Realising the Potential of Space-Based Data and Services for Sustainable Development

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Abstract

Earth Observation (EO) plays an important role in our ability to understand the planet and offers significant and unique solutions to many of the Sustainable Development Goals. The application of EO is not new but its advancements are accelerated by developments in the New Space Economy, investment in satellites, open access to data and tools and improvement in data processing. This large volume of EO data if optimally utilised offers the opportunity to enhance the range and depth of EO applications for sustainable development. However, there are challenges to realising this potential. This policy brief identifies some of the key challenges that need to be addressed to realise the potential of satellite-based EO to achieve the SDG and suggest policy options for decision makers.

EO for society

The value of Earth Observation[1] (EO) to sustainable development, including in terms of monitoring the Sustainable Development Goals (SDG) and improving the formulation and subsequent implementation of policies and programmes of action is recognised by many Member States (ESA 2012; UNOOSA 2022). EO is used in diverse areas, such as in environmental monitoring, natural resource management, health care, climate change, disaster risk reduction and emergency response, agriculture and food security amongst others.

EO also plays a pivotal role during the Covid-19 pandemic. For example, the three space agencies NASA, ESA and JAXA[2] have created a centralised online dashboard to monitor the impact of COVID-19 on the Earth environment and human activities (ESA 2020a). Through satellite data, a sharp decrease in concentration of nitrogen dioxide and a reduction in air travel was observed in most European cities during lockdowns (ESA 2020b; ESA 2020c).

Compared to other data sources, EO is unique because of its global coverage, including in remote or conflict areas. EO is also useful to data-scarce developing countries by complementing other sources of ground-based data (ESA 2020d).

Trends in EO market

With so many uses of EO data, it is not surprisingly that the EO market is experiencing accelerated growth. In 2019, the commercial for EO data was valued at US$4.6 billion and is expected to reach $7.5 billion by 2030 (Satnews 2020; Euroconsult 2021). The growth in EO market is driven by several factors. Lower production cost of satellites coupled by advances in sensor technology, and technological innovations in launch capabilities leading to greater accessibility of space and lower launch cost per kilogram sent to space in the New Space Economy, means that it is now more affordable than before to deploy satellites into orbit and to collect an unprecedented amount of high-quality data about the state of our planet.

Over the years there has been a shift in market players from mainly government and large corporate towards start-ups that not only deploy new technologies to support traditional applications, but also develop new user-driven applications. This dynamic of "democratization of space" implies that more people and organisations are part of the space economy thereby increasing the human capital needed to open up new technological frontiers.

Capitalising on Artificial Intelligence to make sense of big data

The amount of EO data being collected is increasing so rapidly that Artificial Intelligence (AI) would be key to unlocking its value in the future. In particular, Machine Learning algorithms enable the processing and analysing of large datasets in real-time to reveal patterns, trends, and interactions that are currently unrecognized, in addition to performing predictive analysis (DNV). These applications range from bias correction, detection of disease in crops, to rock type classification (Lary et al, 2018). This is supported by cloud technology that allows large amount of data to be analysed and stored online.

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[1] Earth Observation refers to the gathering of information about planet Earth's physical, chemical and biological systems. Earth Observation may be performed by remote-sensing technologies such as by satellites or ground-based techniques (GEO).

[2] ESA: European Space Agency. JAXA: Japanese Aerospace Exploration Agency.

However, the application of AI in EO is at its nascent stage, remaining mainly concentrated on computer vision applications with Very High-Resolution satellite imagery (IARAI, 2021; Geospatial World, 2018a). Nevertheless, the recognition of AI's potential to transform or create entire new types of value chain, scientific knowledge and innovative EO services is reflected in the upward trend in the financing of AI-driven EO start-ups by space technology incubators, accelerators and venture capital firms (ESA BIC; Geospatial World, 2018b).

Technology outlook

Looking forward, EO data could combine with blockchain technology to benefit supply chain management in various industries, improvements in visualisation techniques such as through flexible screens and 3D modelling could enhance the access and distribution of remote sensing and Geographic Information System (GIS) information (DNV). The sector is also focusing on searching for better coverage and revisit time with the aim of providing near-real time Earth monitoring where consequently images or data of a specific location would be precisely comparable over time (ESA 2020e; ESA EO Newcomer guide). Furthermore, on-board data processing would enable processing and compression of data already on board the satellite instead of transmitting the raw data to Earth for data crunching. The transmission of useful information to Earth can take place in real-time, which is key to rapid crisis response (KP Labs). In terms of data accessibility, there is a drive towards systematic and regular provision of satellite data that allows immediate analysis and easy use even by non-specialists, such as Analysis Ready Data[3] (ARD) (Satellite Applications Catapult, 2017).

Challenges

For most countries, the largest socio-economic value would accrue from downstream EO-derived data and services. However, there are challenges facing the adoption and effective use of EO.

- **Availability:** Depending on the specific purpose, there could be a lack of EO data in sufficient temporal, spatial and spectral resolution, and an affordable cost (ESA 2020d). For example, the cost to achieve image and data coverage is significant in regions with large landmasses and/or dispersed populations (ADB, OECD 2020). While most satellite data from space agencies is available for free, they sometimes have to be supplemented with commercial data to be fit for purpose. Commercial data comes at a cost that could be subscription-based or one-off. Continuity of data could also be a problem if a satellite is out-of-operation or discontinued without a replacement.
- **Accessibility:** EO data require complex processing before useful information may be extracted. The complexity of accessing, storing and manipulating EO data is a barrier due to constraints in technical expertise and computing infrastructure. If there is a lack of in-house expertise or if users do not have ownership of the entire data processing chain, users need to have access to partners within or outside the country (UNOOSA 2021a; UNOOSA 2021b). Privacy protection regulation could also impede the use of data processing and analytical platforms depending on the types of data needed to be processed (ADB, OECD 2020).
- **Technical skills:** Understanding of EO data, programming and big data analytical techniques require high level of expertise. In developed countries, there could be a shortage of individuals with the right set of skills vis a vis the level of market demand thus constraining the growth of the industry. Whereas in developing countries, the general level of STEM knowledge and skills could be low.
- **Infrastructure:** Many EO applications rely on fast and reliable internet connectivity which may be limited in developing countries or rural areas.
- **User awareness, acceptance and trust:** Any technology will only be adopted if there is broad awareness of their uses and benefits, and users' acceptance and trust in the outcomes generated through the use of these technologies. Adoption of technology tends to be low in places where digital skills lag (EU 2021).

Policy considerations

The existence of significant synergies across several policy pillars calls for an integrated and multi-faceted approach to create an enabling environment adapted to local realities and level of economic and technological development.

- **Free and open data policy:** To support expansion of science and derive economic benefits from applications, free and open access to EO data

[3] ARD is satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis without additional user effort and interoperability with other datasets both through time and space. (Committee on Earth Observation Satellites)

provided by publicly funded programmes should be encouraged. This can be further complemented by open-source tools. Open data policy is particularly beneficial to governments, universities, and commercial research groups and organisations that have limited budgets (Zhu et al, 2019). EO data and knowledge should also be preserved in case of mission discontinuity (ESA 2020e). The benefits accrued through the use of EO data and of EO-derived services should be monitored and evaluated to encourage public buy-in (ESA 2020d).

- **Capacity building:** To address the skills gap, technical skills in big data and space science can be developed over time through integration of relevant content into formal education curriculums. For example, six Regional Centres for Space Science and Technology Education, affiliated to UNOOSA, provide high quality space science and technologies education programmes in developing countries. In the short-term, the development of technical skills could be encouraged through various forms of knowledge transfer, such as online trainings offered by the Committee on Earth Observation Satellites (CEOS), customized training for government officials, and other free courses and online resources on the UNOOSA SPIDER knowledge portal. General skills in data analytics and programming would also prepare workers for new jobs of the future.
- **Investing in infrastructure:** First, investment in reliable broadband and cellular communications networks that provide universal access, including in remote areas, is critical. Satellite-based connectivity could complement terrestrial systems to provide global connectivity (BCG). Second, an integrated e-infrastructure with open and easy access to affordable processing and data platform could support the scaling up of EO applications and services (UNOOSA GA resolution). The provision of cloud computing and ARD would be important.
- **Entrepreneurship ecosystem:** An active ecosystem that consists of start-up incubators, accelerators, and networking platforms to build partnerships and deepen engagement across the value chain, including between academia, industry, EO specialists and users could be strengthened. Private investment is a driver as investors are increasingly recognising the value from monetization of EO data and services. Public funds may be catalysed to attract private investment in projects where the risk-return to private investors may not be apparent (EIB, 2019).
- **Technology adoption:** Government agencies can play a role in raising awareness of the uses of EO and transferring and mainstreaming EO into society. For example, by supporting the development and application of EO in national pilot projects that directly involve users, perhaps in cooperation with multi-lateral development banks, and planning for such uses and procurement in its budget, government agencies acknowledge and demonstrate the usefulness and importance of EO. Government agencies can also raise awareness of relevant policy frameworks and access to public investment funds and provide assistance in the bureaucratic process.
- **International collaboration:** Tackling global challenges requires greater collaboration at international and regional levels in establishing platforms, mechanisms and infrastructure for disseminating research results and promoting scientific collaboration[4]. The sharing of national datasets would be useful as countries acquire technologies to obtain customized EO data at national level. This can help avoid the duplication of effort and potentially share the risks and cost of associated investments.
- **Mainstreaming gender:** Policy considerations should be given to promoting gender equality as the above policy suggestions may have different impact and effectiveness on different gender due to ICT and STEM education gaps between men and women.

Conclusion

EO plays an important role in science-based policy development and has the potential to support the SDG from environmental monitoring to the creation of jobs of the future. However, an enabling environment for the research and development of EO is fundamental to realising its full potential. Decision makers need to take an integrated and multi-faceted approach from ensuring open access to and availability of data, to building human capital and infrastructure, while adapting to local realities.

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[4] An example is the Earth Observation Training, Education and Capacity Development Network (EOTEC DevNet) which is a network of networks of EO agencies around the world.

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