for 60% of global GDP by 2030.[106]

106 OECD. 'Economy: Developing countries set to account for nearly 60% of world GDP by 2030, according to new estimates'. http://www.oecd.org/dev/pgd/economydevelopingcountriessettoaccountfornearly60ofworldgdpby2030accordingtonewestimates.htm. Accessed July 2018.

The total market size for satellite-based EO[107] globally is increasing from US$3.7 billion in 2018 to US$6.3 billion in 2026[108], see detail in Annex A.

The European market share in Latin America, Middle East and Africa, and Asia, grows from US$389 million in 2018 to US$726 million in 2026. The sectors with the most significant market opportunity by 2026 are Defence & Intelligence with US$164 million, Public Authorities with US$149 million, and Managed Living Resource with US$99 million, see detail in Annex A. These points have been discussed and noted with ESA Member States over the last few years, however, there are some constraints that must be considered in the implementation if this programme concept is to go ahead:

Firstly, the Space4IDA programme and activities must be driven by the requirements of the Development Aid community and must have active engagement of the partners' involved through alignment of their own resources in support of a joint programme of work. The term 'alignment' is used to mean the re-orientation of already planned activities, manpower or financial resources (in-kind contribution), or the assignment of new resources in support of the specific work to be carried out.

Observation: Note that the bulk of activity to be carried out is expected to be in the areas of capacity building and knowledge/skills transfer in the Client States, and therefore it is correspondingly expected that the financial resources needed for this should come primarily from the Development Aid sector. The next point below is an enabler for this to be possible.

Secondly, (and as a consequence of the above point) the Space4IDA programme and activities must be compatible for Official Development Assistance (ODA) financing.

Observation: In this respect, in June 2018 the OECD secretariat recommended that the Space4IDA programme concept be counted as ODA compatible, and this was accepted by the DAC Working Party on Development Finance Statistics (WP-STAT) with the consequent updating of the official OECD ODA information in Annex 2 List of ODA-eligible international organisations[109] and the channel codes in the DAC and CRS code lists.[110]

Thirdly, there are many on-going activities that promote the use of EO in Sustainable Development, and some specific programmes in place focussing on developing countries (in particular, the IPP of the UK Space Agency, the G4AW of the Netherlands Space Office, and the GMES & Africa initiative of both EU and African Union). Therefore, any new initiative should take full account of previous and existing activities in order to avoid duplication and confusion within the development user community and take full benefit results and achievements already in place.

Observation: Here, considerable effort has already been undertaken by ESA to dialogue with the Development Aid community in order to understand the longer-term requirements (with the IFIs) and identify a set of detailed recommendations (with the European National Development Aid Agencies) that would best position any future activity in to complement the current landscape.

— *Why Now?*

The changes taking place both in the supply (satellite environmental information) and demand (Development Aid) sectors lead to a firm belief that this current timeframe is the right time to start the Space4IDA initiative.

On the **supply side**, the initial programmes of work and investments (in both ESA and the EU) to develop and validate the satellite environmental information services have completed (2000-10 timeframe, order of €250 million total investment), the first demonstrations in the context of Development Aid have been carried out and the evidence of benefits are manifest, and the Copernicus EO programme is now being deployed. The entry into operations of the Sentinel satellites, with a full and open data policy, provides a global capacity to massively expand and diversify EO applications and services into other geographic regions, economic sectors and user communities.

On the **demand side**, the SDG indicators and metrics are defined and will drive requirements for environmental information, and the international stakeholders are ready to engage in a longer-term activity to integrate satellite environmental information into Development Aid practices.

There is also a high public and political interest in

107 Includes horizontals as defined by Northern Sky Research: Data, Value Added Service, Information Products, Big Data Analytics

108 Northern Sky Research. Satellite-Based Earth Observation (EO), 9th Edition.

109 OECD. 'Annex 2 List of ODA-eligible international organisations'. www.oecd.org/dac/stats/annex2.htm. Accessed August 2018.

110 OECD. 'DAC and CRS code lists'. www.oecd.org/dac/financing-sustainable-development/development-finance-standards/dacandcrscodelists.htm. Accessed August 2018.

some of the current high-profile societal problems arising from climate change and mass-migration, and consequently there is increased pressure to address the root causes of these problems.

There is also a sense of urgency to act now in order to support the European EO information service sector (currently world-leading in terms of technical expertise) to respond to the opportunity that the Development Aid sector represents for satellite environmental information and to maintain its position as a leader in the global competitive information services markets.

In summary, a window of opportunity presents itself now to capitalise on previous results, maintain and grow momentum with the Development Aid community in order to maximise the economic and societal benefits of investments space infrastructure already committed.

— *Why ESA?*

Since 2010, ESA has developed strong relationships with IFIs (World Bank, ADB and IFAD) as evidenced through 5-year, strategic MoIs to partner on the use of satellite environmental information in support of Sustainable Development. ESA is supporting the UN Statistical Division and the National Statistical Offices to integrate satellite environmental information in their practices to measure, monitor and report progress towards SDG targets.

ESA is seen by these partners as 'an independent, impartial and trusted technical authority on what satellite earth observation as a technology can produce in terms of information'.[111] ESA is not 'in-business' and ensures the technical quality, performance and accuracy standards from the European space sector to ensure Client States are correctly informed regarding the capabilities of satellite technology, as 'over-selling' the technology would lead a loss of confidence in satellite environment information in the user community.

As an R&D organisation, ESA Earth Observation Programmes (EOP) has more than 30 years' experience in developing EO information applications, products & services. In particular, ESA has developed a wide portfolio of satellite environmental information services to meet the needs of 400+ European government agencies and departments during the period 2000-2010. These information services have been transferred into operations and now form the basis of the EU's main six thematic Copernicus Services; Atmosphere, Marine Environment, Land, Climate Change, Emergency Management, Security (see: **http://www.copernicus.eu/main/services**).

In addition, ESA EOP is carrying out many other long-term development activities that are highly relevant to the Space4IDA programme concept (e.g. the 'TIGER' capacity-development initiative for water resources in Africa, the portfolio of global information products in support of UN environmental treaties and conventions, and the Climate Change Initiative; for further information see Annex C: Related ESA activities). Through these developments, ESA has an in-depth knowledge of the European EO information service sector, which allows ESA to source and qualify the best, technically qualified companies and organisations from the European sector to support the Development Aid community and Client States.

As an intergovernmental organisation of 22 European member states and one associated state (Canada), ESA has strong institutional relationships with European National Space Agencies, European Development Aid Agencies, the European Commission, and Directorate-General for International Cooperation and Development (DG DEVCO).

ESA collaborates internationally with non-European Space Agencies such as NASA, Japan Aerospace Exploration Agency (JAXA), Indian Space Research Organisation (ISRO), and the Chinese National Space Administration (CNSA), amongst others. ESA also collaborates extensively with Group on Earth Observations (GEO) and Committee on Earth Observation Satellites (CEOS), including joint authorship of 'Satellite Earth Observations in Support of the Sustainable Development Goals'.[112]

ESA is engaged on the SDG agenda on multiple fronts: as an active member of the GEO initiative on SDGs (EO4SDG), as co-lead of the CEOS Ad-hoc team on SDGs, as member of the Working Group on Geospatial Information (WGGI) of the Inter-Agency Expert Group on SDG indicators (IAEG –SDGs), and as member of a number of expert groups established by UN Agencies for the implementation of SDG indicators (e.g. 15.3.1 on land degradation, 6.6.1 on water-related ecosystems, 11.3.1 on land consumption).

111 Stephen Coulson (ESA). Personal Communication. June 2018.

112 ESA. 'SATELLITE EARTH OBSERVATIONS IN SUPPORT OF THE SUSTAINABLE DEVELOPMENT GOALS'. http://eohandbook.com/sdg/files/CEOS_EOHB_2018_SDG.pdf. Accessed July 2018.

In summary, the breadth and scope of ESA's activities bring technical excellence and leadership in the field of EO and allow ESA to operate as an enabler in space technologies.

— *Why Invest?*

In terms of types of activities (identified above), and overall budget and timescales (addressed in next chapter), the Space4IDA programme concept is roughly in-line with previous actual case experiences of integrating and transferring a high-technologies into Development Aid operations (i.e. the case of mobile telecommunications summarised in section 4).

The overall rationale for investing in a Space4IDA programme concept is given below, from the viewpoints of the different stakeholders involved.

From the Development Aid community perspective (IFIs, National Development Aid Agencies, Private Foundations and Client States): the Space4IDA programme would fully establish the use of an innovative technology as 'best-practice' source of environmental information that has the potential to deliver increased efficiencies for Development Aid operations (probably more for planning of future activities) for an investment of 1-2% of Development Aid resources. The programme activities are also naturally within the mandate of National Development Aid Agencies and IFIs to strengthen and improve local and national capacities in the production and use of satellite environmental information, by transferring these currently available and proven European skills, technological capability and knowledge to Client States within the context of economic development.

From the EO satellite stakeholders' perspective (Space Agencies, Ministries of Research, European EO information service sector): the Space4IDA programme could grow the use of satellite environmental information in Development Aid globally and on a significant economic scale (>€100 million per year) that could take benefit of the expertise and skills available in the European EO information services sector. In addition, it would provide opportunity for governments to evidence the substantial economic and societal benefits of investments in satellite EO.

It also strengthens the opportunity for the European EO information services sector to capture a share of the developing world EO market opportunity, as detailed in Annex A.

— *A First Discussion of Proposed Activities*

A high-level description of the types of activities required against the main barriers identified is presented below. The activities suggested in this chapter are a preliminary proposal and open to iteration with stakeholder feedback.

— *Awareness Barrier Addressed by Risk Reduction Developments*

Main activities consist of developing a working, 'fit-for-purpose' understanding of what satellites can deliver through a range of knowledge sharing materials that are specifically designed and adapted to the needs and language of the Development Aid community. This knowledge set should cover the well-established environmental information products based on previous demonstration projects, and also new developments for higher-risk, less well-established information requirements.

There are many project results for the well-established environmental information products from on-going programmes that can be utilised (ESA EO4SD Phase 1, Netherlands Space Office G4AW[113] and UKSA IPP[114]), and from which the lessons should be brought together and coordinated in a consistent & coherent manner, taking maximum benefit of the investments already made by National Space Agencies, and avoiding duplication of effort.

The new developments should focus on information requirements for themes or types of products that have not been investigated within the Development Aid context. Also those that are of high (and common) interest to National Development Aid Agencies but may be considered too difficult or ambitious (perhaps in terms of geographical or thematic scope) to be addressed by an individual National Development Aid Agency acting alone.

One candidate area for further developments to be undertaken is that of developing countries subject to Fragility, Conflict & Violence (FCV), which is a theme that other programmes have not fully addressed. The FCV theme is a major challenge for development

113 G4AW has 17 projects
114 IPP has 33 projects

due to loss of life, violations of human rights and destruction of cities and infrastructure. Conflict drives mass migration to neighbouring states and beyond – a prominent issue on the European agenda. Initial work has in-progress in this area in the ESA EO4SD Phase 1 activity for Fragility, Conflict & Violence (2018 -2021) and will be delivering results of key relevance to shaping future activity in this domain.

Another candidate for further developments is that of Climate Resilience & Proofing. In this area (as discussed in Chapter 7), Data Analytics offers a promising approach to characterise the non-obvious dependencies and impacts on social and political factors resulting from the predicted changes in baseline climate conditions. However, this is an emerging domain and much technical development remains to be carried out to understand these complex interactions of social, health, economic, and political factors with physical parameters of climate and the environment.

This activity will generate a reference portfolio of results, lessons and working examples of what environmental information satellites can deliver in the Development Aid context that can be shared across the Development Aid community. Communications activities will ensure that organisations learn from the programme, and each other, to replicate knowledge. This activity could use a range of communication channels within the development sector such as the World Bank Open Learning Campus (OLC) and the Asian Development Bank Institute (ADBI). In addition, ESA's communications channels could be used to promote knowledge exchange including the EO4SD **website**, an extension of the EO4SD **series of publications**, and promotion at ESA events including Living Planet Symposium.[115] See further detail in Chapter 11, section on Communications.

— *Acceptance Barrier Addressed by Capacity Building*

Main activities consist of: ensuring availability of data sets/tools together with a comprehensive capacity-building and training programme to ensure that Development Aid stakeholders and Client States understand how to use satellite environmental information easily in their operational activities.

This will require co-design and development (with Development Aid stakeholders and Client States) of accepted methodologies & best-practice guidelines for the use of satellite environmental information in Development Aid working practices (e.g. M&E, Environmental Safeguards policies). The capacity building activity is focused on IFIs and National Development Aid Agencies as the 'funders' and Client States as the 'users'. The capacity building mechanisms would be the same for both, but with variation in content for each audience.

For IFIs and National Development Aid Agencies it would ensure they are up-skilled in the use of satellite environmental information across the lifecycle of Development Aid projects, including: policy/strategy, identification, preparation, appraisal, negotiation, implementation and M&E.

Client State users (mainly government organisations and institutes) will be up-skilled in the use of satellite environmental information to address national development challenges. Again, co-design of methodologies and guidelines in the operational use would ensure end-users are involved early in the process, creating ownership and increasing the potential uptake. This capacity building would extend to organisations with principal roles in specific development sectors such as FAO (agriculture), UNEP (environment) and UNDP, as well as activities within the appropriate partnership networks such as WAVES, Cities Alliance and GFDRR. It would leverage existing relevant initiatives in the framework of GEO and CEOS.

A number of different mechanisms could be used to build capacity, as follows:

ONLINE PORTAL OF PRACTICES AND PROCESSES

This would be a published as a public domain, online portal that would host a library of guidance materials. An example would be 'How to use EO in Environmental Safeguards Systems (ESS)'. This is a long term, public good that all development agencies could benefit from.

The online environment could include a 'Lab' as an exploratory area that would provide satellite environmental information, visualisations and analysis tools for non-expert users, taking on-board feedback and results from a prototype development underway in EO4SD Phase 1 (and based on requirements defined by National Development Aid Agencies) that is currently planned for completion in 2019.

115 ESA. 'Living Planet Symposium'. https://lps19.esa.int/QuickEventWebsitePortal/living-planet-symposium-2019/website. Accessed July 2018.

EXPERT TECHNICAL ASSISTANCE TEAM

Provide a pool of technical experts for provision of technical assistance, training and guidance in all aspects of satellite environmental information in Development Aid working processes. The team could be accessible remotely and also in the IFI and National Development Aid Agency offices. These technical experts would provide custom advice to support the agencies to solve their individual, unique challenges. They would be sourced from the European EO information service sector, most likely from universities, research institutions or training consultancies, to avoid the conflict of interest from the private space sector promoting their own EO solutions.

Technical experts could also train agencies' teams on the use of satellite environmental information, via a 'Train the Trainer' mechanism, to allow a rapid proliferation of the knowledge across the organisation. The teams trained would be different in each development agency, as some, like the World Bank have dedicated geo-spatial team and EO internal working groups, whilst in others it is more likely to be their cross-sectoral technology and innovation teams. This training could be extended to the engineering/geospatial consultancies that commonly support the development agencies across all stages of the project lifecycle, further proliferating the use of EO.

ACCREDITED TRAINING COURSES

Accredited training courses available online and through face to face training on a series of thematically oriented subjects regarding the use of satellite environmental information. This would include an accreditation from ESA or a reputable education partner organisation. Accreditation could focus on topics within the project lifecycle where accreditation is common, for example in M&E. And also, where compliance risk is high, for example Environmental Safeguards Systems (ESS).

Example curriculum modules could include:

- For Development Agencies:
  - Satellite environmental information for Environmental Safeguards Systems (ESS),
  - Satellite environmental information for enhanced M&E, including in fragile or conflict states.
- For Client States:
  - Satellite environmental information for forestry management including Monitoring, Reporting and Verification (MRV),
  - Satellite environmental information for national disaster resilience planning and response.

An analogous example from the mobile telecommunications industry is the GSMA Capacity Building programme. A range of free training courses for policymakers and regulators to stay abreast of industry trends, delivered face-to-face and online, and accredited by the United Kingdom Telecommunications Academy.[116, 117]

— *Adoption Barrier Addressed by Skills/Knowledge Transfer to Developing Countries*

Main activities consist of a long-term, sustained process of knowledge and skills transfer of the existing capabilities (developed over the last two decades) in Europe for the production and analytics of satellite-based information into the developing countries, building on existing national assets (e.g. geospatial data infrastructures) to scale-up local production capability and expertise.

Knowledge transfer to Client State space sectors will ensure that local organisations can build solutions for local problems using their unique contextual understanding of the local environment. This ensures that the programme, 'does not only export solutions but builds capacities'.[118] It ensures long-term sustainability and reduced dependence on Development Aid in the future.

A series of Regional Expert Centres would be established for progressive transfer of this technical know-how and capability to the Client States. Maximum use of existing facilities / organisations in the developing countries should be ensured, and therefore Regional Expert Centres would be housed within government research centres, universities, space agencies or existing technology incubators, which could build upon similar initiatives in the GMES & Africa Programme. There are 1,000 'technology innovation hubs' in Asia and Africa'[119], which have

116 GSMA. '2018-2019 Course Catalogue'. https://www.gsma.com/publicpolicy/wp-content/uploads/2018/01/Capacity-Building-Course-Guide_EN18.pdf. Accessed July 2018.

117 GSMA. 'Capacity Building'. https://www.gsmatraining.com. Accessed July 2018.

118 GIZ. 'Current experiences in the use of satellite information in development aid activities from Germany'. http://eo4sd.esa.int/files/2018/01/GIZ-Presentation-ESA-WS-16.1.2018.pdf. Accessed July 2018.

119 GSMA. '1000 Tech Hubs are Powering Ecosystems in Asia Pacific and Africa'. https://www.gsma.com/mobilefordevelopment/programme/ecosystem-accelerator/1000-tech-hubs-are-powering-ecosystems-in-asia-pacific-and-africa/. Accessed July 2018.

internet bandwidth and computing infrastructure, relationships to the wider technology and investor communities, and a community of software engineering talent. World Bank InfoDev supports innovation hubs globally across Latam, Africa and Asia which could also be developed into Regional Expert Centres.[120]

The European EO information services sector (companies & organisations) would collaborate with the Regional Expert Centres to provide methodologies & guidelines to ensure service standards, quality, and operational use, expansion of the set of information services provided and access to new data sources. The European organisations could be private companies, universities or existing technology incubators. A competitive call process could be used to identify the best partner organisations.

A further incentive for European EO information services sector organisations is that through these activities, they would develop networks and contacts with local partners and potential customers in new geographic regions of developing countries. This could stimulate new potential demand for satellite environmental information products, as quantified in Annex A.

As a parallel example, the European mobile industry operators in the 1990s and 2000s expanded their operations from Europe to developing world countries by launching or acquiring operating companies. Vodafone (UK) has operating companies in Africa and India, Telefonica (Spain) has operating companies in Latin America, and France Telecom has operating companies across Africa. Operators have allowed start-ups to build on top of their networks, thus becoming a technology platform, on top of which a plethora of entrepreneurs can innovate and launch new services (see section 4, An Example of Integrating High Technology into Development Aid: Mobile Telecommunications).

A high-level summary schematic of the mapping of Stakeholders, Barriers & Activities is given in Figure 17.

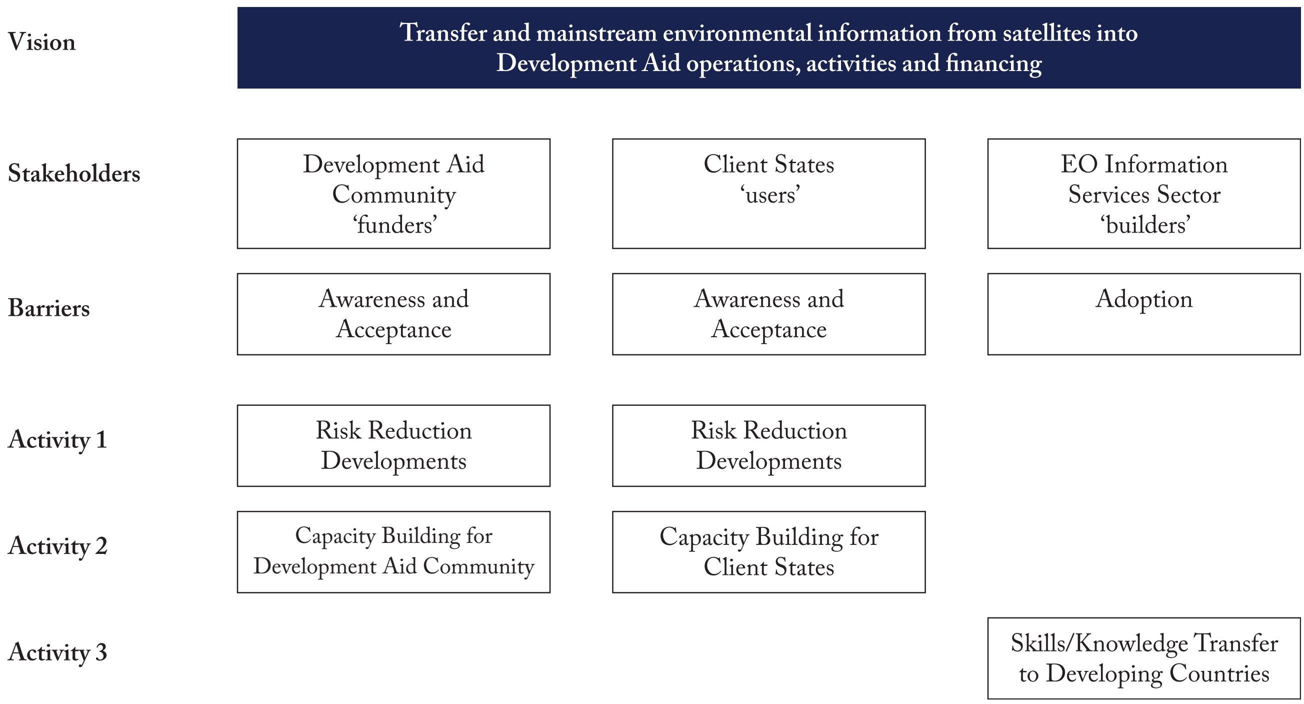


FIGURE 17: Vision, Barriers and Activities

120 Infodev, World Bank. http://www.infodev.org. Accessed August 2018.

— *Advantages of Focus on Capacity Building and Skills/Knowledge Transfer*

The focus on capacity building and skills/knowledge transfer activities within Space4IDA has advantages in addition to avoidance of duplication with European national programmes. These activities are less 'budget intensive' than the provision of grants for consortiums to execute projects. In addition, capacity-building activities can 'leverage' budget by triggering other development agencies to invest their own funding in satellite environmental information, thus amplifying development impact and European space sector growth in parallel.

Common Priorities of European National Development Aid Agencies

A separate analysis has been carried out on the Development Aid activities, planning and priorities of several European countries using publically available information from the OECD and the national Aid Agencies, including France, Germany, Italy, United Kingdom, Netherlands, Norway, Sweden, Switzerland.

Their common priorities are:

- **In terms of thematic priorities,** climate change, supporting Green Growth (with a special focus on Asia), and tackling the root causes of migration (including food security) are topics of major interest, with climate being priority for Norway, Sweden, France, UK and migration for Germany, Italy and Netherlands.
- **In terms of geographic priorities,** for most countries is Sub-Saharan Africa, with Asian countries being top recipients for some donors (e.g. India, China for Germany and Nepal, Myanmar for Switzerland).

Options for Programme Financing

Options for Programme Financing

Key Points

- The overall envelope for the integration of satellite environmental information into Development Aid is proposed on the order of €120-200 million and for a timescale of 2020-2025, with the bulk of the financing (€100-150 million) coming from Development Aid financing, and a small R&D component from ESA Members States (€20–50 million),
- Two options are foreseen for handling the Development Aid financing as follows:
  - Option 1 is for ESA to receive the Development Aid directly and implement Space4IDA activities as a single ESA programme with the Development Aid community,
  - Option 2 is for one or more IFIs to set up a Trust Fund for receipt of Development Aid and implement Space4IDA activities in a joint programme of work between ESA and Development Aid community,
- Both options have advantages and disadvantages for consideration.

This chapter describes the overall programmatic framework (budget and timescales) and two options for how Space4IDA could be implemented, including the roles for ESA Member States, ESA, National Development Aid Agencies, Private Foundations and the European EO information service sector.

Overall Budget & Timescales

From the previous chapter, the strategic vision of Space4IDA is recalled:

> *"Transfer and mainstream satellite environmental information into Development Aid operations, activities & financing"*

Together with the fact that integrating new, complex technology into Development Aid ways of working, will require time and dedicated effort.

Given the previous experiences of on-going programmes (ESA EO4SD, UKSA IPP, NSO G4AW) and the case of the mobile telecommunications technology being integrated into the development sector, the overall envelope for the integration of satellite environmental information is proposed as €120-200 million and for a timescale of 2020-2025, in order to achieve the required scale and impact.

Given also that the bulk of the activities are anticipated to be those of capacity building and knowledge/skills transfer into the developing countries, it is consequently expected that the bulk of the financing for the Space4IDA program should come from the Development Aid sector. A smaller element of financing could come from the traditional sources of ESA Member States in order to carry out mainly Risk-Reduction Developments activities (R&D Element).

Therefore, it is proposed that the National Development Aid Agencies from the developed countries (mainly European) would provide €100-150 million of Development Aid for the Space4IDA programme concept. ESA has initiated dialogue with some European agencies (through the first workshop held in Jan 2018) and could continue this throughout 2018/2019, if required. In addition, Private Foundations are also tentative partner/donors, although there have been little/no discussions by ESA with them to date.

In addition, ESA Member States[121] would contribute €20-50 million funding through their ESA subscriptions (CM19) for the R&D Element. These

121 ESA member states include 22 European states, plus Canada and Slovenia as non-full members.

agreements would be finalised at the next ESA Ministerial Council in end-2019. This financing would be through traditional sources (Ministries of Science & Research) and would not have any Development Aid compliance requirements.

ESA Industrial Policy and Geographical Distribution would ensure the benefit would be shared proportionally back to the contributing Member States through ESA Space4IDA calls for proposals and subsequent procurements.

A high-level breakdown of the ~€120-200 million total budget for initial discussion could be:

Activity 1	
Risk Reduction Development	€20–50 million
Activity 2	
Capacity Building	€40–60 million
Activity 3	
Knowledge/Skills Transfer	€60–90 million
Total	**€120–200 million**

ESA would coordinate and manage a joint programme of work to implement Space4IDA activities with the IFIs. ESA would utilise the experience built up working with IFIs since 2010 to lead the execution of the results framework, including M&E of Space4IDA's development impact, and also the knowledge exchange activities using ESA's communications channels. ESA would lead on collaborations with the European EO information service sector and work with other European government agencies including DG-DEVCO, DG-GROW, and DG-JRC.

The European EO information service sector would support mainly Activity 1: Risk Reduction Developments and partially Activity 2: Capacity Building and Activity 3: Skills/Knowledge Transfer to Developing Countries. These activities also support the secondary aim to grow the European space sector through new export opportunities in developing countries.

Two different options in terms of handling the Development Aid financing are presented below in terms of the stakeholders and their roles in Space4IDA, including ESA, National Development Aid Agencies, developing country users and partners, and the European EO information service sector.

Option 1: ODA Funding from Donors Direct to ESA

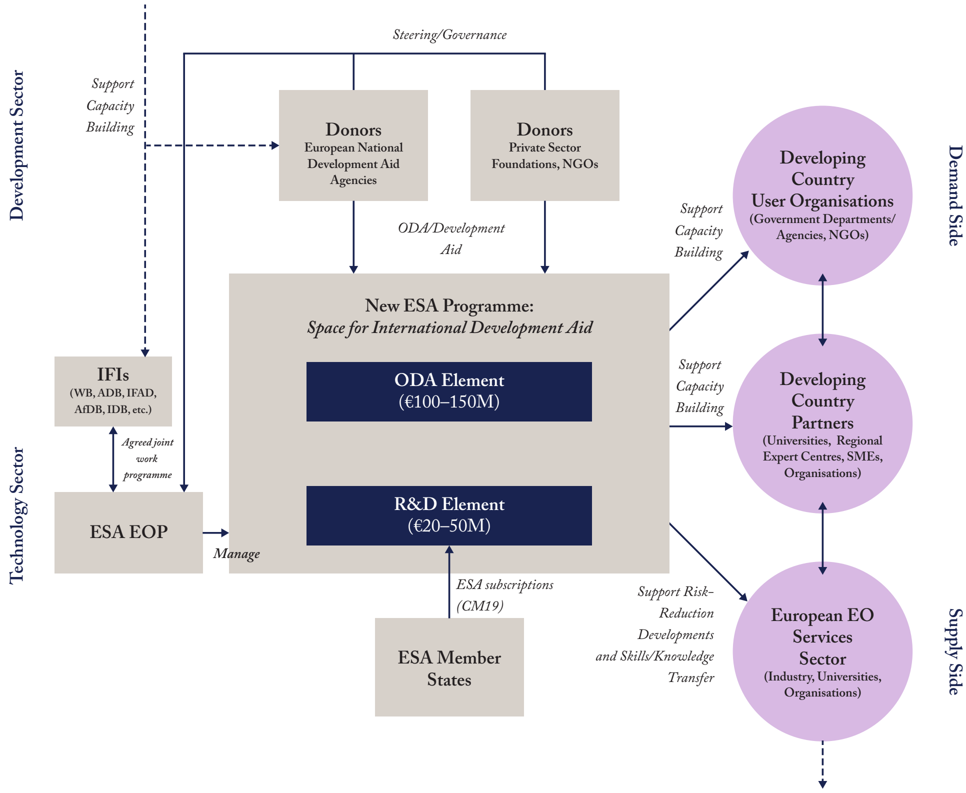


FIGURE 18: Option 1 Stakeholders and Roles

The National Development Aid Agencies and Private Foundations would provide funding directly to ESA for Space4IDA activities. ESA would be the single organisation delivering the programme.

The Space4IDA programme concept has been officially agreed by the ODA DAC as eligible to receive ODA financing, as B-03 bi-lateral aid with ESA as a channel. The IFIs would be involved in a similar role as per Option 2 but would be less proactively involved in the execution of activities as they are not handling financing of the programme.

— *Option 1: Advantages*

- A single programme managed by a single organisation,
- ESA have the technical competency and the proven ability to implement and deliver the results required in this area.

— *Option 1: Disadvantages*

- ESA would be operating beyond of its normal financing scheme through management of ODA funds and this may take initial time and effort to set up, but there are frameworks to handle this new source of financing,
- There is a risk that National Development Aid Agencies would not provide ODA financing to ESA as there could be misunderstandings due to no previous history of this happening,
- There is a risk that satellite environmental information would not integrate as fully into IFIs operations through lack of proactive involvement in implementation of activities.

Option 2: New Trust Fund and Joint Work Programme

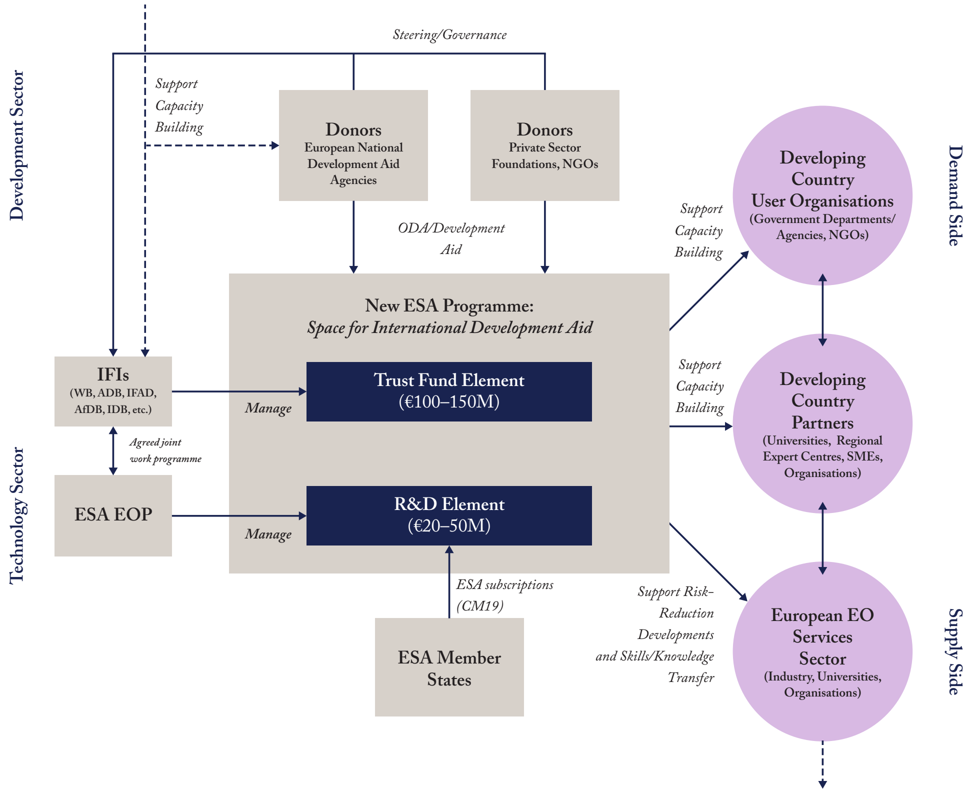


FIGURE 19: Option 2 Stakeholders and Roles

Figure 19 outlines an alternative programmatic structure. One or more IFIs would set up and manage a new Trust Fund(s) and coordinate and manage in partnership with ESA a joint work programme to implement Space4IDA activities, via a defined governance scheme. The National Development Aid Agencies and Private Foundations would be donors to the Trust Fund(s). Trust funds are vehicles used to manage funds contributed by development partners for specific development activities.[122] The World Bank has hundreds of trust funds, managing US$31.6 billion (end FY2017).[123]

— *Option 2: Advantages*

- All organisations are operating within their natural mandates & competencies, ensuring effectiveness and value for money,
- ESA is not required to manage ODA funds and the necessary compliance requirements,
- This scheme has the proactive involvement of the IFIs and directly integrates satellite environmental information into their operations and financing,
- The Trust Fund can be brought into operations through progressive donations that could reflect the changing priorities as they occur in individual National Development Aid Agencies and Private Foundations,
- It maintains separation of funding decisions between the National Development Aid Agencies for contributions to the Trust Fund Element, and the ESA Member State Science Ministries for contributions via ESA subscriptions (CM19) to the R&D Element.

— *Option 2: Disadvantages*

- Distributed management of the joint programme of work across ESA and the IFIs,
- The governance structure will need to be carefully defined and may be complex due to the number of organisations involved.

122 World Bank. 'Fact Sheet on World Bank Trust Funds'. http://siteresources.worldbank.org/CFPEXT/Resources/TFfactsheetapril2017.pdf. Accessed July 2018.

123 World Bank. '2017 Trust Fund Annual Report'. https://siteresources.worldbank.org/CFPEXT/Resources/299947-1274110249410/CFP_TFAR_AR13_High.pdf. Accessed July 2018.

A Stable Foundation from ESA Member State Subscriptions

In both options, establishing ESA subscriptions for Space4IDA will provide a long-term foundation for the programme. That foundation allows subsequent contributions from National Development Aid Agencies and Private Foundations to progressively contribute to in sequence from 2020-2025. This reduces the complexity of requiring multiple donors to agree contributions at the same time, which would be difficult due to their varying decision-making processes. It also allows donors to fund specific activities within the programme that align closely to their own priorities, for example, specific regions or countries.

Governance

As a six-year programme, in a rapidly advancing technology sector, Space4IDA will need to adjust its direction and scope to react to learning, changes in context and evolving partner needs. Whilst the long-term development challenges are well known and defined via the UN SDGs, the precise role for satellite environmental information to address those challenges is nascent and there will be significant learning. The programme will require a streamlined and efficient governance process that enables and supports the ability to adjust direction and scope whilst within the constraints of the original programme strategy agreed by Member States, IFIs and Development Aid Agencies.

Implementation Topics

Implementation Topics

Key Points

- Space4IDA will ensure long term sustainability and reduce dependence on Development Aid in the future by focusing heavily on capacity building and skills/knowledge transfer activities,
- Compliance to ODA requirements will be managed by either the IFIs or ESA depending on the selected programmatic structure,
- The Space4IDA programme will require a robust M&E (results reporting) framework to measure and communicate progress against its primary and secondary aims,
- The Space4IDA programme will generate a reference portfolio of results, lessons and best practice that will be shared across Development Aid Community. Communications activities will ensure that these organisations learn from the programme, and each other, to replicate best practice.

This chapter provides additional detail on some issues regarding how Space4IDA will be implemented, including long term sustainability of impact, ensuring ODA compliance, M&E (results reporting) and communications.

Ensuring Long Term Sustainability of Development Impact

Sustainability in Development Aid programmes is defined by OECD DAC as the 'benefits of a programme or project continue after donor funding ceased'.[124] It is the achievement of an on-going, long lasting impact in the country after the original grant funding ends. Sustainability is a risk for all development programmes. That risk is compounded for Space4IDA as satellite environmental information is complex, comes at cost, international customers are not yet aware of the case for space to solve development challenges, and best practices of how the space sector can address development challenges are only beginning to emerge.

Space4IDA will mitigate this problem by focusing heavily on capacity building and skills/technology transfer activities to ensure long-term sustainability and reduce dependence on Development Aid in the future. Ultimately the long-term goal is that satellite environmental information is a 'business as usual' element for the Development Aid community and Client States, and the need for support from the programme diminishes. The focus in the strategy on capacity building and skills/knowledge transfer via Regional Expert Centres is specifically designed to facilitate this from the outset of the programme.

Managing ODA Compliance

OECD's Development Assistance Committee (DAC) defines Official Development Assistance (ODA) as being focused on 'economic development and welfare of developing countries'[125] and 'is concessional in character'.[126] All development programmes utilising ODA funding must adhere to these principals by ensuring and demonstrating that development is the primary objective of the efforts. In addition, individual National Development Aid Agencies have their own ODA legislation and requirements, for example in the UK.[127] In programmes such as the UK's

124 OECD. 'DAC Criteria for Evaluating Development Assistance'. http://www.oecd.org/dac/evaluation/daccriteriaforevaluatingdevelopmentassistance.htm. Accessed April 2018.

125 OECD. 'DAC List of ODA Recipients'. https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/DAC_List_ODA_Recipients2018to2020_flows_En.pdf. Accessed July 2018.

126 OECD. 'Official development assistance – definition and coverage'. http://www.oecd.org/dac/stats/officialdevelopmentassistancedefinitionandcoverage.htm. Accessed July 2018.

127 UK Government. 'International Development (Official Development Assistance Target) Act 2015'. http://www.legislation.gov.uk/ukpga/2015/12/pdfs/ukpga_20150012_en.pdf. Accessed July 2018.

International Partnership Programme, where UKSA is managing UK ODA directly, robust regimes have been established to ensure ODA compliance and alignment to the UK International Development Act, which has been positively reviewed by the UK's Independent Commission for Aid Impact.[128]

In Option 2 for the programmatic financing, the ODA compliance risk is removed as the IFIs will manage the Development Aid, and ESA will manage its R&D budget through the normal Science and Research channels from Member States. In this model both organisations (IFIs, ESA) are executing 'business as usual' activities, with an IFI being already fully accredited organisations by OECD in the disbursement and management of Development Aid.

In Option 1, ESA have been in discussions during the first half of 2018 as to how the ODA accreditation or eligibility could be managed. The OECD Development and Assistance Committee (DAC) met in June 2018 and officially agreed that the Space4IDA program is considered eligible for ODA financing as un-earmarked (B-03) bi-lateral Development Aid with ESA acting as a channel. Consequently, the official OECD ODA information in Annex 2 List of ODA-eligible international organisations[129] and the channel codes in the DAC and CRS code lists[130] has been updated on the OECD web site.

In this scheme, the donors would be responsible for identifying their contributions to Space4IDA as ODA expenditure. Here, ESA would provide all the necessary supporting material for this to be done.

Monitoring & Evaluation (Results Reporting)

M&E is the process to assess how a Development Aid programme was implemented, what can be learnt, what impact it makes, for whom, how and why. It is a results reporting framework, that focuses not only on short-term outputs, but on long-term development outcomes and impacts.

M&E ensures organisations measure and communicate long-term benefits that Client States desire from the outset, and therefore supports the goal of long-term sustainability, because it communicates why the Client States should adopt the service. It is particularly important for Space4IDA, as using satellite environmental information for Sustainable Development is nascent, and the impact and cost-effectiveness needs to be measured and communicated.

There are well established, formalised methodologies and processes for M&E. M&E is a standard activity within Development Aid and best practice is published by World Bank[131], ADB[132], DFID[133], GIZ[134] and AFD[135], with common principles drafted by the OECD DAC.[136] Space4IDA will develop a single M&E results framework satisfying the requirements of all partners based on this best practice.

The M&E data from the beneficiaries of Space4IDA's activities will need to be aggregated and communicated. This is difficult but is achievable if a unified M&E framework, with common methodologies (including consistent results indicators) is used by both the programme and the grantee consortiums. Caribou Digital executes a similar M&E framework to aggregate the results from IPP's 33 projects into evaluations for UK Government and the public domain.

The main activities within Space4IDA's M&E methodology would include:

M&E Plan: details how the programme would execute its M&E framework including definition of audiences, evaluation questions, methodologies and data collection requirements.

Results Framework: would be structured as a logical framework (logframe)[137] and would include KPIs, SMART targets, results indicators and indicator

128 Independent Commission for Aid Impact. 'Global Challenges Research Fund: A Rapid Review'. https://icai.independent.gov.uk/wp-content/uploads/ICAI-GCRF-Review.pdf. Accessed July 2018.

129 OECD. 'Annex 2 List of ODA-eligible international organisations'. www.oecd.org/dac/stats/annex2.htm. Accessed August 2018.

130 OECD. 'DAC and CRS code lists'. www.oecd.org/dac/financing-sustainable-development/development-finance-standards/dacandcrscodelists.htm. Accessed August 2018.

131 World Bank. 'Monitoring and Evaluation - Some Tools, Methods & Approaches'. http://siteresources.worldbank.org/EXTEVACAPDEV/Resources/4585672-1251481378590/MandE_tools_methods_approaches.pdf. Accessed July 2018.

132 Asian Development Bank. 'Guidelines for Preparing A Design and Monitoring Framework'. https://www.adb.org/sites/default/files/institutional-document/32509/guidelines-preparing-dmf.pdf. Accessed July 2018.

133 DFID. 'Building the evidence to reduce poverty'. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/67729/evaluation-policy.pdf. Accessed July 2018.

134 GIZ. 'Monitoring and evaluation in detail'. https://www.giz.de/expertise/html/4987.html. Accessed July 2018.

135 AFD. 'Evaluation, A Learning Tool to Improve Practices'. https://www.afd.fr/en/evaluate-our-actions. Accessed July 2018.

136 OECD. 'Evaluation of development programmes'. http://www.oecd.org/dac/evaluation. Accessed July 2018.

137 World Bank. 'The Logframe Handbook'. http://documents.worldbank.org/curated/en/783001468134383368/pdf/31240b0LFhandbook.pdf. Accessed July 2018.

sources.

Baseline Evaluation: would be completed at the start of the programme to determine starting (baseline) conditions before the programme starts having an impact. It provides the initial values for the indicators in the results framework, from which progress can be measured.

Midline Evaluation: formally assesses interim progress against the programme's primary and secondary aims, allowing course corrections to be made. The Midline Evaluation (and Endline Evaluation) would align to the OECD DAC Evaluation Criteria (Relevance, Effectiveness, Efficiency, Impact, Sustainability).[138]

Endline Evaluation[139]: at the end of the programme to assess the final achievement of the primary and secondary aims against baseline conditions, to assess progress and to capture key learnings and recommendations for ESA, the partners and wider space and development sectors.

Economic impact: included as part of the Midline and Endline evaluation, would assess the economic impact of the programme on both Client States and European Member States.

Communications

Space4IDA will generate a large volume of results, lessons and best practice that can be shared across the Development Aid community. Communications activities will ensure that organisations learn from the programme, and each other, to replicate best practice. This will lead to amplification of the programme's primary aims for development impact and in parallel the secondary aim for growth of European space sector.

Space4IDA's primary audiences are the Development Aid community and EO4SD can provide an online and real-world forum for the sharing of knowledge and experiences amongst them.

The primary message will be the promotion of satellite environmental information to support development impacts. This message must focus heavily on the development benefits and only secondarily on the technology, as the Development Aid community and Client States are indifferent to the technology itself, so long as it is more accurate, informative, regular and cost-effective than their existing environmental data sources.

The programme would use a range of communication channels within the space and development sectors, such as the World Bank Open Learning Campus (OLC) and the Asian Development Bank Institute (ADBI). In addition, ESA's communications channels to the space sector can be used to promote knowledge exchange including the EO4SD **website**, an extension of the EO4SD **series of publications**, and promotion at ESA events including Living Planet Symposium.[140] ESA has first-rate communication channels across European governments to the European and global space sector and to development agencies. In addition, the Development Community can onward share EO4SD communications through their extensive channels.

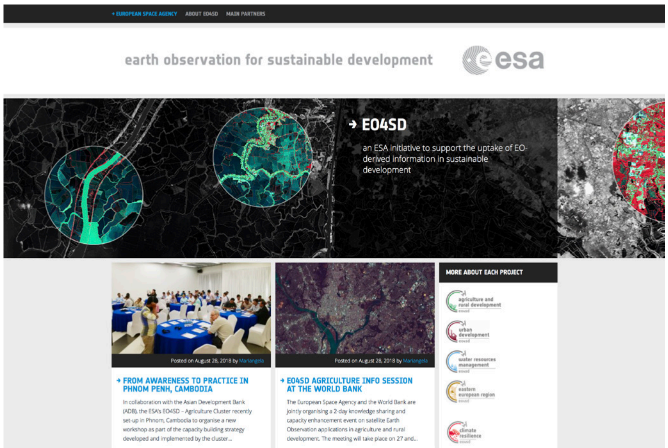


FIGURE 20: EO4SD Website

138 OECD DAC. 'DAC Criteria for Evaluating Development Assistance'. http://www.oecd.org/dac/evaluation/daccriteriaforevaluatingdevelopmentassistance.htm. Accessed July 2018.

139 Also referred to as final, summative, or ex-post evaluation

140 ESA. 'Living Planet Symposium'. https://lps19.esa.int/QuickEventWebsitePortal/living-planet-symposium-2019/website. Accessed July 2018.

Annexes

Annex A: Market Opportunity for the European EO Information Services Sector

As a secondary benefit, the Space4IDA programme would lead to growth in revenues for the European EO information services sector in developing countries.

The developing world population is ~5 of 7.5 billion globally and will account for 60% of global GDP by 2030.[141]

The total market size for satellite-based EO[142] globally is increasing from US$3.7 billion in 2018 to US$6.3 billion in 2026, as per Figure 21.[143]

The total market size in 2018 for Latin America (LAM) is US$192 million, for Middle East and Africa (MEA) is US$277 million and Asia is US$706 million. N.B. These regions include developed and developing countries.

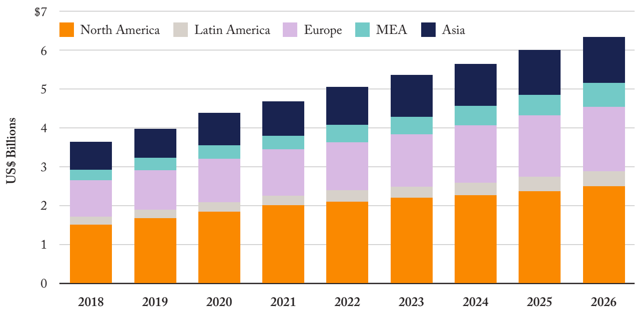


FIGURE 21: Global Satellite-Based EO Market by Region (US$ millions)

The European market share of the global satellite-based EO market is one third, as calculated by the European Association of Remote Sensing Companies.[144] Therefore, the European market share in Latin America, Middle East and Africa, and Asia, grows from US$389 million in 2018 to US$726 million in 2026, as per Figure 22.

The sectors with the most significant market opportunity by 2026 are Defence & Intelligence with US$164 million, Public Authorities with US$149 million, and Managed Living Resource with US$99 million. The definitions of these verticals are provided in Figure 23.

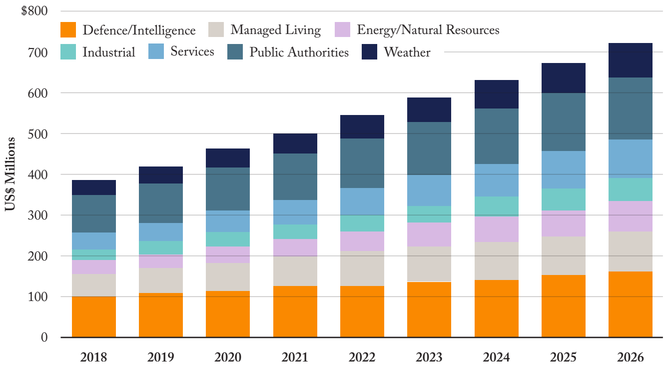


FIGURE 22: European Market Share of LAM, MEA and Asia, Satellite-Based EO Market, by Sector[145]

141 OECD. 'Economy: Developing countries set to account for nearly 60% of world GDP by 2030, according to new estimates'. http://www.oecd.org/dev/pgd/economydevelopingcountriessettoaccountfornearly60ofworldgdpby2030accordingtonewestimates.htm. Accessed July 2018.

142 Includes horizontals as defined by Northern Sky Research: Data, Value Added Service, Information Products, Big Data Analytics

143 Northern Sky Research. Satellite-Based Earth Observation (EO), 9th Edition.

144 Geoff Sawyer. European Association of Remote Sensing Companies. Personal Communication August 2018.

145 Caribou Space analysis using Northern Sky Research, Satellite-Based Earth Observation (EO), 9th Edition.

FIGURE 23: Northern Sky Research Classification of Sectors

Annex B: Satellite Environmental Information for Environmental Safeguard Systems (ESS)

Environmental Safeguard Systems for Development Aid

National and multi-lateral development agencies are working to deliver Sustainable Development and thereby achieve the UN Sustainable Development Goals. They have historically sought to achieve development through individual investment projects, such as building a dam for power generation.

Such development activity is accompanied by environmental policy and procedures to screen proposed projects; and to assess the impacts and performance of projects when implemented. These policies and procedures are termed broadly Environmental Safeguard Systems (ESS), and in recent years the receipt of Development Aid by developing country partners has become conditional upon on the use of these safeguard mechanisms. For individual projects, the means to include environmental impact in decision-making, and therefore deliver Sustainable Development is through Environmental and Social Impact Assessment (ESIA, also EIA).

Whilst the widespread use of ESIA has been a boon for the consideration of the environment within decision-making, it is sometimes viewed as a 'bolt-on' to project implementation, rather than a central consideration of the development process. Consequently, there has been an increase in macro-level interventions including direct budget support; policy reform; sector and programme financing. Under this approach, environmental impacts are mainstreamed into broad policy and strategic decision-making by creating and fostering linkages between environment and economic development. Making such explicit connections allows decision-makers to map out different development pathways, and to better shape the future of a region or a country in a more holistic and sustainable manner.

This strategic sector-wide support tends to involve qualitative programmes working at an organisational and institutional level. For instance, the German Development Corporation (GIZ) works under this approach in Benin, by directly linking poverty reduction and the environment. Application of existing ESS to these types of activities has been challenging, and has led to the development Strategic Environmental and Social Assessment (SESA; also SEA) to assess them.

Harmonisation of ESS, and the Contribution of Satellite Environmental Information

After the Paris Declaration, the International Finance Corporation's (IFC) updated its Policy and Performance Standards on Environmental and Social Sustainability. Following this, most other agencies and multilateral development banks are reported to have updated their systems to harmonise their ESS strategically and procedurally, typically towards the IFC model, and thereby reduce transaction costs and improve the environmental quality of Development Aid.

Accordingly, there are increasingly standardised ways in which satellite environmental information can support ESS across projects from different agencies. Under strategic sectoral aid packages, satellite environmental information may support any quantitative components of a SESA (e.g. where national forest cover and deforestation needs to be mapped to assess outcomes from budgetary support for a forest agency). However, it is on the classic investment project level, where quantitative ESIA is required throughout, that EO has a clear and central role to play.

Satellite environmental information can add significant benefits to each of the predefined stages of the development project cycle, which are:

- Identification, screening and approval (effectively due diligence for new project activities), including impact assessments,
- Monitoring of project implementation,
- Ex-post evaluation of activities.

Identification, Screening and Approval

This is an ex-ante, early phase of aid-activity implementation where social and environmental risks are assessed against the expectations and rules of the development agency. Activities are categorised into different risk levels, which determines the level of scrutiny the project receives under ESS. At this point, satellite environmental information can provide assessment of baseline environmental conditions and inform analyses of the impacts of a project. For instance, in the context of the building of new dam in a forested area, harmonised rules demand that there is no negative impact: the World Bank's operating principle is to assess potential impacts of projects on physical and biological resources.

Project principals will need first to create maps of the vegetation in the project site. In large and remote areas, using satellite data to scale-up field surveys is the only feasible way to do this. Indeed, this is a classic use case for satellite environmental information, called land cover / use mapping, which involves the thematic classification of satellite data. These classified maps help identify intact and high-quality critical habitats for flora and fauna, quantify the connectivity between these, and may indicate their value to local communities (e.g. for non-timber forest products). These high-quality areas may be distinguished from degraded habitats which under increasingly harmonised ESS rules should be prioritised for development.

The impact of the development activities will then need to be assessed, e.g. by plotting maps of the proposed dam's inundation area onto the habitat map to reveal which areas will be flooded (this stage may also involve an element of modelling as well as EO data analysis). Where there are impacts projected on critical habitats, the harmonised ESS rules suggest that it will likely be necessary to offset any significant adverse environmental and social impacts. In the case of the dam, this will involve locating other areas outside the inundation area that are also under threat, but which could be conserved through a project intervention as an offset. Technically, this will require surveying additional candidate areas for their ecological suitability. This can be achieved by scaling up the original land cover map across the landscape. This may simply involve the acquisition and processing of new satellite datasets and using existing field data for calibration.

This represents a huge benefit of using satellite data: without EO, this stage would require a new campaign of field data collection, far greater degree of field-level surveys, elevating time and labour costs.

Monitoring

When a project has been authorised, the impacts on the environment will need to be monitored to ensure that there are not adverse impacts and report on-going impacts to donors. For instance, where a project is developed in a forested area, deforestation will need to be monitored to ensure that the process does not accelerate above the rates anticipated in the impact assessment. Forest monitoring is a type of land cover change detection, which is another classic use case for EO, involving analysis of time-series of satellite images over the project area. Similarly, if offset sites are used to mitigate environmental impacts, these will need monitoring to ensure there is a quantifiable offset effect. As with baseline land-cover mapping, the major benefit of EO is that the same monitoring system can be applied at scale across the landscape, including to the offset sites, without additional costly field surveys. The costs of using EO relative to field surveys for monitoring fall even further when considering multiple surveys.

Evaluation of Project Success

In order to understand aid effectiveness and relative success, projects are evaluated ex post. In such an evaluation, the environmental impacts at a site must be quantified, and compared against historical changes at the site prior to the inception of the development project, and ideally measured against a control site. Returning to the dam example, the project principal would need to compare deforestation rates prior to the start of the dam building project, with those after. By searching data archives, EO analysts can provide historical estimates of deforestation (land cover change mapping applied to archive imagery) and compare those to deforestation observed during the monitoring phase of the project.

For all of these use cases, the general benefits of EO are that it provides:

- Objective intelligence,
- That is replicable over space and time,
- Scalable to other uses cases,
- A means to map land cover and change, in large and remote areas even in the presence of persistent cloud,
- As such, for large-scale projects, EO is typically far more cost-effective than using field teams to conduct surveys.

Types of EO Data used for ESS

The ultimate choice of technology used to support each of the tasks explained above will depend upon the budget available and the degree of accuracy, and temporal and spatial resolution required for the analysis. Typically land cover mapping and land cover change detection is achieved through the analysis of optical satellite data, calibrated with field data.

Examples of freely available optical satellite data include NASA's Landsat-8 satellite providing data at 30m pixel resolution every 16 days. ESA's Sentinel-1 satellite provides data at 10m pixel resolution every six days. However, many development projects are implemented in the cloud-covered tropics, where cloud obscures optical imagery. As such, there is increasing use of satellite radar (Synthetic Aperture Radar from ESA's Sentinel-2 satellite; every 6 days; 10m pixel resolution) data to supplement optical data, since it is cloud-penetrating. Additionally, as an active-sensing technology (emitting a beam of microwave energy at the surface of the earth) it can detect subtle changes in the target, such as degradation occurring within a forest: radar is particularly useful for forest monitoring in tropical countries.

If higher resolution mapping is required, e.g. if the habitat affected by a project is highly fragmented, and existing in small areas, it may be appropriate to use high spatial resolution data from a commercial satellite such as Worldview, which is available at 0.3m. This is ideally suited for mapping out individual habitat features such as narrow wildlife corridors. However, the high resolution is offset by the costs of acquisition, and also of processing. The reader is encouraged to refer to the report from UK Space Agency and Caribou Space called Space for Disaster Resilience in Developing Countries[146] for further information on satellite sensor types.

146 UKSA & Caribou Digital. 'Space for Disaster Resilience in Developing Countries'. https://www.spacefordevelopment.org/library/space-for-disaster-resilience-in-developing-countries/. Accessed August 2018.

World Bank ESS Policies	Associated Operating Principles	EO Applications and Benefits
"To support the integration of environmental and social aspects of projects into the decision-making process"	"Assessing] potential impacts of projects on physical [and] biological resources…"	EO can support this objective by scaling up measurements from the ground of physical and biological resources. Field teams can survey isolated patches of forest. However, this data is limited in the geographic scale it can cover. Satellite data can be used therefore to upscale the mapping of physical and biological systems, like forest biomass, across the landscape (satellite image thematic classification for land cover / use mapping).
"To promote environmentally sustainable development by supporting the protection, conservation, maintenance and rehabilitation of natural habitats and their functions"	Avoiding financing projects, or financing natural forest harvesting or plantation development, causing significant conversion or degradation of critical natural habitats	EO provides the ability to objectively detect and assess landscape changes over time using new incoming data (landscape/habitat monitoring). Analyses can also be applied to archive data to provide historical change analysis.
"To realise the potential of forests to reduce poverty…and protect the global environmental services and values of forests".	Giving preference to siting projects on lands already converted	EO can support this principle through vegetation mapping using satellite image classification to produce land cover / land use maps. The classification will provide a thematic map, showing intact high-biodiversity and carbon forests; degraded forests; water bodies; roads; settlements; and agricultural areas. These thematic maps can be used to support the planning process to avoid development in high-value forests.

TABLE 2: Examples of World Bank ESS Policies, Associated Operating Principles, and EO Applications and Benefits[147]

Environmental Safeguard System	Environmental and Social Impact Assessment (ESIA)	Strategic Environmental and Social Assessment (SESA)
Development approach	Project-level interventions e.g. new dam construction	Macro interventions e.g. budget support, policy reform, sector and programme finance
EO applications	Land cover use mapping (satellite classification and thematic map creation) Land cover/use change detection (ongoing monitoring) Land cover/use change detection (using archive data to map historical changes)	Less clear, as the system tends to be more qualitative, supporting the linkages between organisations There may be cases where specific environmental indicators are used to assess outcomes, e.g. deforestation rates, a classic case for EO

TABLE 3: The Applications of EO to Supporting Environmental Safeguard Systems is Clear in the Case of Project-level Interventions and ESIA, However it is Less Clear for SESA

147 World Bank. 'Table A1 - Environmental and Social Safeguard Policies—Policy Objectives and Operational Principles'. https://policies.worldbank.org/sites/ppf3/PPFDocuments/Environmental%20and%20social%20safeguard%20policie.pdf. Accessed August 2018.

Annex C: Related ESA Initiatives in Earth Observation

This annex highlights some of the main on-going activities in ESA's Directorate of Earth Observation Programmes (EOP) that are relevant to Space4IDA. It is not meant to be comprehensive but is included to indicate the scope and breadth of ESA EOP technical experience in this sector.

ESA Involvement in the SDG Agenda

ESA is engaged on the SDG agenda on multiple fronts: as an active member of the GEO initiative on SDGs (EO4SDG), as co-lead of the CEOS Ad-hoc team on SDGs, as member of the Working Group on Geospatial Information (WGGI) of the Inter-Agency Expert Group on SDG indicators (IAEG –SDGs), and as member of a number of expert groups established by UN Agencies for the implementation of SDG indicators (e.g. 15.3.1 on land degradation, 6.6.1 on water-related ecosystems, 11.3.1 on land consumption).

ESA has participated to various SDG related events: 4th Plenary of UN GGIM Europe (Brussels, June 2017), 7th session of UN GGIM (NYC, July 2017), SDG side meetings at the GEO XIV Plenary (Washington DC, Oct 2017), 5th High Level Forum on UN Geospatial Information (Mexico city, Nov 2017), UN Statistical Commission (NYC, March 2018), UNISPACE+50 High Level Panel on EO solutions for the SDGs (Vienna, June 2018) and High Level Political Forum on SDGs (NYC, July 2018).

As Member of the Working Group on Geospatial Information (WGGI) of the IAEG-SDGs, ESA contributed to the program of work of WGGI and in particular to the WGGI Task Stream on Analysis and Production Ready EO data for SDG indicators.
As Member of UN expert teams, ESA contributed to a number of methodological guidelines prepared by UN specialised agencies on SDGs indicators (e.g. UN Environment for SDG indicator 6.6.1 on extent of water related ecosystems, and UNCCD for SDG indicator 15.3.1 on the proportion of land that is degraded).

In April 2018, ESA launched a new €400K, 18-month duration project on "EO for the Sustainable Development Goals" to support the European EO community to play a prominent role (in cooperation with CEOS and GEO) in the full realisation of EO in the 2030 Agenda for Sustainable Development. This will support countries to measure, monitor and report progress towards the SDGs, and put in place informed development policies, and ensure international accountability. The first activity of the project is to review the EO contribution to the SDG targets and indicators and identify areas of better uptake of EO and European assets.

ESA initiated discussions with the Global Partnership for Sustainable Development Data (GPSDD) to align activities in areas of common interest, addressing a variety of themes in the Sustainable Development context. A Memorandum of Intent (MoI) has been drafted and will be signed after the summer break.

On behalf of the Committee on Earth Observation Satellites (CEOS), ESA published in March 2018 the CEOS **Earth Observation Handbook on SDGs** to showcase the contribution of Earth Observation to the realisation of the 2030 Agenda. The CEOS Handbook was coordinated with the GEO initiative on SDGs and with the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM).

ESA Engagement in the Global Agendas of Multilateral Environmental Agreements (MEAs)

A few examples of ESA's technical expertise and guidance being used in the context some key environmental treaties & conventions are given below.

— *UN Convention to Combat Desertification (UNCCD)*

The UNCCD is the centerpiece of the international community's efforts to combat desertification and land degradation in dry-lands. ESA supports the UNCCD by developing, testing, showcasing and promoting innovative EO approaches and methods for the assessment and monitoring of land degradation and restoration, in relation to the UNCCD strategic objective two (to improve the condition of affected ecosystems) and corresponding progress indicators (trends in land cover and in land productivity/functioning), and to the implementation of SDG Indicator 15.3.1 on degraded lands, for which the UNCCD secretariat is the custodian agency.

ESA supports the UNCCD secretariat and the UNCCD Global Mechanism (GM) in the piloting of the UNCCD Land Degradation Neutrality Target Setting Programme (LDN-TSP) and implementation by its Member States through the ESA-UNCCD partnership that was formally established in October 2016.

The 300m annual land cover maps of the ESA Land Cover CCI project have been used as the main source of information on land cover in 120+ UNCCD contracting parties and used for their national Land Degradation Neutrality (LDN) target setting. As member of the UNCCD expert team on LDN-TSP, ESA provided technical expertise on LDN data processing for LDN TSP countries.

As member of the UN expert team on SDG Target 15.3 (By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world), ESA supports the UNCCD work on methodological guidelines for SDG Indicator 15.3.1 (Proportion of land that is degraded over total land area).

ESA also supported a number of land degradation projects funded by the Global Environment Facility (GEF), one of the financial mechanisms of the UNCCD. ESA is member of the Scientific Advisory Committee of the GEF Land Degradation Monitoring project lead by Conservation International, and which objective is to review the use of satellite environmental information to monitor and report on land degradation over time and at multiple scales.

— *UN Convention on Biological Diversity (CBD)*

The CBD aims at promoting the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources. There are currently 196 parties to the Convention.

ESA contributes to the work of the CBD mainly through its participation to the GEO-BON (GEO Biodiversity Observation Network) advisory committee, working groups and task forces, and through a number of projects to develop and demonstrate relevant satellite environmental information products.

ESA supports the development of the Essential Biodiversity Variables (EBVs), the flagship initiative of GEO BON, which is conducted upon the request of the CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). In this context, ESA initiated in June 2017 the GlobDiversity project with the objective to develop, validate, showcase and scale up a number of HR remotely-sensed Essential Biodiversity Variables (RS-enabled EBVs) on the structure and function of terrestrial ecosystems.

This project provided key input to the information document submitted by GEO BON to the 21st meeting of the CBD SBSTTA on "Remote Sensing enabled Essential Biodiversity Variables" (reference CBD/SBSTTA/21/INF/17, December 2017). The information note aimed at promoting the importance of EO for the CBD Parties, in particular in the context of facilitating biodiversity monitoring by countries and supporting the implementation of the underpinning indicators relevant to the Strategic Plan for Biodiversity 2011-2020 and future editions the Global Biodiversity Outlook.

— *Ramsar*

The Ramsar Convention on wetlands is an intergovernmental treaty that embodies the commitments of its 170 member countries to maintain the ecological character of wetlands of international importance (Ramsar sites) and promote wise use of their wetlands.

ESA is an 'Observer organisation' to the Ramsar Scientific and Technical Review Panel (STRP), the body that has the mandate to provide scientific and technical guidance to the Ramsar convention. ESA contributes to the work of the STRP by providing technical advice on wetlands inventory, assessment and monitoring, a main thematic work area of the panel. By participating to the STRP meetings and processes.

ESA contributed to the Ramsar Technical Report on "Guidance for the use of Earth Observation for wetland inventory, assessment and monitoring, an information source for the Ramsar Convention on Wetlands" released in June 2018 for Ramsar COP 13 (Oct 2018). ESA also participated to the 21st annual meeting of the STRP on 15-17 January 2018, to provide expertise to the STPR on EO best practice methods and tools, and to report on existing ESA activities and projects related to wetlands (e.g. ESA GlobWetland Africa project and GEO Wetlands initiative).

Together with the University of Bonn and Wetlands International, ESA co-leads GEO-Wetlands, the GEO initiative on wetlands, which a collaborative framework for international cooperation, co-design of EO solutions and EO community engagement in support to sustained approaches on wetland inventory, mapping, monitoring and assessment. The GEO-Wetlands initiative addresses different aspects that can facilitate the integration of EO in wetland monitoring systems and processes (e.g. wetland inventory, mangrove mapping, capacity building, EO toolbox, EO knowledge hub, GEO-Wetland portal).

In close cooperation with the Africa group of the Ramsar Secretariat, the ESA GlobWetland Africa project continued to stimulate the exploitation of satellite observations (principally the ESA Sentinel satellites) through free-of-charge and open-source software for wetland inventory, monitoring and assessment, and to provide African stakeholders with EO solutions to fulfil their Ramsar obligations and better monitor the extent, integrity and conditions of wetlands.

ESA supports UN Environment and the Ramsar secretariat, co-custodian agencies of the SDG Indicator 6.6.1 on the change to the extent of water-related ecosystems. ESA contributed to the development of methodological guidelines for the indicator implementation, where EO is now proposed as a major data source to inform SDG 6.6.1 Indicators.

TIGER Initiative

In 2002, responding to the urgent need for action in Africa stressed by the Johannesburg World Summit on Sustainable Development (WSSD), ESA launched the TIGER initiative to promote the use of EO for improved Integrated Water Resources Management (IWRM) in Africa. The overall objective of the initiative is to assist African countries to overcome problems faced in the collection, analysis and use of water related geo-information by exploiting the advantages of EO technology. The aim is to fill existing information gaps relevant for effective and sustainable water resources management at the national to regional scale in thus helping to mitigate the wide spread water scarcity in Africa.

TIGER is an international endeavour that has been endorsed by the African Ministerial Council on Water (AMCOW), contributes to the strategy of the Group on Earth Observations (GEO) and involves the contributions of UNESCO, UNDP and UNECA. TIGER has been further involved in the preparation of the GMES and Africa initiative as part of its water resource thematic priority. Over more than 15 years of existence the TIGER initiative has established and supported capacity building activities and development projects involving some 42 African countries, and reaching more than 150 African water authorities and research institutes.

The TIGER initiative is a demand driven process, where the main focus is on the needs and requirements, in terms of water related information, of water authorities and other stakeholders involved in IWRM in Africa (i.e. Ministries of water and river basin authorities, African technical centres and universities).

The main beneficiaries of the TIGER initiative are the African water authorities (represented at continental scale by the AMCOW), the ministries of water, and the relevant river basin authorities and other regional and trans-boundary organisations with responsibilities to develop and implement water management plans in Africa. The African Regional And National Technical Centres are the main providers and users of geo-information for water management. This includes not only the national or regional remote sensing centres in Africa, but also universities, research centres and other agencies with the capabilities and mandate to provide geo-information to the water authorities to support their water management plans (in particular the four TIGER Regional Offices: AGRHYMET, RCMRD, OSS, WRC/SANSA). Finally, the African

Regional Economic and Development Institutions such as NEPAD and the different Regional Economic Communities e.g., SADC, ECOWAS, ECCAS, UMA, IGAD, EAC play a major role in the uptake of the EO information for decision-making.

Building on more than ten years R&D experience within TIGER, a free, open source Water Observation and Information System (WOIS)[148] has been developed in close collaboration with African water authorities. The WOIS contributes to the local capacity of African water authorities to access and exploit satellite observations, in particular from the ESA Sentinel satellite missions, for monitoring and management of water resources. The WOIS has been demonstrated and validated together with four major African river basin authorities and four national water authorities. The WOIS is available freely to any user, following registration.

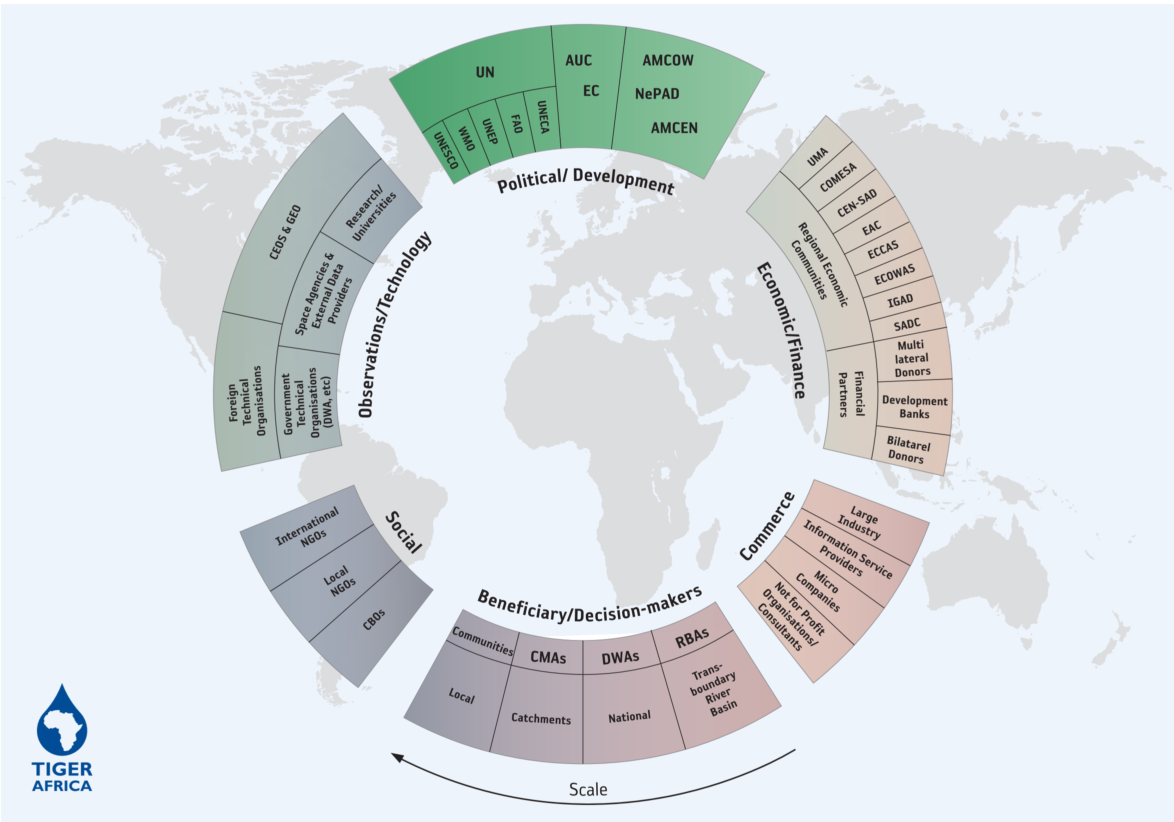


FIGURE 24: Stakeholder Map of the TIGER Initative

148 Tiger Africa. 'WOIS description and product portfolio'. http://www.tiger.esa.int/page_eoservices_wois.php. Accessed August 2018.

Global Monitoring of Essential Climate Variables

Satellite observations are a key element in providing the scientific community with the data they need to improve our understanding of the Earth system, help monitor the climate and predict future change.

ESA's Climate Change Initiative (CCI) programme exploits the 40-year archive of global Earth observation data from ESA and its Member States to provide continuous time series of data of Essential Climate Variables (ECVs). By merging data sets from different missions and sensors in to one long time series, new climate datasets can be derived. This data helps provide the foundation for a Global Climate Observation System, which is required by the UNFCCC (United Nations Framework Convention on Climate Change), in order to make informed decisions on climate management, mitigation and adaptation.

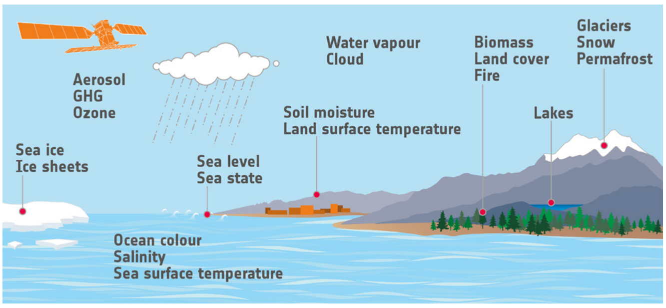


FIGURE 25: The 21 Essential Climate Variables that the CCI programme covers

The first phase of the CCI was launched in 2009, with a second phase, underway in 2017. The programme now covers 21 different Essential Climate Variables (Figure 25). The resulting data sets are available for free through a dedicated portal, with a toolbox to help combine and analyse the data, together with a visualisation tool to engage a broader audience.

The total budget is €165 million for the 18 years (2009-2026) and involves 178 entities roughly evenly divided in three groups, Universities, Other Public Entities (non-Universities) and Commercial Entities.

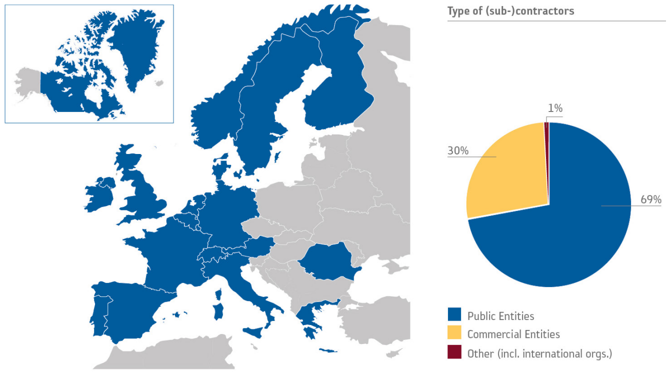


FIGURE 26: Distribution of the 178 entities involved in CCI contracts (June 2018)

Thematic Exploitation Platforms (TEPs)

The Thematic Exploitation Platforms are a set of seven thematically oriented developments that provide environments offering enhanced ICT (massive computing), access to large (Copernicus) EO data (Big Data), and a variety of software tools and algorithms that together allow exploitation to be carried out on scales (both spatially and temporally) not previously possible. The developments are complete, and the TEPs are currently in the pre-operations phase for the first half of 2018.

Thematic Exploitation Platforms are envisaged to play a major role in mediating between the back-office ICT technology and the different science and application communities. There is high interest from EU entities to integrate the TEPs into their initiatives, namely DG/Grow for the DIAS, DG/RTD for EuroGEOSS and DG/CNCT for the European Open Science Cloud (EOSC).

The full potential will be exploitable only when the Copernicus Data and Information Access Services (DIAS) providers host the TEP hosting with access to the full Copernicus population, but meanwhile the individual TEP status can be summarised as of end Q2 2018 as follows:

GEO-HAZARDS (G-TEP) Prime: Terradue (Italy)

- Pre-operations portal at geohazards-tep.eo.esa.int
- Currently 810 registered users
- Disaster Charter Platform Prototype presented at the 38th International Charter on Space and Major Disaster. Foreseen test campaign from July 2018 to January 2019. Feedback and decisions foreseen in the 41st International Charter on Space and Major Disaster (April 2019, Quebec).

COASTAL (C-TEP) Prime: ACRI-ST (France)

- Portal open at **tep.eo.esa.int**
- Close-out of final delivery actions completed April 2018
- Pilot projects and Processors:
  - SAFI (Water Quality and Temperature for Fisheries)
  - Altimetry for Storm Surge Monitoring
  - Change Detection from Illegal Construction
  - Carabinieri Pilot demonstrated to end user with ASI
  - Mediterranean Pilot (Water quality from Globcolour/S3)
  - Bathymetry

FORESTRY (F-TEP) Prime: VTT (Finland)

- Portal open at **forestry-tep.eo.esa.int**
- Final presentation completed February 2018
- Pilot Integration with GEOSS started
- Pilot projects for pre-operations
  - Forest change mapping over Mexico; 200,000 km² analysed over two states using FTEP by local partners, Ministry of Environment and Natural History of the state government of Chiapas (Chiapas Catastro Ambiental) & University of Durango
  - Broadleaved shrub detection over Finland; new service defined in conjunction with Finnish Forest Centre for using quantized NVDI and cross referenced to in-situ data

HYDRO (H-TEP) Prime: isardSAT (Spain)

- Outreach portal open at **hydrology-tep.eo.esa.int**
- Good Progress on Final Delivery, final presentation planned for 3 July
- Pre-Operations for pilot projects started
  - Niger River Basin (WOIS, Flood Mapping, Hydrological Modelling)
  - TIGER (WOIS)
  - CEOSS Flood Pilot (WOIS, Flood Mapping, Hydrological Modelling)
  - Red River Basin (WOIS, Flood Mapping, Hydrological Modelling, Water Quality, Small Water Bodies)

POLAR (P-TEP) Prime: Polar View (GB)

- Outreach portal at **p-tep.eo.esa.int**
- Final presentation completed February 2018
- Pre-operational phase for pilot projects completed:
  - Iceberg detection in support to USCG Cutter Maple –tailored iceberg density products generated from Sentinel-1 data for transit across Baffin Bay
  - Study of iceberg detection and ice sheet discharge from Upernavik Fjord system
- Additional case studies performed with SnowSense project (S1A terrain correction) and GEUS (Sentinel 3 albedo processing)

URBAN (U-TEP) Prime: DLR (Germany)

- Outreach portal open at **urban-tep.eo.esa.int**
- Final presentation completed 12-13 April 2018 with demonstration in Φ-lab, close-out completed
- Pilot projects for pre-operations
  - World Bank Group (WBG): Urban Development and Resilience Unit (Urban Rural Discrimination)
  - Early adopters from UNESCAP, UNESCO, Sultan Qaboos University, POPGRID
  - >200 enquiries for use of GUF and TimeScan products
- New version of VISTA available (Visualisation and analytics Toolbox)
- New Scientific publication **https://doi.org/10.3390/rs10060895**

FOOD SECURITY (FS-TEP) Prime - VISTA GmbH (Germany)

- Portal available at https://foodsecurity-tep.eo.esa.int/
- Dev-ops approach with Agile development
- Second platform release opened to public 23 April: R-Studio, Sen2Agri and WFP regional explorer are available to the public
- Pilot projects:
  - Agricultural intensification in Europe
  - Index based insurances in Africa
  - Aquaculture - project proposed (Tanzania), possible link with Coastal TEP
- User Workshops held 5-8 March 2018 in ESRIN and FAO

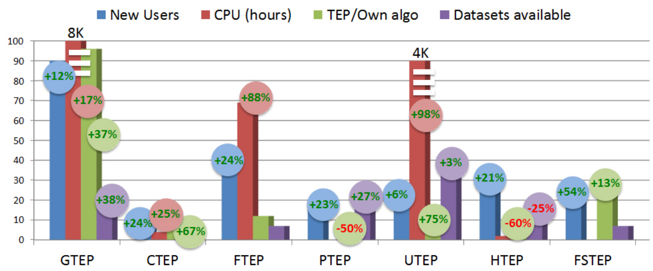
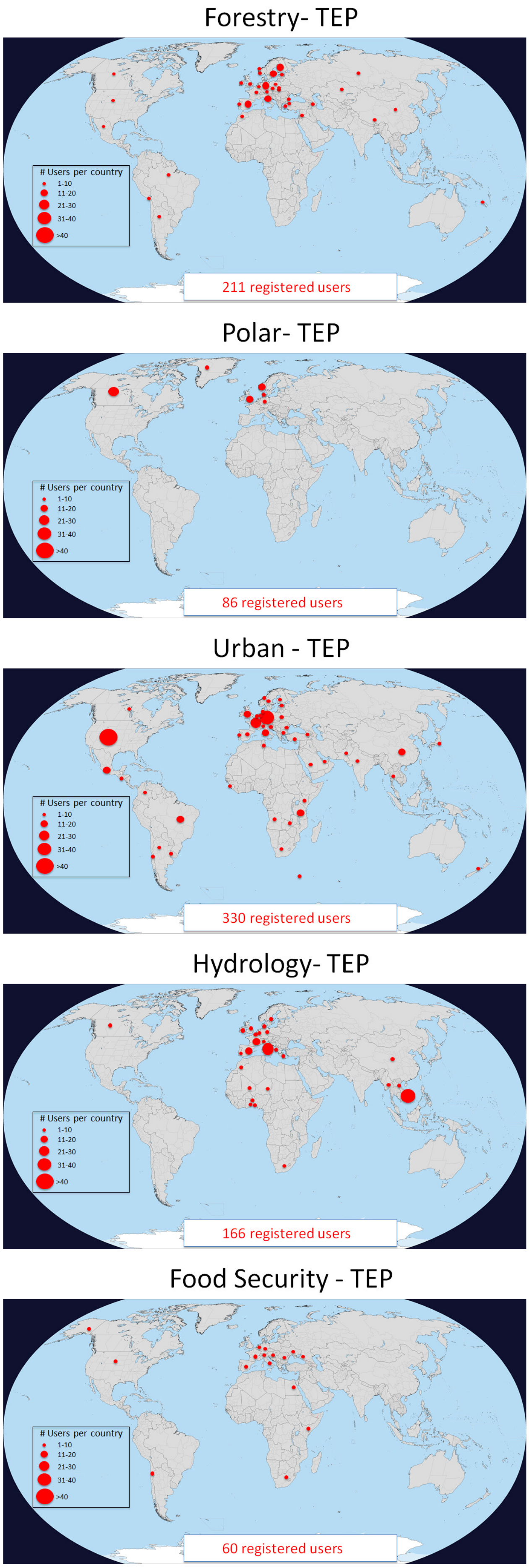


FIGURE 27: TEPs Metrics of User Uptake and Data Coverage for Q2/2018



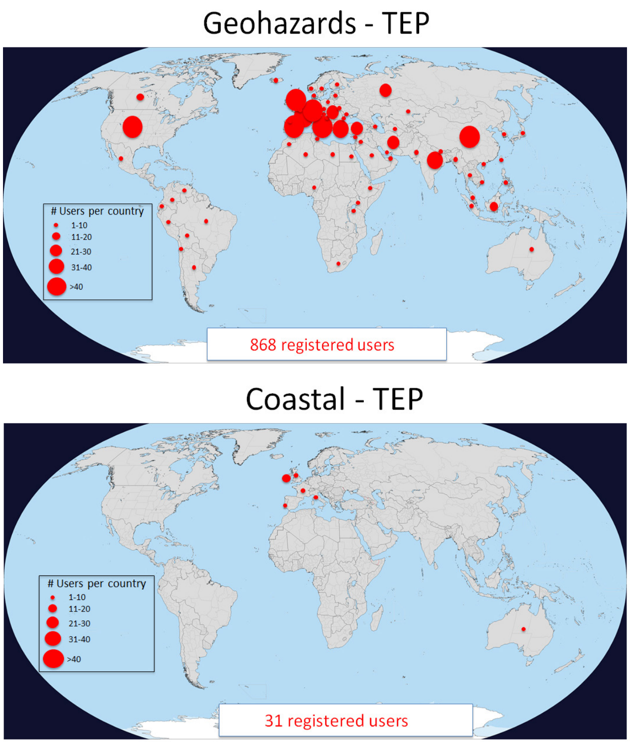


FIGURE 28: TEPs User Volume and Geographic Distribution

Copernicus Data and Information Access Services (DIAS)

Using satellite environmental information by a non-expert is difficult, as highlighted by GIZ *'Too much information is slowing decision processes down. [We] need standardized information products.'*[149] and also by ADB *'We need to simplify the complexity of space… Easy tools are needed for the integration of EO with other data'*.[150]

Simplification of use of satellite environmental information will reduce the need for significant technical skills and computing infrastructure - storage, processing and bandwidth, therefore enabling a wider range of non-expert users to use EO to address development challenges.

ESA has started activities that aim to simplify access to Copernicus data. ESA, acting on behalf of the European Commission, has developed and launched in June 2018 the operations of the Copernicus Data and Information Access Services (DIAS). DIAS will give unlimited, free and complete access to Copernicus data. DIAS will not only provide a cloud-based one-stop shop for all Copernicus satellite data and imagery, as well as information from the six Copernicus services, but will also give access to sophisticated processing tools and resources. Third parties will be empowered to offer advanced value-adding services, integrating Copernicus with their own data and tools to the benefit of their own users.

149 GIZ. 'Current experiences in the use of satellite information in development aid activities from Germany'. http://eo4sd.esa.int/files/2018/01/GIZ-Presentation-ESA-WS-16.1.2018.pdf. Accessed July 2018.

150 Same as above

Annex D: Glossary

CEA: Cost-effectiveness analysis is a 'value-for-money' analysis. It compares the relative cost of achieving the same impact using alternative approaches and can be used to assess whether one solution provides the least costly method to achieve desired results.

CEOS: Committee on Earth Observation Satellites

Client States (CS): This refers to the recipients of development financing. For the main IFIs, these recipients are mostly the governments of the developing country. Note that the main IFIs use their own (differing) terms to identify these recipients. For the Asian Development Bank, it is 'Developing Member Countries', for the Inter-American Development Bank it is 'Borrowing Member Countries, and for IFAD, it is 'Recipient Members'. In this document, the World Bank term for recipients ('Client States') is used as a generic term to cover recipients of all IFIs.

Copernicus[151]: The European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers information services based on satellite Earth Observation and in situ (non-space) data. The Programme is coordinated and managed by the European Commission. It is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU Agencies and Mercator Océan.

Development Aid community: Those stakeholders involved in the provision of Development Aid, including IFIs, National Development Aid Agencies and Private Foundations.

Earth Observation (EO): The gathering of information about the physical, chemical, and biological systems of the planet via remote-sensing technologies, supplemented by Earth-surveying techniques, which encompasses the collection, analysis, and presentation of data. EO is used to monitor and assess the status of and changes in natural and built environments.[152]

EO Information Service Sector: This refers to companies and/or organisations that are producing EO-based information products and services and delivering these to users (either public or private sector).

ESA: European Space Agency

GEO: The Group on Earth Observations (GEO) is an intergovernmental organisation working to improve the availability, access and use of Earth observations for the benefit of society.

GNSS: Global Navigation Satellite System refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location.[153]

151 Copernicus. 'What is Copernicus'. http://www.copernicus.eu/main/overview. Accessed July 2018.
152 Wikipedia. 'Earth Observation'. https://en.wikipedia.org/wiki/Earth_observation. Accessed July 2018.
153 European Global Navigation Satellite Systems Agency. 'What is GNSS?'. https://www.gsa.europa.eu/european-gnss/what-gnss. Accessed July 2018.

International Financial Institutions (IFIs): Refers to the institutions created by a group of countries that provide financing and professional advising for the purpose of development. Examples include World Bank Group, Asian Development Bank, International Fund for Agricultural Development. Note that the main IFIs provide development financing in the form of loans and/or grants, mainly to public sector (i.e. developing country governments). However, there are some IFIs (e.g. International Financing Corporation – IFC – which is part of the World Bank Group) that provide development financing mainly to the private sector.

Landsat-1: A commercial high-resolution optical imaging EO satellite system operating from space. Landsat is a joint effort of the United States Geological Survey (USGS) and NASA.[154]

Monitoring & Evaluation (M&E): Is an objective process of understanding how a project was implemented, what effects it had, for whom, how and why.[155]

National Development Aid Agency: Which provide regional and international development aid and are the government departments responsible for administering ODA, for example UK DFID, German GIZ, France AFD.

ODA: Official Development Assistance is a term defined by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD) to measure aid.[156]

OECD: The Organisation for Economic Co-operation and Development is an intergovernmental economic organisation with 37-member countries, founded in 1961 to stimulate economic progress and world trade.[157]

Private Foundation: Are philanthropic organisations providing funding in international development including Bill and Melinda Gates Foundation, MasterCard Foundation, Rockefeller Foundation and Omidyar Network.

SatComms: Satellite Communications

UN SDGs: United Nations Sustainable Development Goals

Stakeholders: This refers to the body of users closely involved in the planning and implementation of international development activities. These can be either IFI staff (especially for the planning of new activities), and/or agencies and organisations in the countries in which the development activities are taking place. These are typically government agencies involved in the implementation of the development project.

Synthetic Aperture Radar (SAR): Synthetic Aperture Radar (SAR) satellites are a form of radar using the motion of the satellite to create a larger 'virtual' antenna that is used to create two or three-dimensional images of objects, such as landscapes.[158]

UAV: an Unmanned Aerial Vehicle, commonly known as a drone, is an aircraft without a human pilot aboard.[159]

154 USGS. 'Landsat Project Description'. https://landsat.usgs.gov/landsat-project-description. Accessed November 2017.
155 Caribou Digital.
156 Wikipedia. 'Official development assistance'. https://en.wikipedia.org/wiki/Official_development_assistance. Accessed July 2018.
157 Wikipedia. 'OECD'. https://en.wikipedia.org/wiki/OECD. Accessed July 2018.
158 Same as above
159 Wikipedia. 'Unmanned aerial vehicle'. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle. Accessed July 2018.

Caribou Space supports organisations to bridge the space and development worlds.

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