SCIENCE DIVISION

UN environment

FORESIGHT Brief

014

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Early Warning, Emerging Issues and Futures

Building a digital ecosystem for the planet

Emerging frontier technologies have dramatically boosted the ways in which we can monitor the health of our planet. If we can leverage this information effectively, we will be able to assess and predict risks, increase transparency and accountability in the management of natural resources, inform markets and consumer choice and guide the political action required to counter the environmental risks and crises; and ultimately stand a better chance of achieving the Sustainable Development Goals (SDGs).

For this vision to become a reality, stakeholders must collaborate to build and deploy a global digital ecosystem combining data, infrastructure, analytics, and insights.

This Foresight Brief shows how such a global digital ecosystem can be achieved – as well as what we risk despite the 10-year span still available to achieve the SDGs. The next 12 months will be especially critical due to key determinative events scheduled to take place.

All available evidence shows that we are not on track to avert the two greatest existential environmental challenges: the climate crisis and the nature crisis.[1]

We are not even effectively measuring global progress against the SDGs. A total of 68% of the 93 environmental SDGs indicators cannot yet be measured due to a lack of data (Figure 1).[2] It is thus of paramount importance to marshal knowledge and action through having a digital ecosystem in place.

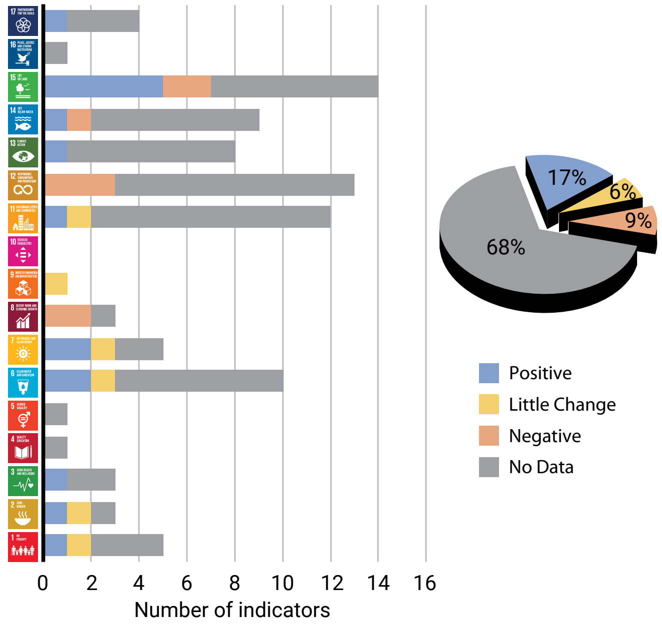


Figure 1: Status of data sets for the 93 environmental SDG indicators

Key upcoming determinative events

- The Climate Summit in New York in September 2019 that will set the climate change agenda for the next decade.
- The Climate COP in the UK in 2020 that will revise the Paris Agreement.
- The Kunming COP on biological diversity that will set new 20-year targets for the "more silent crisis" of the slow loss of nature.
- Finally, the UN Convention on the Law of the Sea that will set the agenda for the hydrosphere through a new global oceans' treaty.

Introduction

Dramatic digital transformation is underway (Figure 2).[3] Over 90% of all the world's data has been generated during the last two years.[4] Mobile devices connect five billion people on the planet.[5] New satellite technologies image the Earth's surface daily to a resolution of three meters.[6] New cloud computing and artificial intelligence algorithms allow us to monitor, detect and predict environmental and climate threats based on a stream of earth observations, ground sensors and other data points. In addition to being an information gathering tool, social media has become a political force, shaping perceptions and influencing environmental and climate change discourse.

To effectively utilize the digital ecosystem to our advantage, policy makers, businesses and citizens need to more actively embrace the complexity, scale and magnitude of these changes and their consequences. The challenge is that while there is broad recognition that we must capitalize on this massive technological diversity (Figure 2), there is no common vision, directed strategy nor governance framework.[7] Current public and private sector actions are haphazard and fragmented.

Although some private sector actors are beginning to offer global public goods and related analysis,[8] this is happening without a broader understanding of the long-term business models and incentives that should sustain and finance these services. A global conversation is therefore needed around sustaining these global public goods, privacy, inter-operability and quality standards, governance and payment models. This will yield answers to the question of how to maintain a balance between public and private sector interests and incentives.

The UN Science-Policy Business Forum established a working group on “Data, Analytics and AI” in May 2018 to kick-start this global conversation. Over 100 stakeholders from the scientific and citizen-science research communities, government and policy institutions, technology companies and non-governmental organizations are involved. In early 2019, the working group made a strong case for a digital ecosystem on the environment.[9] The remaining sections of this Foresight Brief summarize the perspectives of these thought leaders and call upon public and private sector actors to continue building on this common vision.

Building a Digital Ecosystem for the Planet

A digital ecosystem can be defined as ***'a complex distributed network or interconnected socio-technological system'.*** It features adaptive properties like self-organization and scalability. Much like natural ecosystems, a digital ecosystem, is characterized by <u>both</u> competition <u>and</u> collaboration among its many diverse public and private sector components; and it is the numerous interactions and linkages between these seemingly separate or autonomous entities that make an ecosystem functional. Similarly, a digital ecosystem must connect individual data sets with algorithms and analysis in order to create robust and timely environmental insights and intelligence. Timing, scale and format will be key in influencing decision-making, action and future investment for sustainable outcomes (Figure 3).

Satellites

4,987 Satellites in orbit in 2019
5,700 generated scenes per day (open source)
Landsat archive **32 years** - over **5 million scenes**
Entire terrestrial surface imaged every day

Sensors

15.4 billion sensors in 2015
75 billion by 2025

Internet of Things

IoT creates **400 zettabytes of data** per year

Mobile phones

5 billion unique phones offering opportunities for geocoded data collection as well as daily movements

Mobile apps

3 million unique apps

Internet access

Over **4.4 billion people, 57.3%** of population

Digital platforms

Every minute of the day in 2018:
Youtube users watch **4,333,560 videos**
Amazon ships **1,111 packages**
Uber users take **1,389 rides**

Censuses and surveys

More than **7 billion people** are covered by censuses every 10 years

Citizen science

500 million records on eBird
58 million records on Artportalen
16 million records on iNaturalist

Publications and doc

Over **2.2 million scientific articles** on science and engineering
Over **50,000 corporate sustainability reports**

Administrative data

Governments, utility companies, and other services providers maintain data related to **registration, transaction and record keeping**

Finance data

Financial databases cover **189 countries** to date

Figure 2: Big data and frontier technologies that can contribute to a digital ecosystem for the planet. *(Adapted from The Case for a Digital Ecosystmes for the Environment)*

There are four elements to a global digital ecosystem: raw data; a supporting technological infrastructure; algorithms and analytics; and insights and applications. These all combine to support a social tipping point that results in a transformation in our thinking and produces and delivers sustainability (see Figure 3). Governance strategies and standards will be needed for each step of the transformation process:

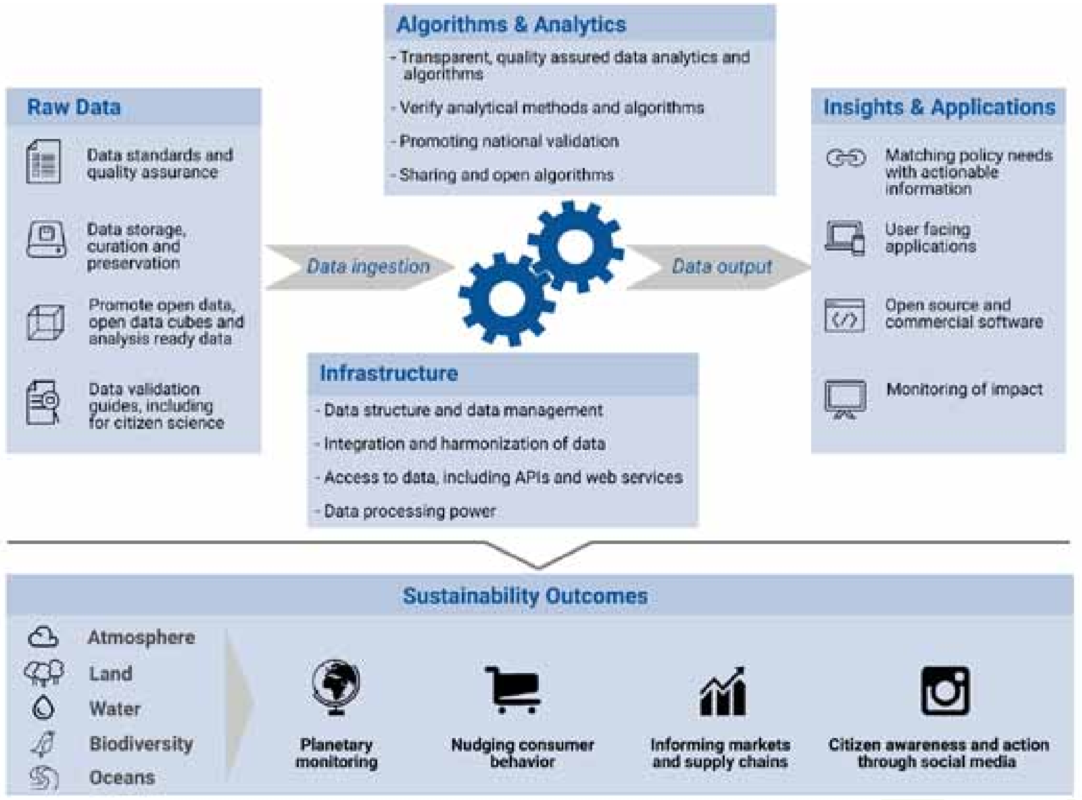


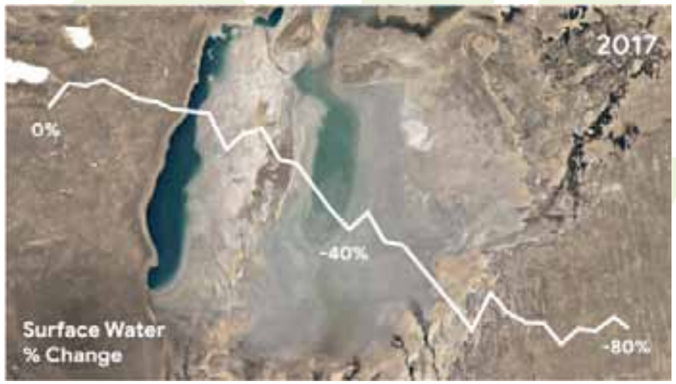
Figure 3: A digital ecosystem integrates data, infrastructure, algorithms to generate insights that can be used to achieve different sustainability outcomes.

- **Raw Data:** The foundation of a digital ecosystem is numerous environmental data sources, including small and big data collected through a variety of methodologies. These include official statistical reporting, earth observations, in-situ sensors, citizen science, commercial datasets and other relevant data streams. The ecosystem will include essential information such as metadata documentation and provenance, collection methodologies and peer review. It will need to delimit for potential biases, confidence levels and relevant use constraints. For each type of data source, standards and guidance will need to be adopted for quality assurance, data labeling and inter-operability.[10, 11, 12, 13] This will also require investments to ensure that data models are developed in a way that informs policy and that data is structured and managed in a way that allows high-quality, comparable and trusted analysis. At a minimum, contributors must be required to publish FAIR data (Findable, Accessible, Interoperable and Reusable).[14]
- **Infrastructure:** This will store, process and connect existing databases. It must seek to improve metadata, discoverability and accessibility. The volume and complexity of the system will require that data, algorithms and processing power be distributed but connected into various clouds, in a manner where data can flow and interoperate seamlessly. Compliance with open application programming interfaces (APIs) and other emerging standards will be important. For this reason, all actors contributing to the digital ecosystem will be obliged to publish information on the infrastructure they are using together with information about their open source and commercial software.
- **Algorithms and Analytics:** Data and supporting infrastructure are the backbone of the digital ecosystem. But these will require algorithms and analytics in order to extract actionable insights and business intelligence. Data science and artificial intelligence (AI) algorithms are already available and growing in number and quality. These will be used to yield data insights. But processes are needed to ensure quality and transparency while avoiding bias and protecting privacy. Peer reviews, open algorithms, and public documentation of processing methods will be essential to ensure public trust.
- **Insights and Applications:** The final part of the process is to transform the knowledge thus generated into actionable insights and evidence. Such insights and evidence must be made comprehensible to decision-makers, investors, consumers and citizens alike. Timing is essential if public participation, accountability and market pressure is to be sustained in pursuit of the sustainability goal. So is placement, scale and format. Public trust in the resulting insights will be best assured when applications are co-designed together with end users and related institutions. Increasingly, we are witnessing calls for companies to publish information on the business models they are using. This will be needed if potential conflicts of interest can be identified and managed. Some of the outputs could include: real-time planetary monitoring and predictive analytics for global and national environmental targets; environmental risk information to markets and commodity supply chains; product sustainability information to inform and nudge consumers; and verified scientific information for social media to educate and engage citizens.

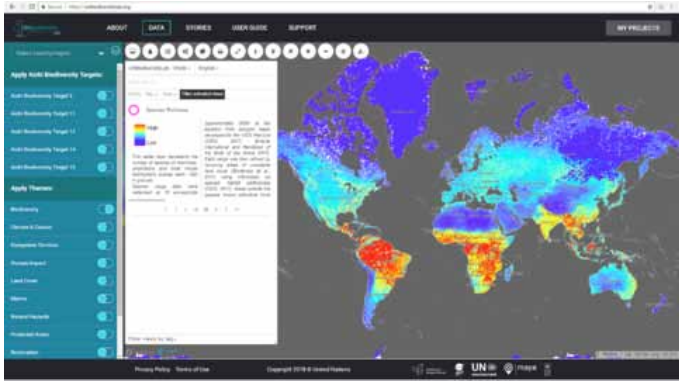
What is already being done?

The foundations of a global digital ecosystem for the planet are already being built and tested by a variety of public and private sector actors. The following examples show how a combination of data sets and new technologies can provide environmental insights and intelligence that are better, faster, cheaper and easier to access when compared with business as usual. They also show how new sources of data can be collected from a combination of public and private actors as well as citizens. Importantly, these examples are committed to publishing derived data products in an open format as a **global public good**, contributing to open source software and adopting important global standards and transparency measures.

Monitoring Global Water Extent
The European Commission's Joint Research Centre (JRC), Google Earth Engine and UNEP teamed up to develop the sdg661.app for Water-Related Ecosystems. The Surface Water Viewer shows changes in global water extent based on satellite images and machine-learning algorithms. The period covered is 1984 to 2018. It yields interactive maps, graphs and full-data download and a robust set of critical statistics for every country's annual surface water. This data is currently being used as a globally consistent baseline for SDG indicator 6.6.1 (change in extent of water-related ecosystems over time) with UNEP offering quality control and data custodianship.



The UN Biodiversity Lab

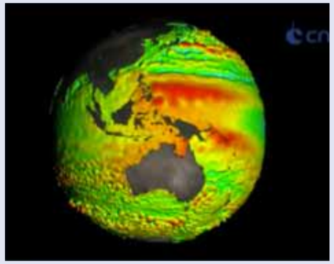


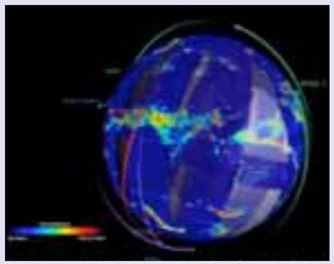
The UN Biodiversity Lab, jointly developed by UNDP, UNEP, the World Conservation Monitoring Center and the Global Environment Facility, aims to help countries increase the amount of spatial data and analysis used in their 6th National Reports to the Convention on Biological Diversity (CBD). The Lab combines over 80 global high-quality spatial datasets with analysis, visualization and storytelling tools. It has been designed specifically for policymakers. It aims to help them make evidence-based decisions. All reporting countries are provided with customized private cloud workspaces for uploading and analyzing national data (including their own) in the context of broader global datasets. The Lab is powered by an open source web mapping architecture developed by UNEP and GRID-Geneva called MapX. The UN Biodiversity Lab continues to evolve, planning to upgrade its interoperability with other biodiversity and protected areas platforms including Protected Planet, the Digital Observatory for Protected Areas (DOPA), the Biodiversity Indicators Partnership (BIP) Dashboard and the Global Biodiversity Information Facility (GBIF).

Space Climate Observatory
The Space Climate Observatory (SCO), established at the end of 2017 by France on the eve of the One Planet Summit, aims to combine satellite and field data with scientific research to model, predict and track climate change and its impact at national, regional and local levels. It harvests information from space agencies in Europe, the US, China, India, Israel, Russia, Mexico, Morocco and the UAE and will play a key role in SDG monitoring. 00

SCO Use Causes

Coastal vulnerability to future seal level rise and submersion can now be evaluated combining satellite altimetry data , imagery and geodesy obtained from 34 satellites. Geodetic satellites are a vital element of the procedure, serving as the reference system required to adjust the topography and sea level. This satellite based method validated by ground truth is today applicable everywhere. Whether rocky or sandy, urban or undeveloped, no coastlines will be spared by rising sea levels but regional differences in sea level rise are now predictable. Climate change is impacting extreme weather event and severe flooding particularly in the tropics: To predict these risks, we can count on the conjunction of 10 satellites in the International GPM (Global Precipitation Measurement) constellation and from an innovative ground method measuring signal fluctuations due to rain droplets between thousands of cellphone relay antennas. This allows scientists to produce both regional and very-high-resolution local rainfall maps and predict floods at a resolution never obtained before.





The Open Data Cube

The Open Data Cube technology, developed by Geoscience Australia, has been further supported by the Committee on Earth Observation Satellites and the Group on Earth Observations (Figure 4). It has been modified and deployed in Colombia and Switzerland with about 50 other countries at different levels of maturity and use. Digital Earth Africa will build on Open Data Cube[15] technology to deliver a unique continental-scale platform. The aim is to “democratize” access to operational and analysis-ready satellite data. It will track changes across Africa in the following areas: soil and coastal erosion, agriculture, forest and desert development, water quality and changes to human settlements. A Steering Committee for Phase I of Digital Earth Africa was formed in 2018 and includes Ghana, Kenya and South Africa, representatives from the World Economic Forum, the Global Partnership for Sustainable Development Data and the Group on Earth Observations as members.

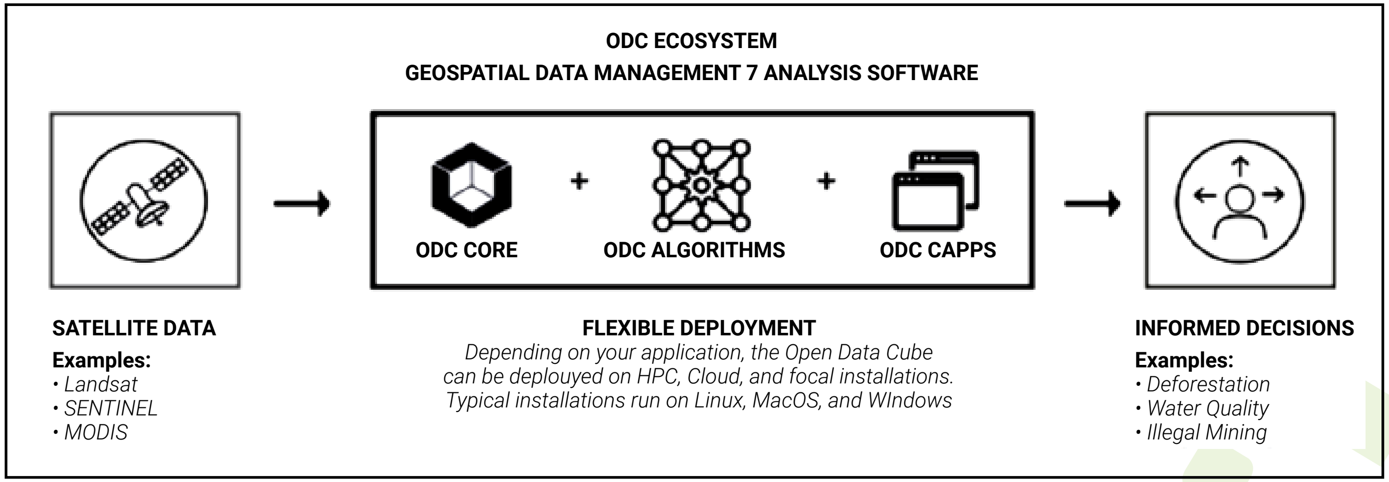


Figure 4: Open Data Cube Ecosystem

The Allen Coral Atlas

Earth Challenge 2020

Earth Challenge 2020 will engage citizen scientists in collecting and sharing one billion open and interoperable data points including air and water quality, pollution, biodiversity, food systems and climate change. They will collect and share earth science data in their local communities leveraging sensors including mobile apps. It is a partnership between the Earth Day Network, the Woodrow Wilson International Center for Scholars and other partners to be powered by Amazon Web Services using in-kind credits.