Earth Observation and Sustainable Development Goals in the Netherlands

Towards more synergetic use of Earth Observation: An exploratory study

G4AW
GEODATA FOR AGRICULTURE AND WATER

Netherlands Space Office

Ministry of Foreign Affairs of the Netherlands

Executive summary

How can satellite information contribute to achieving the Sustainable Development Goals (SDGs)? What is the added value of earth observation in monitoring and progress reporting, with special attention to the Dutch policy themes related to the Geodata for Agriculture and Water (G4AW) Facility. This is the main objective of this report. To achieve this objective, the actors, the playing field and the possible contribution of Earth observation (EO) in relation to the SDGs need to be identified. Secondly, the (possible) contribution of EO applications to SDGs will be communicated to policy makers, with a focus on agriculture, water, sustainable landscape management and climate. The findings of this report are based on a literature study and interviews with stakeholders.

The SDGs are interesting and important for the Netherlands from both a national and an international perspective. Internationally especially capacity building and technical assistance are important. Priorities of the European Union and the Netherlands are to transfer from free trade to sustainable trade. The Netherlands aims at a fully circular economy by 2050. Inclusive green growth, sustainable development and sustainable landscapes are key elements for achieving a circular economy.

In the last decade, satellite data has become available in increasing quantities and at no or very low cost. This makes Earth observation applications more attractive for addressing societal challenges. Earth observation can feed politics with factual information and quantitative data that facilitates informed decision making. With the help of Earth observation this can be done cheaper and quicker than with conventional methods and more information can be provided, especially in developing countries where few or no monitoring systems supporting SDG reporting are operational. A second main benefit is that Earth observation helps ensure that governments, businesses, knowledge institutions, NGO's and people everywhere have the relevant information and awareness for sustainable development. Earth observation can make a contribution to both achieving the SDGs and to assess progress towards targets by monitoring indicators.

The report presents an overview of SDG targets and indicators and the possible contribution of Earth observation. This is done for the following categories: general, agriculture, water, sustainable landscape management and climate. There are similarities and differences in the potential contribution of Earth observation for the SDGs related to these categories. Summarizing, the main benefits are saving of costs and time, quality improvement and process control. For Earth observation applications, work needs to be done on data-related, knowledge and skills-related (capacity building) and communication related issues.

To reach synergy at a higher level, issues such as standardisation, interoperability, harmonisation, multiple use of data, operating massive volumes of data, setting up and maintaining in-situ networks and citizens' observatories all need attention. Public-private partnerships are a good instrument to tackle these issues. In analogy to the G4AW Facility, Earth observation for SDGs will need further support to realise its full potential. Earth observation is supporting Dutch policy for the SDGs, but with synergy and focus the impact of current and future activities and interventions can be increased. It is expected that such a strategy will also strengthen the position of the Dutch Earth observation sector with respect to knowledge and information services for the SDGs.

To achieve an optimal contribution of Earth observation to the SDGs, in terms of synergy and policy support, the main recommendations are:

1. Carry out a more in-depth investigation into the potential synergy and cooperation for Earth observation and the SDGs. What are the possible options?
2. Formulate an action agenda for achieving more coherence in government policy (alignment of research, technical assistance and capacity building).
3. Find ways to capitalise on the investments that have already been made, or that are planned in the (near) future.

List of acronyms

AMIS	Agricultural Market Information System (FAO)
CBS	Statistics Netherlands
CCI	Climate Change Initiative
CGIAR	Consultative Group on International Agricultural Research
CIESIN	Center for International Earth Science Information Network (US)
CieMER	Netherlands Commission for Environmental Assessment
CIFOR	Centre for International Forestry Research (CGIAR organisation)
CO2	Carbon Dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DLR	German Space Agency
EARSC	European Association of Remote Sensing Companies
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable (as defined by ESA)
EEA	Europe Environmental Agency
EO	Earth Observation
EO4SDG	Earth Observation for SDGs
ESA	European Space Agency
FAO	Food and Agriculture Organisation
FRA	Forest Resources Assessment (FAO)
G20	Group of Twenty
G4AW	Geodata for Agriculture and Water (NSO)
G4IFF	Geodata for Inclusive Finance & Food
GAEZ	Global Agro-Ecological Zones
GCOS	Global Climate Observation System
GEMI	Integrated monitoring of water and sanitation related SDG indicators (UN-Water)
GEO	Group on Earth Observations
GEOBON	GEO Biodiversity Observation Network (GEO)
GeoCAP	Geomatics in Support of the Common Agricultural Policy (JRC action)
GEOGLAM	GEO Global Agricultural Monitoring (GEO)
GFDRR	Global Facility for Disaster Risk Reduction (World Bank)
GFOI	Global Forest Observation Initiative (GEO)
GFW	Global Forest Watch
GHG	Greenhouse Gas
GHSL	Global Human Settlement Layer (EC)
GODAN	Global Open Data for Agriculture and Nutrition
GOFC-GOLD	Global Observation for Forest and Land Cover Dynamics
GPSDD	Global Partnership for Sustainable Development Data
GRDC	Global Runoff Data Centre (Germany)
GSGF	Global Statistical Geospatial Framework (UNSC/UN-GGIM
GUF	Global Urban Footprint (DLR)
HLPF	High-Level Political Forum (UN)
IAEG	Inter-Agency and Expert Group (UN)
ICRAF	World Agroforestry Centre (CGIAR organisation)
IDH	The Sustainable Trade Initiative (the Netherlands)
IIASA	International Institute for Applied Systems Analysis (Austria)
IISD	International Institute for Sustainable Development
ILM	Integrated Landscape Management
INCOIS	Indian National Centre for Ocean Information Services
INEGI	National Institute of Statistics and Geography (Mexico)
IPCC	International Panel on Climate Change (UN)
ISLA	Initiative on Sustainable Landscapes (IDH)
ITC	Faculty of Geo-Information Science and Earth Observation (Twente University)
IWA	International Water Ambition (the Netherlands)
JAXA	Japan Aerospace Exploration Agency
JRC	Joint Research Centre (EC)
LGN	Land Use Netherlands
LiDAR	Laser Imaging Detection and Ranging
MENA	Middle East and North Africa
MEWS	Malaria Early Warning System
MRV	Measuring, Reporting and Verification
NASA	National Aeronautics and Space Administration (US)
NFP	Netherlands Fellowship Programme
NGO	Non-Governmental Organisation
NICHE	Netherlands Initiative for Capacity development in Higher Education
NSI	National Statistical Institution
NSO	Netherlands Space Office
NWO	Netherlands Organisation for Scientific Research
NUFFIC	Dutch Organisation for Internationalisation in Agriculture
ODIS	Ocean Data and Information System
PBL	Netherlands Environmental Assessment Agency
PES	Payment for Ecosystem Services
PvW	Partners for Water (the Netherlands)
REDD	Reduced Emissions from Deforestation and Forest Degradation
RWS	Rijkswaterstaat (the Netherlands)
SAI	Supreme Audit Institution
SDG	Sustainable Development Goal
SDSN	Sustainable Development Solutions Network (UN)
SEEA	System of Economic-Environmental Accounting
SLM	Sustainable Landscape Management
STATS SA	South Africa Statistics
SWERA	Solar and Wind Energy Resource Assessment
TEEB	The Economics of Ecosystems and Biodiversity
TU Delft	Delft University of Technology (the Netherlands)
UN	United Nations
UN-GGIM	UN Committee of Experts on Global Geospatial Information Management
UNEP	UN Environmental Program
UNESCO	UN Educational, Scientific and Cultural Organisation
UNESCO-IHE	UNESCO Delft Institute for Water Education (the Netherlands)
UNSD	UN Statistics Division
US	United States
UT	University of Twente (the Netherlands)
VITO	Flemish Institute for Technological Research (Belgium
WaPOR	Water Productivity Open-Access Portal (FAO)
WASH	Water, Sanitation and Hygiene
WAVES	Wealth Accounting and Valuation of Ecosystem Services (World Bank)
WGGI	Working Group on Geo-Information
WOTRO	Science for Global Development (NWO)
WRI	World Resources Institute (US)
WUR	Wageningen University & Research (the Netherlands)

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Introduction

This study is commissioned by the Netherlands Space Office (NSO) and the Ministry of Foreign Affairs and was carried out in the period May - June 2017. Answering the question of how and where satellite information can contribute to achieving the SDGs and to monitoring and progress reporting on the Sustainable Development Goals (SDGs), with special attention to Dutch policy themes related to the Geodata for Agriculture and Water (G4AW) Facility[1], is the main objective of this report.

The G4AW-related SDGs:
- SDG-2 "Zero hunger";
- SDG-6 "Clean water and sanitation";
- SDG-12 "Responsible consumption and production";
- SDG-13 "Climate action"; and
- SDG-15 "Life on land".

Because the added value of Earth observation manifests itself in the combination of different applications and the reuse of data, a broad scope is taken into account in the analysis.

The goal of this report is to identify the actors, the playing field and the possible contribution of Earth observation (EO) in relation to the identified SDGs and to communicate the feasibility and contribution of EO to policy makers, with a focus on agriculture, water, sustainable landscape management and climate. This creates a win-win situation: Earth observation can function as a game changer for contributing to and monitoring of progress towards achieving the SDGs and the focus on SDGs opens up new markets related to water, environment and climate that were previously less attractive economically, caused by the fact that the real value of environmental resources is not or inadequately captured by current economic models.

The increased interest in and use of Earth observation does not take place in isolation. It fits in the general trends of innovation, internet of things, the big data concept and the re-use of (free) public data[2]. The report therefore gives attention to the role of Earth observation in this broader context and the financial benefits and the new forms of cooperation that result from it.

STATS SA Statistician-General cited the following steps that are needed to tackle glaring data gaps and that illustrate the benefit of Earth observation in data provision and analysis:

1. Explore new data acquisition and integration approaches;
2. Aim for availability, quality, timeliness and disaggregation;
3. Consider adopting open data policies;
4. Facilitate broad and open access to existing data; and
5. Establish mechanisms for easy access and easy data discovery.

Jointly with this report an infographics[3] is produced. The infographics visualises and provides examples of how Earth observation can support the SDGs and how Earth observation can be used for monitoring of some of the SDG indicators. Due to the exploratory character of this study, the current version of the infographics conveys only a general impression at this stage.

The report contains the following elements: a description of the methodology used, an overview of the SDGs, an overview of Dutch policy related to the SDGs, the identification of the potential EO contribution, including a description of the synergy with the G4AW Facility and a description of the link with international initiatives, an analysis of the findings and preliminary recommendations.

The report serves as discussion document for a workshop for stakeholders in Earth observation and the SDGs in the Netherlands. The goal of the workshop is to formulate final recommendations (on vision and strategy) and follow-up actions that might be initiated to enhance the contribution of EO to achieving the SDGs and the monitoring of SDG indicators, including the creation of synergy with information services being developed in the G4AW Facility.

Methodology

The findings of this report are based on a literature study and interviews with Dutch stakeholders. The literature consulted deals with the SDGs in general, SDGs related to the Netherlands, Earth observation (and geospatial information) for the SDGs and specific EO applications for the SDGs. A reference list is attached to the report. A list of stakeholders interviewed is presented in Annex 1.

As indicated above, this exploratory study deals primarily with SDGs that are related to the policy themes addressed by the G4AW Facility, but also takes a broader context into account, where and when relevant. The focus is both on the Netherlands' policy, efforts and compliance with SDGs in the Netherlands, as on the international activities of the Netherlands related to SDGs (with footprint calculations providing a crosslink between the two).

Parallel to (but not part of) the study for NSO the following, related activities were carried out and information derived from these activities was used as input for this report:

- Participation in the Work Plan Symposium of the Group on Earth Observations (GEO), held in Pretoria, South Africa in May 2017[4]. The workshop was entirely dedicated to EO and SDGs.
- Participation in the European GEO workshop "EuroGEOSS: shaping the European contribution to GEOSS" in Helsinki, Finland in June 2017[5]. In this workshop the author moderated a brainstorm / discussion on Earth observation and SDGs.

The exploratory study aims to a be a building block for a process that leads to an integration of efforts, continued coordination and interaction, identification of priority areas and initiatives, and increased impact with respect to the utilisation of Earth observation for achieving the SDGs.

GEO, Group on Earth Observations

Earth observations for the benefit of humankind

GEO is a partnership of more than 100 national governments and in excess of 100 Participating Organisations that envisions a future where decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations.

GEO is a unique global network connecting government institutions, academic and research institutions, data providers, businesses, engineers, scientists and experts to create innovative solutions to global challenges at a time of exponential data growth, human development and climate change that transcend national and disciplinary boundaries. The unprecedented global collaboration of experts helps identify gaps and reduce duplication in the areas of sustainable development and sound environmental management.

Together, the GEO community is creating a Global Earth Observation System of Systems (GEOSS) to better integrate observing systems and share data by connecting existing infrastructures using common standards. There are more than 200 million open data resources in GEOSS from more than 150 national and regional providers.

Ministers of the GEO member governments meet periodically to provide the political mandate and overall strategic direction for GEO.

ⓘ http://www.earthobservations.org

Ger Nieuwpoort,
Director Netherlands Space Office

"Many global challenges are impossible to face without the use of satellite data. I am convinced that achieving the UN sustainable development goals is among them. The opportunities provided by satellite systems such as, for example, the European Copernicus constellation are almost endless."

Sustainable development goals - an introduction

The 2030 Agenda aims to stimulate action over the next fifteen years in areas of critical importance for humanity and the planet: people, planet, prosperity, peace and partnerships. For monitoring SDG progress the 17 global goals are anchored by 168[6] targets and 232[7] indicators. The 2030 Agenda specifically calls for new data acquisition and exploitation of new data sources to support implementation.

This report focuses on those aspects of the SDGs that are relevant to Earth observation. A link to the complete list of SDGs, targets and indicators can be found in the reference section. An overview of the potential contribution of Earth observation to the SDGs is presented in Annex 2. In this section some general elements of the 2030 Agenda are presented that should be considered when looking at (potential) use of Earth observation applications.

The Inter-Agency and Expert Group (IAEG) on SDG indicators was created by the United Nations Statistics Commission to provide a proposal for a global indicator framework.

Tiers of SDG Indicators, as defined by the IAEG (March 2016):
- Tier I with approximately 100 indicators (about 40%) for which statistical methodologies are agreed and global data are regularly available;
- Tier II with approximately 50 indicators (about 20%) for which clear statistical methodologies are agreed, but little data is available; and
- Tier III with approximately 80 indicators (about 30%) for which there are no agreed standards or methodology and no data is available.

Obviously, the biggest contribution of Earth observation is expected for indicators that are not Tier I.

The report "SDG Index and Dashboards"[8] arrives at findings that also have bearing on the application of Earth observation. The following limitations are identified and conclusions are drawn with respect to SDGs and indicators:
1. It is impossible to track some SDGs between countries;
2. There is only limited consideration of international spill-over effects;
3. Inclusion of non-official indicators is possible;
4. There is no consideration of time series of data.

Earth observation can contribute to overcoming some of the limitations: cross-border monitoring is possible and time series of data are available. Finally, use of Earth observation may contribute by providing more transparency (making information available to all).

Overall findings of the "SDG Index and Dashboards" report are:
1. Every country faces major challenges in achieving the SDGs;
2. Poor countries need help to achieve the SDGs;
3. Countries should usefully benchmark themselves against their peers as well as against the goal thresholds;
4. Countries and international agencies need to make substantial investments in statistical capacity to track the SDGs.

The following considerations with respect to the identification of technically-sound quantitative indicators for each goal that meet five quality criteria for data selection are presented:
1. Global relevance and applicability to a broad range of country settings;
2. Statistical adequacy;
3. Timeliness;
4. Data quality;
5. Coverage.

Earth observation complies with all these requirements and is therefore well-suited to support the process of monitoring SDG-indicators.

The observations until now were related to how governments comply with SDGs. Contributions at the local and at the business level are no less important. To do this successfully, it is important to follow an "outside-in"-approach: by looking at what is needed externally from a global perspective and setting goals accordingly, the gap between current performance and required performance will be bridged. Earth observation can play a role in clarifying the connection between the global perspective and the local level and business ecosystems through information provision for informed decision-making.

In the short term, the High-level Political Forum on Sustainable Development (HLPF) that will take place from 10-19 July 2017 is particularly relevant, as it is one of the first opportunities for the Netherlands to inform about and get feedback on progress towards the SDGs. The central event is the three-day ministerial meeting of the Forum on 17-19 July.

The Netherlands is one of the 30 countries that will present their national voluntary reports for review on the following SDGs at the 2017 HLPF:
- SDG-1: "No poverty";
- SDG-2: "Zero hunger";
- SDG-3: "Good health and well-being";
- SDG-5: "Gender equality";
- SDG-9: "Industry, innovation and infrastructure";
- SDG-14: "Life below water"; and
- SDG-17: "Partnerships for the goals".

Sustainable development goals and the Netherlands

There are many interesting and relevant aspects to the Netherlands policy, planning, action and progress with respect to the Sustainable Development Goals. This section only highlights some salient features to sketch the general framework in which Earth observation interventions can take place. The following documents are especially relevant:

- *Meten van SDGs - Een eerste beeld voor Nederland* (CBS, 2016)[9];
- *Sustainable Development Goals in Nederland – Bouwstenen voor leefomgevingsbeleid voor 2030* (PBL, 2016)[10]; and
- *Nederland ontwikkelt duurzaam - Eerste Nederlandse SDG rapportage* (2017)[11].

The SDGs are interesting and important for the Netherlands from both a national and an international perspective. Internationally especially capacity building (knowledge transfer) and technical assistance (expertise) are important and the Netherlands is traditionally strong in these fields. Priorities of the European Union and the Netherlands are to transfer from free trade to sustainable trade. The Netherlands aims at a fully circular economy by 2050[12]. This includes Dutch activities in the areas of aid, trade and investments in the rest of the world.

Working on the footprint of the Netherlands remains a challenge, as trade and agriculture are very important parts of the economy, e.g. how to calculate and reduce the footprint of the production of food (in tropical countries) for livestock (in the Netherlands)? Climate is also a problem (with the presence of industry, the Rotterdam harbour and Schiphol airport). Water quality and the phosphate surplus in agriculture need special attention.

Inclusive green growth, sustainable development and sustainable landscapes are key elements for achieving a circular economy. Until now, there has been insufficient attention for nexus between environment, energy, water, and food security.

Two-thirds of the SDG indicators are covered by existing and used indicators, albeit that not always sufficient data is available. As National Statistical Institution (NSI), Statistics Netherlands (CBS) is responsible for monitoring the SDGs in the Netherlands and has the mandate to apply, modify and create indicators.

The analysis of CBS was primarily dedicated to identifying already existing indicators that are closest to the SDG indicators. It is impossible to generate an internationally complete, valid and sound set of indicators. However, this is not a urgent problem, because the process will last until 2030. Hence, European and national implementation enjoys a higher degree of freedom with respect to indicators: no one-on-one mapping is required, existing indicators can be used. A European proposal is still being developed and discussed. If relevant, new indicators will be developed. Reporting on the general SDG indicators is mandatory only once a year.

Which indicators and tools are suitable for developing the appropriate intervention policy is a more interesting question, than the selection of "official" indicators. The main challenge is to fit the different pieces of the puzzle together: combining interesting ideas and initiatives from different disciplines into a consistent whole. A sense of ownership is fundamental.

As indicated above, end 2016 CBS published the report *"Meten van SDGs - Een eerste beeld voor Nederland" (Measuring the SDGs - An initial picture for the Netherlands)*. The CBS report is for discussion purposes. Within CBS a SDG-monitoring group is formed and CBS is investing in innovation, e.g. in the use of big data, including crowded sourced and satellite data. Moreover, a consultation will take place with 30 societal organisations. The selection was done by the Ministry of Foreign Affairs in cooperation with CBS. The selected organisations are leading in their field, have (access to) extensive data and a good international network. A pilot consultation on SDG-2 and SDG-15 has started with Rijkswaterstaat (RWS) and Wageningen University & Research (WUR). CBS also regularly publishes the *Monitor Duurzaam Nederland (Sustainability Monitor for the Netherlands)*, jointly with the Planbureau voor de Leefomgeving (PBL; Netherlands Environmental Assessment Agency) and recently announced the publication of a *Monitor of Well-Being*[13], based on the recommendations of a parliamentary committee.

Another interesting development is the SDG Charter. The SDG Charter is a Dutch foundation that facilitates partnerships that support the SDGs. The SDG charter is a civil society initiative and around 100 parties have subscribed. Activities are: organizing workshops and other events where people can meet and exchange information and experiences, advocacy, finding opportunities for funding and communication (including media appearances).

The PBL-report *"Sustainable Development Goals in Nederland – Bouwstenen voor leefomgevingsbeleid voor 2030" (Sustainable Development Goals in the Netherlands – Building blocks for environmental policy for 2030)* identifies the following categories and dimensions: quality of life (here and now), natural resources (future) and the Netherlands in the world (elsewhere). In addition, four different types of capital are distinguished as elements of the broad well-being concept: economic capital (machines, buildings and knowledge); human capital (level of education and skills of individuals), natural capital (raw materials, natural resources, biodiversity and climate) and social capital (social networks, relations and institutions). To measure sustainable development, parallel[14] accounts, such as environmental accounts (System of Environmental and Economic Accounts, SEEA) are needed. Environmental accounting is already made mandatory by the European Union. Different dashboards, such as the *Better Life Index*[15] , reporting on sustainable development by Eurostat[16] and the *Monitor Duurzaam Nederland* [17], will jointly paint a picture of progress and challenges.

As indicated, the efforts of the Netherlands vis-à-vis the SDGs do not take place in isolation, but are part of the European policy for sustainable development, as documented in the *"The new European consensus on development – Our World, our dignity, our future"*[18], *"Key European action supporting the 2030 Agenda and the Sustainable Development Goals"*[19] and the communication *"Next steps for a sustainable European future – European action for sustainability"*[20]. The role of Europe focuses on leveraging national activities towards addressed SDGs and on providing guidance, rather than on issuing rules and regulations on the subject. The responsibility and mandate for action towards the SDGs and reporting clearly rests with the member countries.

Hugo G. von Meijenfeldt,
SDG Coordinator Ministry of Foreign Affairs

"It is clear that if we want to move forward to achieve the Sustainable Development Goals, we need a variety of data technology to monitor our progress. Without a doubt I can say that the added value of satellite data at least looks very promising".

The Netherlands supports the SDGs internationally

Beyond Europe, the Netherlands aims at providing assistance to other countries to address the challenges of the Sustainable Development Goals. A general guideline for the Netherlands' international policy towards achieving the SDGs is the combination of trade and development cooperation that targets both economic growth and reduction of poverty and inequality. The Netherlands has the infrastructure that is necessary to comply with assessment of progress for the Sustainable Development Goals. In developing countries this infrastructure is lacking. As indicated above, the Netherlands could support these countries with capacity building and expertise. On the other hand, developing countries use new and innovative tools, e.g. simple visualisation, that could be interesting for the Netherlands as well. An example of a concrete activity is the support of CBS to the Urban Data Centres initiative in other countries. Another example is the initiative of the Algemene Rekenkamer (Court of Audit) for the improvement of national audits in a number of Middle Eastern and North African (MENA) countries through the Sharaka-project, which helps prepare these countries for the SDGs. In addition to other types of expertise, working with big data and applying an integrated approach are strong points of the Netherlands for international cooperation.

Knowledge transfer and capacity building are important elements of Dutch international cooperation. The Netherlands has a strong and internationally oriented knowledge sector. Scientific research, innovation and acquisition of knowledge and skills are needed to enhance the capacity of developing countries to achieve the SDGs and monitor progress. New technologies, such as Earth observation, create opportunities that can accelerate this process. In this respect the *Nationale Wetenschapsagenda*[21] (with an investment proposal specifically aimed at SDGs and inclusive global development) and the - recently closed - NWO-WOTRO call for proposals on *Tackling Global Challenges through Use-Inspired Research*[22] of NWO-WOTRO Science for Global Development and seven Dutch knowledge institutes - are worth noting. Both initiatives state that one of the main challenges for the research community concerns the wicked problem of inclusive development at global level. Complexity thinking, the availability of big data (e.g. via Earth Observation), and the technical capabilities to expose and access this knowledge provide opportunities for exploring global inequality in all its coherent aspects. We must use both western and southern perspectives in a sectoral and transdisciplinary scientific system approach.

The Netherlands' higher education system has a long tradition of international cooperation and the last decades show a trend towards further internationalisation of Dutch education. Although generation of additional income is certainly a driver, an important part of these efforts is directed at development cooperation. International educational institutes, now mostly merged with universities, have been around for more than 60 years, and programmes supporting students from developing countries (NFP) and building capacity in developing countries (NICHE)[23] have been existing (under different names) for just as long.

Although not explicitly targeting the SDGs, the publication *"Global challenges, Dutch solutions"*[24], summarises the expertise that the Dutch private sector deploys for sustainable solutions in different fields. Equally, Dutch NGOs contribute to achieving the SDGs, with emphasis on the fields of water and sanitation, agriculture, gender and education. The Netherlands' government provides support to these initiatives through various programmes.

There are many other international activities that contribute to the SDGs that receive support from either the Dutch government or the Dutch private sector or Dutch academia. A number of initiatives related to G4AW topics are presented in the next chapters. Dutch policy aspects dealing with G4AW topics are also presented in these chapters.

The broad spectrum of knowledge for SDGs (Nationale Wetenschapsagenda)

To research global inclusivity, we need to recognise and use a broader spectrum of knowledge types and innovation styles than applied in Western science. Besides, connecting to social actors is crucial in choosing solution strategies, creating knowledge and in implementing social change. This requires cooperation between different knowledge systems, in which co-creation contributes to new knowledge through the integration of scientific knowledge and more practical knowledge from non-scientific partners. Such a complex collaboration between different normative and instrumental knowledge systems benefits from a horizontal knowledge organisation where knowledge creation takes place through collaboration and through the absence of an exclusive owner of knowledge.

The Sustainable Development Goals require new, evidence-based science to give insights in the interdependence of the subsystems. Also, a knowledge infrastructure that offers space for pluriform value and knowledge systems is indispensable for developing, managing and sharing new scientific knowledge, technologies and experiences.

(Source: SDG-route Nationale Wetenschapsagenda)

Earth observation and the SDGs

The key proposition and message is that Earth observation can feed politics with factual information and quantitative data that facilitates informed decision making. With the help of Earth observation this can be done cheaper and quicker than with conventional methods and more information can be provided.

In the second part of Article 76 of the 2030 Agenda the following is stated: "*.... We will promote transparent and accountable scaling-up of appropriate public-private cooperation to exploit the contribution to be made by a wide range of data, **including Earth observation and geo-spatial information**, while ensuring national ownership in supporting and tracking progress*"[25].

This statement is further specified in detail in the terms of reference of the IAEG working group on geospatial information (WGGI): "*Consider how **geospatial information** can contribute to the indicators and metadata: 1) as a direct indicator in itself; 2) to support and augment statistical data; 3) to improve the production process of statistical data; 4) to validate national statistical data inputs; 5) to communicate and visualise the geographic dimensions and context of the indicators where appropriate; and 6) to provide granularity and disaggregation of the indicators where appropriate*"[26].

Martin Herold (WUR) is a member of the working group (representing GOFC-GOLD) and the *Group on Earth Observations*[27] (GEO) is also represented in the group through the Earth observation for SDGs (EO4SDG) initiative. GEO is the lead for two Tier III Indicator case studies: SDG 6.6.1, on water quality, and SDG 15.3.1, on land degradation.

In the Global Sustainable Development report of 2016[28], in which the following crucial emerging technologies are identified: *big data technologies, internet of things, 5G mobile phones, 3-D printing and manufacturing, cloud computing platforms, open data technology, free and open-source data, massive open online courses, micro-simulation, E-distribution, systems combining radio, mobile phone, **satellite, GIS, and remote sensing data**, data sharing technologies (including citizen science-enabling technologies), social media technologies, mobile Apps to promote public engagement and behavioural change, pre-paid systems of electricity use and automatic meter reading, digital monitoring technologies, and digital security technology.*

For further reading and understanding it is important that integration of Earth observation with other emerging technologies is kept in mind; as stand-alone the added value of Earth observation is limited. Furthermore, the success of utilisation of Earth observation applications will depend on the embedding in organisational and business process.

Taking the above into account, Earth observation can make a contribution to both achieving the SDGs and to assess progress towards targets by monitoring indicators. Although it is not always possible to make a clear distinction between EO applications for achieving SDGs and for monitoring indicators, for practical purposes this distinction is maintained throughout this report, as the requirements for both types of activities may be different. The GEO EO4SDG[29] initiative concludes that there are clear opportunities for EO to directly inform some indicators.

Annex 2 gives an overview for G4AW related SDGs (taken in a broad sense), as result of an analysis for this report. Of course, work with statistical agencies is needed to ensure the methods are sound and the metadata for indicators need to be established and stored to document methods and clarify data sources. Earth observation can thus contribute to bring Tier III indicators up to the level of Tier II and Tier I.

Groundwork on geospatial information for the SDGs is done by the United Nations Statistics Division (UNSD) and experts on the proposed Global Statistical Geospatial Framework (GSGF), with involvement of both statistical and geospatial communities. The following general principles were adopted in 2016:

1. Use of fundamental geospatial infrastructure and geocoding;
2. Geocoded unit record data in a data management environment;
3. Common geographies for dissemination of statistics;
4. Interoperable data and metadata standards; and
5. Accessible and usable geospatially enabled statistics.

In combination with the development of a general data framework for the SDGs an interoperable system will be established. The report "*Transforming our World – Geospatial information key to achieving the 2030 Agenda for sustainable development*"[30] of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) provides additional information.

The EO4SDG initiative carried out a preliminary analysis of SDG targets that can be supported by Earth observation. The analysis coincides largely with the findings of this report and is presented in figure 1. A specification of applications is provided in the tables of this report, Annex 2 and in the infographics[31] that is elaborated jointly with this report. The complete listing and description of SDGs and indicators can be found in both Dutch and English in the CBS document "*SDG doelen en indicatoren: vertaling Engels – Nederlands*"[32].

EO4SDG also presents a decision tree to assess the feasibility of Earth observation applications for SDGs. A Data4SDGs toolbox is under development, but not operational yet[33]. The findings of GEO until now are summarised in the article "*Earth observation in service of the 2030 Agenda for Sustainable Development*"[34] that was published (June 15, 2017) during the course of this study.

In parallel to working for the SDGs the contribution of Earth observation to achieve compliance with and international agreements (that are also relevant to the SDGs), such as the *Paris Agreement*[35] on climate, the *Sendai Framework for Disaster Risk Reduction*[36] and the *Convention on Biological Diversity*[37] (Aichi Biodiversity Targets[38]) needs to be developed further. The PBL-report "*Sustainable Development Goals in Nederland – Bouwstenen voor leefomgevingsbeleid voor 2030*" provides an overview of the relation between targets and international agreements and Dutch policy targets for environmental SDGs.

Guiding principles are that Earth observation functions as an enabler, concrete applications are developed for the SDGs and that the client is in the driver's seat. To achieve this close cooperation

Figure 1: Areas in which Earth observation contributes to the SDGs (source: EO4SDG)

with national statistical institutions, ministries, agencies, knowledge institutions and the private sector is needed. In that framework the following actions are needed:

- Facilitation of (further) development, testing and operationalisation of promising Earth observation applications, integrated into solutions;
- Capacity building at appropriate levels for all actors involved;
- Easily accessible, reproducible, scalable and workable products and services;
- Advocacy of successful solutions (at national and international level).

There are still a number of challenges that need to be addressed: data disaggregation, easy access to datasets, integration of different data sources, complementing statistical methods with other methods of data acquisition, accounting for the effect of scale (national and sub-national data, national and global/ regional data), scalability of applications, cooperation across disciplines, complexity-of-use for non-experts, handling large and complex data, getting from isolated initiatives to integrated efforts, etc.

That Earth observation is very much on the agenda is shown by the establishment of Radiant.Earth[1], an organisation that aims to make geospatial data available for the global development company. Radiant Earth is supported by the Bill and Melinda Gates Foundation and the Omidyar Network for a period of three years and will make use of the Amazon platform. The initiative is not operational yet and a business model still has to be developed, making it too early to tell what the possible contribution to the Sustainable Development Goals will be. Radiant.Earth sees itself as complementary to GEO (see text box below).

Radiant

A global contribution to various SDGs

Radiant launched operations in August 2016 to answer the call for open access to geospatial data, with analytical tools for global development practitioners designed to improve decision-making, and to foster entrepreneurship worldwide.

Bill and Melinda Gates - who are also custodians of legendary investor Warren Buffet's billions – have joined forces with Pierre Omidyar, founder of eBay, to fund the 'Radiant Earth' project, a repository and archive of the world's satellite, aerial and drone imagery.

ⓘ https://www.radiant.earth/

Radiant
Earth Imagery for Impact

EO4SDGs, Earth Observations in Service of the 2030 Agenda for Sustainable Development

Earth observations for the Sustainable Development Goals

EO4SDGs is an initiative in the framework of the Strategic Plan 2016 – 2025 of the Group on Earth Observations (GEO). NASA, JAXA, and INEGI co-lead the GEO EO4SDGs Initiative. The Initiative aims to:

- Advance a portfolio of national pilot projects in one or more GEO Member countries focused on integrating Earth observations with national statistical accounts to better measure, monitor and achieve the SDGs;
- Organise capacity building activities that aim to provide support to institutions and individuals in the implementation of Earth observation methods and data to achieve the SDGs;
- Support the development of data and information products to advance the provision, access, discoverability, and applicability of Earth observations for use with the SDGs; and
- Develop a portfolio of outreach and engagement activities to promote the consideration and adoption of Earth observations for the SDGs by nations and stakeholders.
- Further, the Initiative participates in the Inter-Agency and Expert Group on Sustainable Development Goals (IAEG-SDGs) Working Group on Geospatial Information (WGGI) and works to enhance its engagement with the UN, expand GEO's current partnerships, and ensure alignment with international coordinating organisations, foundations, and initiatives, such as the Global Partnership for Sustainable Development Data (GPSDD), the UN Sustainable Development Solutions Network (SDSN), and the International Institute for Sustainable Development (IISD), among others.

ⓘ http://www.earthobservations.org

GEO

G4AW and the SDGs - an introduction

G4AW Facility: Space for Food Security

A contribution to SDG-2

The G4AW Facility promotes and supports private investments for large scale, demand-driven and satellite based information services. It provides a platform for partnerships between public organisations, research institutes, private sector operators, NGOs, farmer cooperatives, satellite data/service operators, businesses and transmission operators. The goal of the G4AW Facility is to reach at least 4.5 million food producers with services that increase income, agricultural production and productivity and/or provide more resilience by 2022. The G4AW Facility started in 2013 and will run until 2022. For the past three years, the Netherlands Space Office (NSO) has been responsible for executing the G4AW Facility and supporting its 17 ongoing projects in 10 countries (anno 2017).

https://g4aw.spaceoffice.nl

G4AW related SDGs are the following:
- SDG-2 "Zero hunger";
- SDG-6 "Clean water and sanitation";
- SDG-12 "Responsible consumption and production";
- SDG-13 "Climate action"; and
- SDG-15 "Life on land".

These SDGs, with the exception of SDG-14 "Life below water", coincide with the SDGs that are selected as GEO Engagement Priorities for the period 2017 – 2019.

The main lessons learned from the mid-term review are:

- A clear focus in offered products and services and implementation strategy for these products and services should be clear from the start.
- A local, strong and active business partner with a clear focus increases the chance of success considerably.
- Partners that know and have worked together before the start of the project have an advantage, one that could increase the chance that the initiative will be sustainable.
- A good baseline study of demographics of target group (gender focus), user-demand, and challenges and opportunities for adoption is not only a necessary requirement; it also provides valuable information on agricultural practices.
- In many cases, the direct beneficiary of the activity is an intermediate organisation that transfers these benefits to the food producers.
- When benefits are transferred through an intermediate organisation, the metrics to measure results become more complicated and are less attributable to the individual food producer.
- Aspects related to sustainable use of resources, climate and gender are not easily captured by the current performance indicators.
- When looking at innovation, the whole chain from research to commercialisation should be taken into account.
- There is a need for knowledge exchange to celebrate and copy successes and to learn from and avoid repetition of mistakes.

The main lessons learned[40] of the implementation of the G4AW Facility until July 2016 (derived from the mid-term review executed by Food & Business Knowledge Platform[41] on behalf of Ministry of Foreign Affairs) are presented below.

These lessons are valuable when looking at bottom-up initiatives for SDGs. The formation of new (and sometimes unexpected) partnerships has been especially striking. The importance of an intermediate organisation that has a direct link with the target group (the so-called "aggregator") is also of crucial importance. G4AW is mentioned as an example in international context of how to successfully use Earth observation for smallholders, notably by the European Commission on several occasions.

Of the SDGs not included in the list presented above, G4AW provides a clear contribution to SDG-1 (poverty reduction) and possibly contribution to SDG-14 (life below water) through support to sustainable fisheries and aquaculture (although there are no projects dedicated to these topics yet).

The G4AW contribution to SDG-2 (reducing hunger) can be summarised as increasing production, productivity and resilience of smallholder farming. In addition to the gains for smallholders, the new, increased and improved information flows allow countries (and districts) to sharpen policy formulation. G4AW is complementary to (large) crop monitoring initiatives, such as GEOGLAM (see text box).

The G4AW contribution to SDG-6 focuses on more efficient use of water and increase of water productivity in agriculture (which is in virtually every country the biggest water user). A commercial angle may not be the best to approach water issues, as the resource is usually under-priced or not priced at, but in combination with the SDGs powerful tools can be created to make production chains sustainable. Moreover, the increased amount of data and improved accuracy in measurements helps countries to improve (scarce) water resources management.

The contribution to SDG-12 is better information provision and contribution to increasing the sustainability of production chains. Target 12.8 formulates this very well: *"By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature"*. Information flows derived from G4AW projects can be used as input for policy making on sustainability of production chains.

The contribution of G4AW-projects to SDG-13 is mainly on climate adaptation: the conditions for successful adaptation are created. Through e.g. crop calendars, drought and extreme rainfall prediction and monitoring it becomes easier to spot trends and consider and compare alternative scenarios. Here again, improved information flows are very valuable for elaborating plans at a higher level.

The contribution to SDG-15 in terms of making production chains sustainable is already mentioned above. This includes savings in potentially harmful chemicals, such as those in fertiliser and pesticides. Through targeted advice considerable savings can be achieved, without a loss in production. G4AW projects also provide valuable information that can be used for maintaining biodiversity, sustainable land management and policy formulation.

GEOGLAM, Global Agricultural Monitoring

A contribution to SDG-2

GEO's Global Agricultural Monitoring Initiative (GEOGLAM) forms part of the G20 Action Plan on Food Price Volatility. The goal of GEOGLAM is to strengthen the international community's capacity to produce and disseminate relevant, timely and accurate forecasts of agricultural production at national, regional and global scales through the use of satellite and ground-based EO. The initiative builds on existing agricultural monitoring programmes and initiatives at national, regional, and global levels. GEOGLAM is designed to harmonise reporting among these programs to arrive at global consensus reporting.

The GEOGLAM Crop Monitor for AMIS bulletins provide monthly crop condition assessments for wheat, maize, rice and soybeans, the four primary crop types; for 49 countries (G20 Members plus Spain and seven additional countries), representing 80–90% of global production, consumption and trade of the four commodities. Informed by EO-derived indices, meteorological information and field data used to monitor crop growth conditions, maps, graphs and texts depict crop stage, crop conditions by region, and climatic drivers affecting these conditions.

GEOGLAM also produces the Crop Monitor for Early Warning, addressing crop growth monitoring in more than 80 countries at risk of food insecurity. Many of the Countries at Risk are monitored by more than one organisation, each with its own combination of available data, tools, information and professional contacts.

Several Dutch organisations contribute to GEOGLAM through the EC FP7 SIGMA project.

https://cropmonitor.org/
http://www.geoglam-sigma.info

Reader to the following chapters

An overview of SDG targets and indicators and the possible contribution of Earth observation is presented in the following sections, with a more detailed overview in the annexes. The targets and indicators are selected according to the following general criteria:

- There is a relevant spatial component;
- Earth observation provides added value;
- The relation with the target and/or indicator is not too indirect; and
- The target or indicator is more or less G4AW related.

The criteria are loosely applied: some more general and promising applications that are relevant to the work of e.g. CBS and the Rekenkamer are included, because the basic information layers they require are also applicable to activities that are implemented under the G4AW Facility.

The division in the categories general, agriculture, water, sustainable landscape management and climate is far from absolute. There is considerable overlap between SDGs and categories; SDGs are relevant and applicable to different categories and vice versa. For convenience sake, each target or indicator appears only once.

The summary tables list information on Earth observation applications, the benefit of the application, whether the application is most likely to be used in the Netherlands or internationally (or both), what is required to make the application successful and some examples of the application (if available).

The aim is to look for general characteristics and similarities that provide guidance towards the identification of opportunities and synergy. Promising applications can then be investigated more in-depth to find the best way for provision of solutions and policy support.

As identified above, there is considerable overlap with the target and indicators that were selected as relevant by the EO4SDG initiative. In general, more targets and indicators are presented for analysis in this report, but some targets and indicators that were listed by EO4SDG were not used for this report. Annex 4 provides an overview of the reasons why they were not selected.


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Earth observation for the SDGs - General

This section, referred to as SDG-0 General, deals with the required actions that are relevant to and provide basic information for all SDGs. Annex 5 (table) gives an overview of possible applications of Earth observation for a wide range of SDGs, with special attention to monitoring of progress and compliance. Only those targets and indicators are listed that are not better captured by the other categories of agriculture, water, sustainable landscape management and climate. This does not mean that they are not related, there are many cross-links..

Next to statistical offices, also other organisations such as Court of Audits might be involved in establishing formal national structures and procedures for SDG reporting, as is illustrated by the Sharaka project coordinated by the Algemene Rekenkamer (Court of Audit).

The Rekenkamer checks that the Dutch government spends public funds and conducts policy as intended. In addition to its national mandate and operations, the Rekenkamer is also active internationally. The Rekenkamer helps other countries to improve national audits and to improve preparedness and review capacities for the SDGs. Through a number of interventions the cooperating institutions will be strengthened to enhance the preparedness of their countries to implement the SDGs.

This practical experience leads to an interest in geospatial applications, including Earth observation. What Earth observation can do needs to be translated in concrete products and services that are accessible and easy to use and understand for non-experts. Capacity building is needed to improve preparedness and performance audits. Geospatial data and earth observation play an important role, as they are tools to monitor and visualise processes and provide a synoptic overview of the state-of-the-art, leading to informed decision-making. Nationally, control is very important and internationally, capacity building. The Rekenkamer, together with cooperating partners, will determine priorities for each country, which will then be elaborated more in-depth. During a Sharaka workshop in The Hague (March 28, 2017), NSO introduced Earth observation to the workshop attendees. Special attention was given to the opportunity to prioritise "water productivity" (SDG-6) using the FAO Water Productivity Database (see chapter SDG-6).

Sharaka

The Sharaka programme is a five year regional peer-to-peer development programme that will build on the long-standing cooperation between the Netherlands Court of Audit and colleague Supreme Audit Institutions in the Arab region (Algeria, Iraq, Jordan, Lebanon, Morocco, Palestinian Authority and Tunisia). As well as building the individual institutional capacity of the respective SAIs, it will contribute to developing a practise hands-on regional cooperation, parallel audits and exchange of experience financed by the Dutch Ministry of Foreign Affairs. The programme has regional as well as bilateral components. At this point the project works on two main regional projects: the Sustainable Development Goals (SDG) and IntoSAINT.

Egbert Jongsma,
project manager Knowledge Center GIS & Audit, Netherlands Court of Audit

"Geography is the missing link between the policy world and the real world. Making it possible to connect policy interventions, public expenditures and the impact for citizens."

Earth observation for the SDGs - Food security

Food security is connected to many SDGs, but the main SDGs related to agriculture are SDG-2 and SDG-14 (for fisheries and aquaculture). There are also strong connections to SDG-6, SDG-13 and SDG-15.

In the Netherlands achievement of SDG-2 is not a concern. However, there are problems related to (international) footprints, nutrient balances and emissions caused by a combination of livestock and peatlands. Biomass assessments could help provide a better insight in this issue.

Internationally, food security, sustainable agriculture and climate adaptation are goals that are actively pursued by the Netherlands. The Geodata for Agriculture and Water (G4AW) Facility[42] is an example(see section on G4AW and the SDGs).

An interesting development is the formation of partnerships that come up with innovative solutions and where Earth observation companies work together with (for them) non-traditional partners, such as micro-finance organisations, insurance companies, farmers' organisations, fertiliser and seed companies and telecom providers, making use of different business models.

Through its focus on smallholders, this initiative is complementary to general agricultural monitoring programs, such as GEOGLAM[43] (Group on Earth observations global agricultural monitoring) that monitors selected crops in Africa and Central Asia in connection with the agricultural management information system (AMIS) of the G20. GODAN[44] (Global Open Data for Agriculture and Nutrition) and GrowAsia[45] are other examples of global and regional initiatives that promote use of geodata and other open data farming applications to improve food security.

Sustainable fisheries and aquaculture have not yet been addressed by the G4AW Facility, but several options for the use of Earth observation are available, as Annex 6 illustrates.

For the long term, financial sustainability and affordable services for (smallholder) farmers are most promising, which requires a role for the private sector as well. Dutch service providers have developed various services with agri-value chain stakeholders, such as:

- FruitLook[46], developed by eLEAF with and for South African farmers
- SpaceCertified, developed in a NSO SBIR project by WaterWatch Cooperative and Satelligence, together with launching customer UTZ
- Crop Disease Alert 2.0[47], a recent initiative of SAP and Waterwatch Cooperative to support multinationals, such as Nestlé and Unilever, in managing the whole supply chain points in this direction.
- Services for index-based insurance, e.g. by EARS and VanderSat

Another recent development is the recognition that Earth observation data provides transparent, objective sources of information to increase outreach of financial services especially to rural areas and for smallholder farmers[48]. The Netherlands Platform for Inclusive Finance[49], together with a few of its members amongst other Rabobank, are initiating and developing the Geodata for Inclusive Finance & Food initiative (G4IFF).

Crop Disease Alert 2.0

A contribution to SDG-2

In a collaboration between SAP, Waterwatch Solutions, InfoPlaza and The Next View the Crop Disease Alert 2.0 was developed. The user target is farmers in developing but also developed countries all over the world. Benefits for the farmers will be up to 40% savings in pesticides, up to 25% increase in yield due to less diseases, and overall, prevent crop diseases and improve yield.
This application will be available from September 2017 globally at affordable costs for farmers. It combines satellite information from weather information (rain, humidity levels, extreme weather events), disease as well as other information and with a 3-step notification system (green, yellow, red) will send notifications to the user with an accurate forecast of 7 days in advance.

ⓘ http://waterwatchcooperative.com

WATERWATCH COOPERATIVE

Pierre van Hedel,
Director Rabobank Foundation

"Food security is the main focus of the Rabobank. The Board aims to promote the usage of information services based on geodata, which are mainly derived from satellites, to increase access to finance for smallholder farmers and agro-entrepreneurs in developing countries." [50]

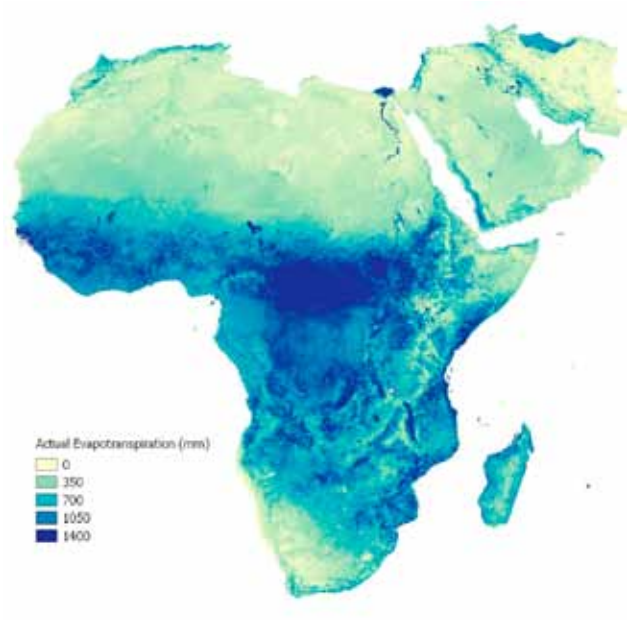
Earth observation for the SDGs - Water

Although SDG-6 is the main SDG for water, water related issues are critical for many SDGs, particularly SDG-2, 3, 11, 13, 14 and 15. Annex 7 gives an overview of SDG targets and indicators and Earth observation applications for water-related issues.

The international plans and goals of the Netherlands are reflected in the International Water Ambition (IWA)[51]. The aim is to increase water security and safety, with emphasis on developing countries, through an action-oriented approach that is coordinated by the Partners for Water (PvW) program. Moreover, the Netherlands invests largely in WASH initiatives to provide access to drinking water and sanitation in developing countries.

In the Netherlands a study was carried out to assess the feasibility of using Earth observation for indicators 6.4.1 (water use efficiency) and 6.4.2 (water stress). The study was done by Deltares and eLEAF, in close cooperation with CBS[52]. The study follows a ladder approach, which integrates existing data (from national accounts, water statistics and SEEA-type water accounts) and supplementary data from satellites and models into a consistent whole, based on statistical data, model data and satellite data. The biggest advantages of using Earth observation are that actual evapotranspiration is used, the higher spatial and temporal resolution, that Earth observation is applicable everywhere and allows for cross-country comparison and that time series are available. Disadvantages are that the focus is mostly on agricultural use, that there is difficult to estimate actual irrigation water withdrawal and that there is a high variation in estimates of environmental water requirements.

The Netherlands takes part in the GEMI-project[53] on integrated monitoring of water and sanitation related SDG targets, together with five other countries (Bangladesh, Jordan, Senegal, Peru and Uganda) and seven UN-agencies. The nationally oriented study mentioned above is part of this initiative and eLEAF and Deltares carried out an additional study on remote sensing for water in Uganda, Jordan and Peru. Initial findings have been published on 6.1 – 6.6 and 11.7 (water-related disasters)[54]. A synthesis report of UN-Water is planned for May 2018.



FRAME L1: *2015 Annual Actual Evapotranspiration, taken from FAO Water Productivity (test data).*
This image illustrates the ability of remote sensing based data to delivering high resolution data consistently for a large area, making it possible to compare different areas. (Produced by the FRAME consortium: eLEAF, VITO, ITC, Waterwatch foundation)

Job Kleijn,
Senior policy advisor Water Affairs, focal point MENA

"Focus of the Netherlands is to contribute to a stable and secure world. Water as a scarce resource plays an increasingly important role, both as a basis for cooperation, but also as a cause of conflict. As the pressure on water resources is increasing and as agriculture is the largest water user, the Ministry of Foreign Affairs has introduced a target to achieve a 25% increase in water productivity, starting in all Dutch financed projects. The Netherlands promotes the use of satellite data to map and monitor water use in agriculture."

An important initiative that is supported by the Netherlands is the establishment of the FAO *Water Productivity Open-access Portal* (WaPOR)[55] ; the beta-version was released in May 2017. The database is an instrument to achieve the Netherlands' aim of sustainable and responsible water use, which is seen as a necessary condition for a stable world. Long-standing efforts have shown how difficult it is to create the much needed awareness and understanding that leads to good water management. FAO is committed to maintain the database after the Dutch support has ended. Advocacy is needed to stimulate use of this database for a broad range of applications.

FAO WaPOR: Monitoring Water Productivity through Remote Sensing

A contribution to SDG-6

Achieving Food Security in the future while using water resources in a sustainable manner will be a major challenge for us and the next generations. Agriculture is a key water user and a careful monitoring of water productivity in agriculture and exploring opportunities to increase it is required. With financial support from the Netherlands, FAO is developing a publicly accessible near real time information system using satellite data to monitor water use in agriculture. The FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data (WaPOR) provides access to 10 years of continued observations over Africa and the Near East. The portal provides open access to various spatial data layers related to land and water use for agricultural production and allows for direct data queries, time series analyses, area statistics and data download of key variables to estimate water and land productivity gaps in irrigated and rain fed agriculture, monitor trends of water use in irrigated areas and assess the influence of droughts on agricultural production. Content for the WaPOR database is generated by eLEAF, Waterwatch Cooperative, ITC (NL) and VITO (B).

http://www.fao.org/in-action/remote-sensing-for-water-productivity/wapor/en/

Food and Agriculture Organization of the United Nations

Ministry of Foreign Affairs of the Netherlands

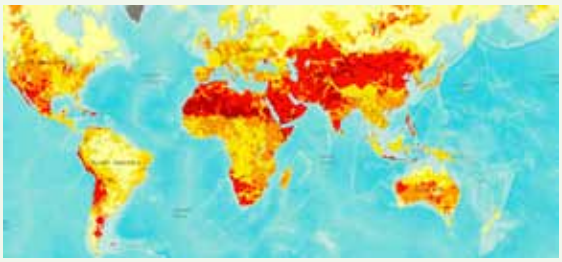
WRI, as many other stakeholders, has recognised water scarcity and excess of water as a major problem for coming decades. For that reason WRI and partners have developed Aqueduct, launched in 2013. Dutch research organisations Deltares, PBL, Vrije Universiteit Amsterdam and Utrecht University cooperate with WRI in the integration of Global Flood Analyzer in Aqueduct[56].

WRI Aqueduct

A contribution to SDG-6

Water scarcity is one of the defining issues of the 21st century. In its Global Risks 2013 report, the World Economic Forum identified water supply crises as one of the highest impact and most likely risks facing the planet. With the support of a diverse group of partners, the World Resources Institute built Aqueduct to help companies, investors, governments, and communities better understand where and how water risks are emerging around the world.

The Water Risk Atlas uses a robust, peer reviewed methodology and the best-available data to create high-resolution, customizable global maps of water risk.



The World Resources Institute is committed to transparency and open data. The data and methodology behind Aqueduct are documented and available for download. All the products, methodologies, and datasets that make up Aqueduct are available for free use under the Creative Commons CC:BY license.

Dutch research organisations Deltares, Vrije Universiteit Amsterdam and Utrecht University cooperate with WRI. WRI receives funding from Ministry of Foreign Affairs.

http://www.wri.org/our-work/project/aqueduct

WORLD RESOURCES INSTITUTE

Ministry of Foreign Affairs of the Netherlands

Many Earth observation and geo-ICT service providers in the Netherlands offer value added products for water related issues. They can be found on NWP website www.dutchwatersector.com.

Earth observation for the SDGs - Climate

SDG-13 is the climate SDG, but (changing) climate has impact on all SDGs. The *Paris Agreement* is leading. The Netherlands is promoting an even stricter implementation of the agreement, aiming at a maximum temperature rise of 1.5 degrees, instead of the agreed upper limit of 2 degrees. Science, based on Earth observation, supplies information that helps create awareness and contributes to improved policy making that is the basis for investment in mitigation and adaptation.

Earth observation also contributes to other interesting developments. For example: in an effort to reduce footprints, the steel industry invests in agriculture and agriculture invests in forestry. For a better targeting of these efforts, more knowledge is needed. To achieve a better translation of climate goals to the local level, the links between causes and effects at the micro-level and the macro-level need to be clarified. The challenge is to provide the right information, without causing overload. Annex 9 summarises a number of Earth observation applications for SDGs related to climate.

Climate adaptation is a priority for the Netherlands (without neglecting mitigation). The Netherlands will host the *Global Centre of Excellence on Climate Adaptation*[65]. This is a global centre that is supported by the Netherlands and Japan and is announced through the G20. The Centre is expected to start operations at the end of 2017 (to be announced at the Climate Summit in October).

Data and information, derived from systematic Earth observations can support national reporting, mitigation and adaptation efforts, global stocktaking. Earth observation can also help to make process transparent and improve public access to information. Earth observation provides basic information for reviews by technical experts.

The Group on Earth Observations (GEO) has committed itself to establish (by 2030) a global observation system of carbon and greenhouse gases (GHGs) that provides comprehensive

data for scientists and direct support for decision-making. The corresponding initiative is called GEO Carbon and GHG Initiative, or short GEOCARBON[66]. With respect to mitigation this entails improved and comprehensive data on emissions; with respect to adaptation the aim is to provide spatial data and maps that are readily utilizable in planning and information and recommendations to support policy making. ESA is supporting SDG-13 through the Climate Change Initiative, generating a consistent set of "Essential Climate Variables" for climate modelling (see box).

Earth observation applications are also expected to support the following aspects:

- Measuring, reporting and verification (MRV) mechanisms for climate, building on and extending the MRV-mechanism for REDD+;
- Verification of mitigation and adaptation measures;
- Data and services to IPCC special reports;
- Definition of metrics and methodologies in IPCC in emissions analysis;
- Reporting and information requirements of the parties to the agreement on climate impacts and adaptation;
- Further recognition of the role of the private sector in implementation; and
- Long-term investments in reducing vulnerability and disaster risk reduction measures.

ESA Climate Change Initiative

A contribution to SDG-13

To respond to this UNFCCC and GCOS need for climate data, the European Space Agency (ESA) has undertaken the Climate Change Initiative programme. The objective of the Climate Change Initiative is to realise the full potential of the long-term global Earth Observation archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the Essential Climate Variable (ECV) databases required by UNFCCC. It ensures that full capital is derived from ongoing and planned ESA missions, including ERS, Envisat, the Earth Explorer missions, relevant ESA-managed archives of Third-Party Mission data and the Sentinel constellation.

The programme undertakes the activities necessary to meet its objective of supporting the UNFCCC through the GCOS defined ECVs. This includes the periodic processing of the EO data sets applying the most up-to-date algorithms, plus development of improved algorithms for the ECV production from emerging data sources consistent with the long-term record.

Amongst others ITC, KNMI and WUR are involved in ESA CCI.

http://cci.esa.int/

Marcel Beukeboom,
Climate Envoy
Kingdom of the Netherlands

"Earth observation has played a critical role in creating awareness about climate change and thus the start of a period of climate action. For climate action earth observation can once again become indispensable as it has the unique capability to reach scale quickly at relatively low cost."

Earth observation for the SDGs - Sustainable landscape management

The main SDG for sustainable landscape management (or integrated landscape management (ILM)) is SDG-15, but the subject is very much related all SDGs. An important tool for the promotion of sustainable land management is to make impact measurable and Earth observation facilitate this. The link with the SDGs leads to a broadening of public support for sustainable landscape management. Annex 8 gives an overview of SDG targets and indicators and Earth observation applications for issues related to sustainable landscape management.

The report *"Landscape partnerships for sustainable development: Achieving the SDG through integrated landscape management"* [57] lists a number of achievements of integrated landscape management (see box).

Integrated landscape management:
- Generates solutions that achieve multiple objectives at once;
- Improves inter-sectoral coordination and cost-effectiveness at multiple levels;
- Empowers communities through multi-stakeholder processes and inclusive governance;
- Enhances transboundary and regional cooperation;
- Contributes to national and regional strategies for addressing climate change.

Based on this the report formulates six recommendations to support national governments to build ILM into every level of their strategy development and utilise it as an integration and implementation mechanism for achieving the SDGs:

1. Utilise landscapes as the building blocks for development of socio-ecological resilience.
2. Institute a "whole of government" approach.
3. Structure policy and public budgets to enable adaptation to the local context and empower sub-national actors.
4. Use integrated landscape management as a central feature in "inclusive green growth" economic development models.
5. Catalyse knowledge sharing and the adoption of best practices.
6. Identify and adopt integrative and leverage indicators to track coherence of SDG progress.

This advice illustrates the integrated and multi-disciplinary aspects of sustainable land management. (Participatory) mapping and use of Earth observation can help to provide quantitative information. Creating maps of ecosystems, while monitoring change over time, supports sustainable spatial planning and land use, and the rights of indigenous populations.

The Netherlands Government supports technical assistance for integrated land management in the form of the ISLA program (initiative on sustainable landscapes).The initiative brings together actors from the commercial sector and environmental and societal organisations. A number of projects are carried out in different countries, mainly in Africa. The goal is to create awareness, get the dialogue on sustainable landscape management going and demonstrate successful approaches.

Earth observation to monitor deforestation, as done by the World Resources Institute (WRI) / Global Forest Watch, is a well-known example. FAO will shift from a five-year cycle with its Forest Resource Assessment to a continuous and consistent one-year monitoring cycle. GOFC-GOLD Land Cover Office[58], coordinated by WUR, focuses on land cover as an essential climate variable (ECV) and on REDD+[59]. In combination with other initiatives, such as GFOI[60] and REDD+, this makes SDG indicator 15.1.1 a likely candidate for monitoring

Blackshore Cerberus

A contribution to SDG-15

Solving world problems using the power of the crowd, satellites and a bit of gaming

A major climate change driver is deforestation often caused by "illegal" logging activities. The reason for this is often not for the wood, but being done by farmers looking for fertile grounds. Farmers, in development countries, are working lands being poorly managed getting struck by diseases for example. Countering this Cerberus assists them in better managing their existing land plots, increase yields and eliminate the need to cut down our rain forests.

The Cerberus crowdsourcing platform directed at agriculture and forest monitoring. The Cerberus platform is a "serious gaming" environment in which the crowd is asked to help mapping out what can be seen on satellite photos. While the crowd is doing this, they learn and get directly engaged to world problem areas in need of help generating awareness. The output of Cerberus are maps usable for precision farming directly usable by organisations active in the (sustainable) food industry or for example by organisations working on forest monitoring protection.

ⓘ http://www.blackshore.eu BlackShore Cerberus

with remote sensing (see the box below). However, the indicator itself is not clear: not only "total area" is important, but the degree of reforestation, quality of forest, etc. needs also to be assessed. Australia will come up with a report on Earth observation for 15.3.1 "Proportion of land that is degraded over total land area" shortly.

WRI Global Forest Watch

A contribution to SDG-15

A dynamic online forest monitoring and alert system that empowers people everywhere to better manage forests.

Global Forest Watch (GFW) is free and simple to use, enabling anyone to create custom maps, analyse forest trends, subscribe to alerts, or download data for their local area or the entire world. Users can also contribute to GFW by sharing data and stories from the ground via GFW's crowdsourcing tools, blogs, and discussion groups. Special "apps" provide detailed information for companies that wish to reduce the risk of deforestation in their supply chains, users who want to monitor fires across Southeast Asia, and more. GFW serves a variety of users including governments, the private sector, NGOs, journalists, universities, and the general public.

Discussions of WRI with Dutch stakeholders for cooperation are ongoing.

ⓘ http://www.globalforestwatch.org/

Food and Agriculture Organization of the United Nations

Ministry of Foreign Affairs of the Netherlands

Closely related to the issue of integrated land management is the subject of environmental or natural capital accounting. There are many initiatives, such as the WAVES[61] program of the World Bank (supported by CBS and PBL) and the natural capital studies and protocol of TEEB[62], which are directed at both the private and the public sector. CGIAR organisations CIFOR and ICRAF coordinate the Global Landscape Forum[63].

Monitoring and maintaining biodiversity is a very important aspect of integrated landscape management. An example of a model used for biodiversity is the PBL GLOBIO computer model that includes food, water, gender and land elements. Another example of applications for biodiversity is the GEO initiative GEOBON, in which several Dutch organisations collaborate.

GEOBON: Biodiversity Observation Network

A contribution to SDG-15

GEOBON has facilitated the development or enhancement of at least 25 national biodiversity observation systems, representing most of the Earth's major biomes that are coordinated and can contribute to regional and global biodiversity assessments.

At least 10 regularly updated operational products (e.g. global change detection maps of forest cover; compendium of marine environmental databases) have been developed, providing high quality observations, information and data to scientists, decision-makers and the public at various scales; remotely sensed and in-situ data (based on the Essential Biodiversity Variables) are routinely used as inputs to these observation products and contribute to models that support improved policy assessments and scenarios at multiple scales.

Amongst others ITC, IUCN, NIOZ and WUR are involved in GEOBON.

ⓘ http://geobon.org GEO BON

A list of European agreements and directives and of international agreements related to landscape management is provided in the PBL report *"Sustainable development in the Netherlands – Building blocks for environmental policy for 2030"*[64]. An easily drawn, but valid, conclusion is that these agreements and the SDGs reinforce each other: the SDGs tend to have the effect of linking the agreements and to re-emphasise the sense of urgency.

The role of private sector is sustainable landscapes is for instance facilitated through initiatives such as IDH and certification (e.g. UTZ/RainForest Alliance, FSC, Max Havelaar). Earth observation service providers in the Netherlands offering value added products for sustainable landscape management include amongst others NEO, Satelligence, SarVision, TerraSphere, WaterWatch Cooperative.

Analysis

The key proposition and message is that Earth observation can feed politics with factual information and quantitative data that facilitates informed decision making. With the help of Earth observation this can be done cheaper and quicker than with conventional methods and more information can be provided. Earth observation acts therefore as an enabler and facilitator for implementing the SDGs.

Furthermore, Earth observation complies with the requirements for technically-sound quantitative indicators that were listed earlier:

1. Global relevance and applicability to a broad range of country settings;
2. Statistical adequacy;
3. Timeliness;
4. Data quality; and
5. Coverage.

Earth observation is therefore well-suited to support the process of monitoring SDG-indicators. As stated earlier, the biggest contribution of Earth observation is expected for indicators that are not Tier I. Earth observation can thus contribute to bring Tier III indicators up to the level of Tier II and Tier I.

The main benefits of the use of Earth observation in terms of spatial information are: saving of costs and time, quality improvement and improved process control (see Annex 10 for details). But benefits provided by Earth observation go beyond spatial. Target 16.7 and target 12.8 capture the essence of the impact of Earth observation:

12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature;

16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels.

The projects carried out in the framework of the G4AW Facility show that the combination of Earth observation and smart mobile apps can make SDG target 12.8 a reality for smallholders[67]. What can be done for agriculture can be extended to other areas. The final aim of all SDG-related Earth observation applications is SDG target 16.7: apart from facilitating more informed decision-making, Earth observation visualises complex issues in a way that is easy to understand and therefore creates the conditions for broad participation. What cannot be stressed enough is that Earth observation is only one element that contributes to the SDG process: solutions are almost never found in isolation and Earth observation should be used in combination with other (mostly non-spatial) tools.

The main challenge is therefore to achieve synergy through the use of Earth observation data. Annex 11 sums up three categories of challenges for making Earth observation applications a success (data-related, knowledge and skills-related and marketing-related), but to capitalise on the potential and to achieve synergy more is needed. Traditionally governments (including space agencies), the academic sector (institutions and scientists specialised in Earth observation) and commercial value-adders in Earth observation are the main players, but the landscape is changing: other government sectors, NGOs, the financial sector, investors, companies with a diverse range of activities and citizens all broaden the range of stakeholders. Below, developments and requirements are briefly discussed.[68]

Cooperation between government, academia and business
Public-private partnerships are essential. To exploit commercial data effectively, first scientific research is needed and, at a later stage, innovation needs to stimulated and testing and implementation of solutions facilitated. The introduction of new technological solutions is virtually impossible without cooperation between the government, academia and the private sector. Public-private partnerships are also important for implementation, depending on conditions. For example, in G4AW projects dedicated to agricultural insurance governments jump in as the main stakeholder, once they realise how well the value propositions aligns with their national policy goals.

Free, open and easily accessible datasets
Facilitating discoverability of datasets at different scales and formats is an important aspect of leveraging Earth observation information and applications. National data portals and the Copernicus[69] programme are means to realise this. The data of the satellites launched under this programme are open and free. Furthermore, Copernicus aims at developing services and at establishing a firm connection with in-situ networks and citizens' observatories. The establishment of in-situ networks and citizens' observatories receives a lot of support from the European Commission, as they are much needed complements to Earth observation data from space. Especially in developing countries there is a huge need for both.

The use of free and open data has increased tremendously over the past decade[70]. However, this alone is not enough to make the use of Earth observation mainstream. Much effort still has to go into standardisation and interoperability, thus improving harmonisation of the whole data cycle workflow. (Partly) due to the use of free and open data and improving capabilities of operating massive volumes of data[71], there is a shift towards value adding rather than ownership of data. The efforts of GEO are directed at tackling these problems and at reducing fragmentation in the data landscape and establishing a sustainable and long-term framework for successful use of Earth observation.

As the amount of free and open data increases, there are many services that are built on readily available datasets. The work of GOFC-GOLD, with office at WUR, on land cover and the FAO water productivity database WaPOR, funded by the Netherlands, and with support of Dutch organisations for content, should be mentioned in this respect. Annex 3 provides some examples.

Capacity building and the role of knowledge institutions
Capacity building and research are important at the national level, but even more so at the international level with an emphasis on developing countries. Research at national level

should be mostly directed at new technologies and applications and at achieving synergy, through the topics that were mentioned above. With respect to investment in research and development, reference is already made to the Nationale Wetenschapsagenda. Through the H2020 programme, the European Commission also invests considerably in research, development, innovation and commercialisation for Earth observation.

To achieve synergy within the Dutch Earth observation sector, perceived competition issues between companies and knowledge institutions should be sorted out, building on the strong points of each side (and preferably abolishing talk about "sides"), while recognising that there will always be some overlap in activities.

The following elements of Earth observation in developing countries all need capacity building to fully contribute to the SDGs:

- Improvement of the national infrastructure (including space-borne capacity, access to third party missions, ground-based / in-situ monitoring networks, modelling and computing capacity, EO data exploitation platforms);
- Achieving a critical mass of EO researchers;
- Creation of a strong industry base;
- Establishment of a space authority; and
- Capacity building itself (increase knowledge and skills of individuals, institutional strengthening, improvement of infrastructure).

Funding of Earth observation for SDGs

The market for SDG-related products and services is mainly institutional, although investments by the private sector become increasingly important. For issues related to sustainable water and landscape management and climate action it is more difficult to develop a business model than for increasing agricultural production and productivity. However, the G4AW Facility and other initiatives have shown that successful business models can be found for addressing the needs of smallholders, and smallholders are not a logical first choice when looking at commercial activities. A more "natural" flow of supply and demand would be achieved, if a sustainability dashboard that includes natural wealth accounting and footprint calculations would be applied globally and not only used for parallel accounting, but for real decision-making. Presently, this is not the case, but with the general adoption of the SDGs this may change. If there is a paradigm shift in this direction, the size of the market for Earth observation will be considerable.

Within the Netherlands the limitations for Earth observation for the SDGs are less related to the willingness to pay, but more related to the availability of many other data sources and the relatively small area that needs to be covered. In the international context the situation varies: some governments hire Earth observation companies on a regular basis, in some countries in-house government agencies do virtually all the work and some governments are almost entirely dependent on external technical assistance.

Policy support

Earth observation is used for policy support, but usually on a one-off and experimental basis. After the pilot studies have been completed, the step to regular implementation is too big or more time is needed to develop the application to achieve a better fit. In some cases the studies show that there are big unknowns than cannot be solved with the help of Earth observation. For example, the study done by Deltares and eLeaf on the SDG indicator 6.4.2 "water stress" shows that the environmental water requirement is very difficult to determine and that the outcomes of different models differ considerably. However, this does not disqualify the use of Earth observation; it only shows that Earth observation alone is not a cure-all. Earth observation can improve policy making on water scarcity (and the resulting stress), if the context is appropriate and the inevitable "known unknowns" are taken into account properly.

There are cases where Earth observation is (already) applied to support policy- and decision-making. Examples are forest monitoring in Brazil and agricultural monitoring in Europe, the US and Mexico. The government can act as contracting agency, but cooperation in the form of a public-private partnership can be more beneficial to achieve alignment with long-term government needs.

Therefore, in analogy to the G4AW Facility, Earth observation for the SDGs will need some catalyst support to realise its full potential. Earth observation can then be used to support Dutch policy for the SDGs (both nationally and internationally) and to strengthen the international position of the Dutch Earth observation sector with respect to services for the SDGs.

Suggestions for recommendations

At this point no conclusions are presented, because the aim of this report is to prepare for a discussion that should lead to an action agenda. A number of suggestions for recommendations, to be elaborated for this agenda are given below, as input for the discussion. The recommendations are derived from the interviews held and can be divided in three more strategic recommendations and eight more practical recommendations. The practical recommendations are directed at "low-hanging fruit" and in that sense can be considered "quick-wins", while they support and could be part of a plan to implement the more strategic recommendations.

Strategic recommendations:

1. Carry out a more in-depth investigation into the potential synergy and cooperation for Earth observation and the SDGs. What are the possible options?
   Rationale: as this report shows, various studies on the potential of Earth observation for SDGs have been done and there are more in the pipeline (Germany (DLR), EARSC, and the European Commission). The emphasis until now has been on fitting existing initiatives into the SDG framework. Connecting ("verbinden") is a strong point of the Dutch approach and could be exploited more by deepening this exploratory study, selecting a number of priority areas.
2. Formulate an action agenda for achieving more coherence in government policy (alignment of research, technical assistance and capacity building).
   Rationale: there are many different initiatives in different sectors, which all have their merit. However, applying more coherence to these efforts and to the government policy that connects adds value and enhances the Dutch position in the international context (aid and trade).
3. Find ways to capitalise on the investments that have already been made, or that are planned in the (near) future (e.g. by CBS, Rekenkamer, CieMER, G4AW, PPPs, FAO WaPOR).
   Rationale: this recommendation supports the other two recommendations, while stressing that achieving synergy and coherence should be done by building on and combining existing efforts. However, as these efforts are different in nature and there is little geographical overlap, the issue requires special attention.

Practical recommendations:

1. Develop promotion packages for selected target groups, such as Embassies of Kingdom the Netherlands. For the embassies the contents should be relevant for the multi-annual plans of the embassies. Use cases and case studies should demonstrate how impact can be measured.
   Rationale: promotion packages help promote solutions and the embassies can function as an agent for the introduction of solutions driven by new technology in the country concerned.
2. Develop a starter's toolkit for 10 – 15 partner countries. The toolkits should clearly demonstrate what Earth observation can do for SDGs and contain (links to) datasets and instruction material. Distribution of the toolkits should be linked to capacity building.[72]
   Rationale: a toolkit shows what is possible with Earth observation. In addition, it gives partners the opportunity to experiment and select what is most needed. If linked to capacity building, it could be a powerful tool to strengthen capabilities to achieve the SDGs and monitor progress. As indicated in the report, the creation of a toolkit can also bring actors from different disciplines together in a partnership.
3. Integrated problem solving, connecting, keeping the dialogue open (in short: "polderen") are strong points of the Netherlands. Different stakeholders can form a partnership to promote this Dutch approach. This recommendation is linked to recommendations 1, 2, 4 and 6.
   Rationale: to achieve the SDGs and do successful monitoring, cooperation is needed. Bringing many disciplines and competencies together for effective and productive cooperation is not easy, especially when there are cultural constraints and power relations are dominant. Showing, non-intrusively, how cooperation can work, can create goodwill and interest in Dutch solutions and the Dutch approach.
4. Proof-of-concepts of Earth observation applications help building a convincing business case. A selection of proof-of-concepts should be developed, based on requests of stakeholders, and demonstrated. This recommendation can support recommendations 1, 2 and 3. In turn the recommendation is supported by recommendation 6 and can be part of recommendation 8.
   Rationale: as indicated in the report, showing how solutions actually work is very important to create and enlarge the "SDG-market" for Earth observation.
5. "Low-hanging fruit datasets" and applications should be promoted and advertised. This applies in particular to those datasets and applications that are directly relevant to citizens. This recommendation also strengthens recommendation 2.
   Rationale: this need is expressed by many stakeholders, especially from outside the Earth observation community. Currently the data is difficult to find and/or unintelligible for non-experts. In combination with advocacy, demonstrations are needed that visualise the problem and point to solutions and that are easy to understand.
6. More advocacy is needed, not only for Earth observation applications in general, but also for Dutch expertise and initiatives funded by the Netherlands, such as the FAO water productivity database. Advocacy is complementary to all other recommendations.
   Rationale: as becomes evident from this report, advocacy is crucial. There are many solutions based on Earth observation that people are not familiar with. This leads to missed opportunities and limits market growth for Earth observation.
7. NSO should establish a firm link with the Global Centre for Climate Change Adaptation, to be established later this year in the Netherlands.
   Rationale: as indicated in the section on climate, climate adaptation is an important priority for the Netherlands. As Earth observation can provide a considerable contribution to climate change adaptation and the associated expertise, the establishment of the Centre provides a unique opportunity to get this contribution firmly on the (research, development and innovation) agenda.
7. Incentives should be given to promising initiatives on Earth observation on the SDGs, building on the experiences of the G4AW Facility (but not copying the Facility).
   Rationale: as indicated in this report, there are many opportunities for Earth observation and the SDGs, but gentle nudges are needed to get solutions beyond the so-called "Valley of Death". Moreover, incentives can help the Dutch Earth observation sector to strengthen its comparative advantages, which is needed, because international competition will be fierce. The focus could be on the first two points mentioned by the South African Statistician-General[73]:
   1. *Explore new data acquisition and integration approaches; and*
   2. *Aim for availability, quality, timeliness and disaggregation.*

Implementing (a subset) of above recommendations will create also business opportunities for provision of sustainable information services; market demand that cannot be addressed by operational services yet requires research and innovation. All this requires to a more coherent strategy and implementation actions to be set by policymakers.

References

Algemene Rekenkamer. *The NCA Sharaka programme 2016-2020*. Brochure.

Anderson, K. et al. (2017). *Earth observation in service of the 2030 Agenda for Sustainable Development*. Geo-spatial Information Science.
http://www.tandfonline.com/doi/full/10.1080/10095020.2017.1333230

Bastos-Lima, M.G. et al. (2017). *The Sustainable Development Goals and REDD+: Assessing institutional interactions and the pursuit of synergies*. International Environmental Agreements: Politics, Law and Economics.
https://link.springer.com/article/10.1007/s10784-017-9366-9

Bill & Melinda Gates Foundation (2017). *Digital strategy – Agricultural development program*.

Bom, J. (2016). *Groene Breinbrekers*.
http://www.p-plus.nl/resources/articlefiles/22-25-P75-science.pdf

CBS (2017). *CBS to compile a monitor of well-being*.
https://www.cbs.nl/en-gb/news/2017/07/cbs-to-compile-a-monitor-of-well-being

CBS (2017). *Monitor duurzaam Nederland – Update indicatoren*.
https://www.cbs.nl/-/media/_pdf/2017/20/eindversie%202017ep22%20monitor%20duurzaam%20nederland%20cbs-versie.pdf

CBS (2016). *Meten van SDGs – Een eerste beeld voor Nederland*.
https://www.cbs.nl/nl-nl/publicatie/2016/44/meten-van-sdgs-een-eerste-beeld-voor-nederland
https://www.cbs.nl/-/media/_pdf/2016/44/sdg%20%20eng_web.pdf

CBS (2016). *SDG doelen en indicatoren: Vertaling Engels – Nederlands*.
https://www.cbs.nl/-/media/_pdf/2016/45/sdg_summary.pdf

CBS (2016). *Sustainable Development Goals for water - SDG 6.4 - Three step approach for monitoring*.

Copernicus User Forum (2017). *Supporting the UN Sustainable Development Goals – The Copernicus contribution*.

CSR Asia (2016). *Agribusiness and the SDGs – How the agribusiness sector in ASEAN can embrace the Sustainable Development Goals*.
http://www.csr-asia.com/report/Agribusiness-and-the-SDGs.pdf#page51

Data4SDGs toolbox
http://apihighways.data4sdgs.org/
http://www.data4sdgs.org/toolbox/

Denier, L., et al. (2015). *The little sustainable landscapes book – Achieving sustainable development through integrated landscape management*. Global Canopy Programme.
http://globalcanopy.org/sites/default/files/documents/resources/GCP_LSLB_English.pdf

Digital Globe & Geospatial Media (2016). *Transforming our world – Geospatial information key to achieving the 2030 Agenda for Sustainable Development*.
http://ggim.un.org/docs/meetings/GGIM6/TRANSFORMING%20OUR%20WORLD.pdf

ESA (2016). *ESA activities supporting sustainable development – Catalogue 2016*.
http://www.esa.int/Our_Activities/Preparing_for_the_Future/Space_for_Earth/Space_for_Sustainable_Development/For_a_sustainable_future/(print)

European Commission (2017). *The new European consensus on development – 'Our world, our dignity, our future'*.
https://ec.europa.eu/europeaid/new-european-consensus-development-our-world-our-dignity-our-future_en

European Commission (2016). *Next steps for a sustainable European future – European action for sustainability*.
https://ec.europa.eu/europeaid/commission-communication-next-steps-sustainable-european-future_en

European Commission (2016). *Key European action supporting the 2030 Agenda and the Sustainable Development Goals*. Commission staff working document.
https://ec.europa.eu/europeaid/commission-communication-next-steps-sustainable-european-future_en

Eurostat (2016). *Sustainable development in the European Union – A statistical glance from the viewpoint of the UN Sustainable Development Goals*.
http://ec.europa.eu/eurostat/en/web/products-statistical-books/-/KS-02-16-996

FAO. *Remote sensing for water productivity*.
http://www.fao.org/in-action/remote-sensing-for-water-productivity/en/

GEO (2017). *Earth observations in support of the 2030 Agenda for Sustainable Development*.
http://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf

GEO (2017). *GEO SDG update report - Work programme symposium - Programme board*.
http://www.earthobservations.org/documents/meetings/201705_geo_wps/201705_geo_wps_geo_sdg_report.pdf

GEO GI-18 team (2017). *GEO initiative 18: Earth observations in service of the 2030 Agenda for Sustainable Development*. Draft for Program Board.
https://www.earthobservations.org/documents/pb/me_201701/pb07_201701_4th_pb_gi_sdg_implementation_plan.pdf

GOFC-GOLD (2016). *GOFC-GOLD land cover and GFOI R&D science meeting – Summary report*. The Hague.
http://www.gofcgold.wur.nl/documents/Sciencemeeting2016/ScienceMeeting-SummaryReport.pdf
http://www.gofcgold.wur.nl/sites/gofcgold-gfoi_sciencemeeting2016.php

GOFC-GOLD (2016). *A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation*. GOFC-GOLD Report version COP22-1, (GOFC-GOLD Land Cover Project Office, Wageningen University, The Netherlands).
http://www.gofcgold.wur.nl/redd/sourcebook/GOFC-GOLD_Sourcebook.pdf

GRI. *SDG compass – The guide for business action on the SDGs*. UN Global Compact and WBCSD.
http://sdgcompass.org/wp-content/uploads/2015/12/019104_SDG_Compass_Guide_2015.pdf

Helbing, D. (2013). *Globally networked risks and how to respond*. Nature.
www.nature.com/articles/nature12047

IAEG-WGGI (2016). *Draft Terms of Reference*.
https://unstats.un.org/sdgs/files/Working-Group-ToR--GeoSpatial.pdf

ICA. *A map perspective on the Sustainable Development Goals*.

ICSU (2017). *A guide to SDG Interactions: From science to implementation*.
https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf

ISLA factsheets
https://www.idhsustainabletrade.com

IUCN, et al. *SUSTAIN-Africa – Sustainability and inclusion strategy for growth corridors in Africa*.
https://www.iucn.org/sites/dev/files/content/documents/iucn_-_sustain_africa_-_web_2.pdf

JRC (2017). *Atlas of the human planet 2017 – Global exposure to natural hazards*.
http://ghsl.jrc.ec.europa.eu/atlas2017Overview.php

JRC (2017). *Mapping human presence on Earth - The Global Human Settlement Layer (GHSL)*

Landscapes for people, food and nature. *Landscape partnerships for sustainable development: Achieving the SDGs through integrated landscape management - A white paper to discuss the benefits of using ILM as a key means of implementation of the Sustainable Development Goals*.
http://ecoagriculture.org/publication/landscape-partnerships-for-sustainable-development/

Letouzé, E. (2017). *Big Data: what is it and how can (could?) it contribute to sustainable development?* Data-pop alliance. Presentation.
http://sdtalks.unssc.org/immagini/video/Data4SD1.pdf

MetaMeta (2010). *Promoting growth and equity. Examples and experiences*. http://www.metameta.nl/wp-content/uploads/2011/04/PromotingGE_DEF_LR1.pdf

Ministerie van Buitenlandse Zaken, et al. (2017). *Eerste Nederlandse SDG rapportage – Nederland ontwikkelt duurzaam*.
https://www.tweedekamer.nl/downloads/document?id=3a92c111-fc8d-4048-b6ee-7438282afc59&title=Eerste%20Nederlandse%20rapportage%3A%20Nederland%20ontwikkelt%20duurzaam.docx

Ministerie van Economische Zaken (2016). *Energieagenda - Naar een CO_2-arme energievoorziening*.
https://www.rijksoverheid.nl/documenten/rapporten/2016/12/07/ea

Ministerie van Infrastructuur en Milieu. *Sustainable Development Goals – Water cruciale rol binnen ontwikkelingsdoelen*. Factsheet.
http://www.waterinternationaal.nl/files/documents/factsheet_developmentgoals.pdf

Ministerie van Infrastructuur en Milieu (2016). *Global Centre of Excellence on Climate Adaptation seeks residence in the Netherlands.* News item.
https://www.government.nl/latest/news/2017/02/06/global-centre-of-excellence-on-climate-adaptation-seeks-residence-in-the-netherlands

Ministerie van Infrastructuur en Milieu (2016). *Aanpassen met ambitie - Nationale Klimaatadaptatiestrategie 2016 (2016).*
https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/12/02/nationale-klimaatadaptatiestrategie-2016-nas/nationale-klimaatadaptatiestrategie-2016-nas.pdf

Netherlands National IHP-HWRP Committee (2016). *Report integrated monitoring for SDG 6 (GEMI) - Work in progress workshop.* Delft, September 2016.
https://static1.squarespace.com/static/57fddec6725e25594e4847bb/t/58cbf535ff7c503c571ad1a1/1489761632043/GEMI+Work+in+Progress+Workshop+-+Report+-+October+2016.pdf
http://www.sdg6monitoring.org/news/2016/9/14/work-in-progress-workshop-in-the-netherlands-7-9-september-2016

NWA investeringsvoorstel – Sustainable Development Goals voor inclusieve mondiale ontwikkeling.
http://www.wetenschapsagenda.nl/wp-content/uploads/2016/06/19-SDG-investeringsverzoek_DEF.pdf

NWO. *Onderzoeksprogramma duurzame businessmodellen.*
http://hetgroenebrein.nl/wp-content/uploads/2016/01/Informatieboekje-DBM.pdf

NWO-WOTRO (2017). *Tackling global challenges through use-inspired research - Leave no one behind.*
Joint SDG research initiative of Dutch research organisations and NWO-WOTRO.
https://www.nwo.nl/financiering/onze-financieringsinstrumenten/wotro/joint-sdg-research-initiative/joint-sdg-research-initiative.html

OECD. *Better life index*
http://www.oecdbetterlifeindex.org/

Partos et al. (2016). *Ready for change? Global Goals at home and abroad.*
https://partos.nl/fileadmin/files/Documents/Partos_RFC_Publication_May_2016.pdf

PBL (2017). *Compiling biodiversity accounts with the GLOBIO model - A case study of Mexico.*
http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2017-compiling-biodiversity-accounts-with-the-GLOBIO-model-2607.pdf

PBL (2016). *Sustainable development goals in Nederland - Bouwstenen voor leefomgevingsbeleid voor 2030.*
http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-sustainable-development-goals-in-nederland_1798.pdf

PBL (2015). *The landscape approach - The concept, its potential and policy options for integrated sustainable landscape management.*
http://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2015_The_Landscape_Approach_1555.pdf

PBL (2015). *Adaptation to climate change in the Netherlands – Studying related risks and opportunities.*
http://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2015-Adaptation-to-climage-change-1632.pdf

Radiant.Earth
https://www.radiant.earth/

RvO (2014). *Global challenges, Dutch solutions.*
http://english.rvo.nl/sites/default/files/2014/01/Global%20Challenges-Dutch%20Solutions_ENG_2.pdf

Sachs, J. et al. (2016). *SDG Index and Dashboards - Global Report.* Bertelsmann Stiftung and SDSN.
http://www.sdgindex.org/

Sawyer, G. and Vries, M. de (2012). *About GMES and data: geese and golden eggs - A study on the economic benefits of a free and open data policy for Sentinel satellite data.*
Report:
http://esamultimedia.esa.int/docs/EarthObservation/Open_Data_Study_Final_Report.pdf
Animation:
http://vimeo.com/63079712

STOWA (2016). *Verkenning remote sensing producten voor het waterbeheer.*
http://stowa.nl/upload/Publicaties2016/STOWA%202016%2017_Web%20LR%20DEF.pdf

Sustainable Development 2015. *Tests of success for the SDGs – A tool for assigning and assessing Sustainable Development Goals and targets.*
http://www.stakeholderforum.org/fileadmin/files/SDGsTestsOfsuccess.pdf

Sustainable Development Goals in the UK. Discussion.
https://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/596/59602.htm

Telos, VNG international (2017). *"Zo kan het ook" – Governance monitor duurzame gemeenten 2016.*
https://vng.nl/files/vng/20170117-governance-monitor-eindrapport_0.pdf

The New York Academy of Sciences (2017). *Summit on science and technology enablement for the Sustainable Development Goals.*
https://www.nyas.org/events/2016/summit-on-science-and-technology-enablement-for-the-sustainable-development-goals/

Tweede Kamer der Staten-Generaal (2017). *Parlementair onderzoek breed welvaartsbegrip.*
https://www.tweedekamer.nl/sites/default/files/atoms/files/34298-3.pdf

United Nations. *Transforming our World – The 2030 Agenda for Sustainable Development.*
https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

United Nations. *Global sustainable development report – 2016 edition.*
https://sustainabledevelopment.un.org/content/documents/2328Global%20Sustainable%20development%20report%202016%20(final).pdf

United Nations. *Global sustainable development report – 2015 edition.*
https://sustainabledevelopment.un.org/content/documents/1758GSDR%202015%20Advance%20Unedited%20Version.pdf

United Nations (2017). *Revised list of global Sustainable Development Goals indicators.*
https://unstats.un.org/sdgs/indicators/Official%20Revised%20List%20of%20global%20SDG%20indicators.pdf

UNCCD. *Land degradation neutrality – Resilience at local, national and regional levels.*
http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Land_Degrad_Neutrality_E_Web.pdf

UNCCD. *3S initiative.*
http://www2.unccd.int/sites/default/files/relevant-links/2017-01/3S%20Initiative-brochure_0_0_1.pdf

United Nations Economic and Social Council, Statistical Commission. *Report of the Inter-Agency and Expert Group on Sustainable Development Goal indicators.*
http://ggim.un.org/docs/WG6/IAEG%20SDGs-2016-Global%20Indicator%20Framework-Rev1-E.pdf

UNSD (2017). *Work plans for Tier III indicator.*
https://unstats.un.org/sdgs/files/meetings/iaeg-sdgs-meeting-05/TierIII_Work_Plans_03_03_2017.pdf

UN Water. *World water development reports.*
http://www.unwater.org/publication_categories/world-water-development-report/

World Bank (2017). *Atlas of Sustainable Development Goals 2017 – From World development indicators.*
https://openknowledge.worldbank.org/handle/10986/26306

Endnotes

[1] https://g4aw.spaceoffice.nl/
[2] Sawyer, G. and Vries, M. de (2012). About GMES and data: geese and golden eggs - A study on the economic benefits of a free and open data policy for Sentinel satellite data.
http://esamultimedia.esa.int/docs/EarthObservation/Open_Data_Study_Final_Report.pdf
For the related video, see http://vimeo.com/63079712
[3] https://g4aw.spaceoffice.nl/en/sdg-workshop/
[4] http://www.earthobservations.org/meetings.php
[5] https://ec.europa.eu/easme/en/european-geo-workshop-2017
[6] As counted in the "Revised list of global sustainable development indicators" of March 2017.
[7] Actually 244, but some appear twice.
[8] http://www.sdgindex.org/download/
[9] https://www.cbs.nl/nl-nl/publicatie/2016/44/meten-van-sdgs-een-eerste-beeld-voor-nederland
https://www.cbs.nl/-/media/_pdf/2016/44/sdg%20%20eng_web.pdf
[10] http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-sustainable-development-goals-in-nederland_1798.pdf
[11] https://www.tweedekamer.nl/downloads/document?id=3a92c111-fc8d-4048-b6ee-7438282afc59&title=Eerste%20Nederlandse%20rapportage%3A%20Nederland%20ontwikkelt%20duurzaam.docx
[12] 2050 is too late to meet the Energy SDG that is scheduled for 2030.
[13] https://www.cbs.nl/en-gb/news/2017/07/cbs-to-compile-a-monitor-of-well-being
[14] "Satellite accounts" is more often used, but in relation to Earth observation the term is confusing.
[15] http://www.oecdbetterlifeindex.org/
[16] http://ec.europa.eu/eurostat/en/web/products-statistical-books/-/KS-02-16-996
[17] http://www.monitorduurzaamnederland.nl/
[18] https://ec.europa.eu/europeaid/new-european-consensus-development-our-world-our-dignity-our-future_en
[19] https://ec.europa.eu/europeaid/commission-communication-next-steps-sustainable-european-future_en
[20] https://ec.europa.eu/europeaid/commission-communication-next-steps-sustainable-european-future_en
[21] https://www.nwo.nl/joint-sdg
[22] https://www.nwo.nl/joint-sdg
[23] NFP and NICHE are administered by NUFFIC, https://www.nuffic.nl/
[24] https://www.government.nl/documents/reports/2014/01/21/global-challenges-dutch-solutions
[25] https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
[26] https://unstats.un.org/sdgs/files/Working-Group-ToR--GeoSpatial.pdf
[27] https://www.earthobservations.org
[28] https://sustainabledevelopment.un.org/content/documents/2328Global%20Sustainable%20development%20report%202016%20(final).pdf
[29] This is an activity carried out in the framework of the second ten year implementation plan of the Group on Earth observations (GEO)
[30] http://ggim.un.org/docs/meetings/GGIM6/TRANSFORMING%20OUR%20WORLD.pdf
[31] https://g4aw.spaceoffice.nl/en/sdg-workshop/
[32] https://www.cbs.nl/-/media/_pdf/2016/45/sdg_summary.pdf
[33] http://www.data4sdgs.org/toolbox/
[34] http://www.tandfonline.com/doi/full/10.1080/10095020.2017.1333230
[35] http://unfccc.int/paris_agreement/items/9485.php
[36] http://www.unisdr.org/we/coordinate/sendai-framework
[37] https://www.cbd.int/
[38] https://www.cbd.int/sp/targets/
[39] https://www.radiant.earth/
[40] https://g4aw.spaceoffice.nl/en/news/67/doing-business-with-satellite-based-apps-and-services-for-smallholder-farmers-and-pastoralists.html
[41] http://knowledge4food.net/
[42] https://g4aw.spaceoffice.nl
[43] https://cropmonitor.org/
[44] http://www.godan.info/
[45] https://www.growasia.org/
[46] http://www.eleaf.com/?st_portfolio=project-12
[47] http://waterwatchcooperative.com/tag/crop-disease-alert-2-0/
[48] www.geodataforinclusivefinanceandfood.nl
[49] http://www.inclusivefinanceplatform.nl/

[50] http://www.inclusivefinanceplatform.nl/what-s-new/news/495/npm-and-rabobank-foundation-launch-board-of-inspiration-geodata-for-inclusive-finance-and-food
[51] http://www.waterinternationaal.nl/files/documents/iwabrochure_internationaal.pdf
[52] https://www.cbs.nl/-/media/_pdf/2016/51/sdgs-6-4-monitoring%20nl-ladder%20approach.pdf
[53] http://www.fao.org/nr/water/aquastat/projects/index.stm
[54] https://static1.squarespace.com/static/57fddec6725e25594e4847bb/t/58cbf535ff7c503c571ad1a1/1489761632043/GEMI+Work+in+Progress+Workshop+-+Report+-+October+2016.pdf
http://www.sdg6monitoring.org/news/2016/9/14/work-in-progress-workshop-in-the-netherlands-7-9-september-2016
[55] http://www.fao.org/in-action/remote-sensing-for-water-productivity/wapor/en/
[56] https://www.deltares.nl/en/software/aqueduct-global-flood-analyzer/
[57] http://ecoagriculture.org/publication/landscape-partnerships-for-sustainable-development/
[58] http://www.gofcgold.wur.nl/
[59] http://www.un-redd.org/
[60] http://www.gfoi.org/
[61] https://www.wavespartnership.org/
[62] http://www.teebweb.org/
[63] http://www.landscapes.org/
[64] http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-sustainable-development-goals-in-nederland_1798.pdf
[65] http://www.un.org/sustainabledevelopment/blog/2017/02/new-global-centre-of-excellence-on-climate-adaptation/
[66] https://www.earthobservations.org/activity.php?id=113
[67] The Gates Foundation, supports this view: see reference list
[68] This includes findings from discussions at the GEO European workshop 2017: https://ec.europa.eu/easme/en/european-geo-workshop-2017
[69] Copernicus is an initiative, headed by the European Commission (EC) and the European Space Agency (ESA), with the aim to provide accurate, timely and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change and ensure civil security.
[70] Thanks to the efforts of GEO members and participating organisations.
[71] The issue of big data has its own challenges, see: Helbing, D. (2013). *Globally networked risks and how to respond*. Nature. www.nature.com/articles/nature12047
[72] The Italian Civil Protection and partners (DEWETRA) have developed similar toolkits for floods, called Flood-PROOF, and wildfires, called RISICO. http://dewetra.cimafoundation.org
[73] The other three points are taken care of by GEO with active support from NSO.

Annexes

Annex 1 List of people interviewed

Job Kleijn	Ministry of Foreign Affairs
Hugo von Meijenfeldt	Ministry of Foreign Affairs
Omer van Renterghem	Ministry of Foreign Affairs
Marcel Beukeboom	Ministry of Infrastructure and the Environment
Niels Vlaanderen	Ministry of Infrastructure and the Environment
Koos Wieriks	Ministry of Infrastructure and the Environment
Hermanus Rietveld	Statistics Netherlands (CBS)
Martin Herold	Wageningen University & Research
Saskia Visser	Wageningen University & Research
Harry Derksen	Waterwatch Cooperative
Evert van Holthoon	Waterwatch Cooperative

Group meetings:

Court of Audit (Algemene Rekenkamer):
Egbert Jongsma, Abdel Elabassi, Diny van Est, Merel Hendriks

Ministerie of Economic Affairs:
with presentation from Lieneke Hoeksma (CBS) and Eppy Boschma (VNO/NCW)
Evelyn Jansen (presiding SDG meeting), Hans Brand, Peter van Velzen, Marcel Klok, Hans van den Heuvel, Hadewich Hoos, Dirk-Jan van der Stelt, a.o.

Annex 2 Earth observation applications that contribute to achieving SDGs and monitoring of indicators

1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

EO contribution to achieving target: Mapping of land use and developments, base mapping for land administration, assessment of compliance with land use regulations and property rights, infrastructure mapping (for market access and access to basic services).

1.4.2 Proportion of total adult population with secure tenure rights to land, with legally recognised documentation and who perceive their rights to land as secure, by sex and by type of tenure

EO contribution to achieving target: Mapping for verification of land tenure rights

1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

EO contribution to achieving target: Risk assessment and simulation models / Forecasting and early warning

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

EO contribution to achieving target: Agricultural knowledge and information systems, crop health and yield monitoring, market access, agricultural land rights, agricultural market information, site evaluation, tackling pest and diseases, fertiliser advice, crop calendars

2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size

Monitoring of indicator with EO: parcel identification and crop monitoring

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

EO contribution to achieving target: See 2.3 + drought early warning, agricultural insurance, market access and infrastructure analysis, climate adaptation scenarios

2.4.1 Proportion of agricultural area under productive and sustainable agriculture

Monitoring of indicator with EO: land use / land cover mapping and monitoring

3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases

3.3.3 Malaria incidence per 1,000 population

EO contribution to achieving target: early warning systems for vector-borne diseases

3.3.5 Number of people requiring interventions against neglected tropical diseases

EO contribution to achieving target: early warning systems for vector-borne diseases

3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents

EO contribution to achieving target: Base mapping for the identification of roads and assessment of road conditions (paved, unpaved)

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all

EO contribution to achieving target: Infrastructure and population density mapping to assess access to basic services (health facilities) disaggregated by population group; base map for planning of creation of health facilities

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

EO contribution to achieving target: Air quality and water quality monitoring systems; mapping of potentially dangerous infrastructure (waste management facilities, industry, mining, nuclear facilities, etc.)

3.9.1 Mortality rate attributed to household and ambient air pollution

EO contribution to achieving target: air quality monitoring and early warning systems

3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)

EO contribution to achieving target: surface water quality monitoring

4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education

4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university

EO contribution to achieving target: Infrastructure and population density mapping to assess access to educational services (schools) disaggregated by population group; base map for planning of creation of schools

5.4 Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate

5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences

5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws

EO contribution to achieving target: Assessment of access to health facilities, arable land, infrastructure, schools, etc. in terms of travel time (throughout the year)

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

EO contribution to achieving target: assessment and monitoring of available water resources for drinking water

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

EO contribution to achieving target: Assessment of proximity to and availability of drinking water, sewerage and drainage systems and wastewater treatment plants

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

EO contribution for achieving target: Water quality monitoring

6.3.2 Proportion of bodies of water with good ambient water quality

Monitoring of indicator with EO: (Surface) water resources monitoring and water quality monitoring

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.4.1 Change in water-use efficiency over time

Contribution to achieving target and monitoring of indicator with EO: Water resources assessment and monitoring; input for water accounting and water productivity assessments

6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Contribution to achieving target and monitoring with EO: Water resources assessment and monitoring; input for water accounting and water productivity assessments

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.5.1 Degree of integrated water resources management implementation (0-100)

Contribution to achieving target and monitoring with EO: Water resources assessment and monitoring; input for water accounting and water productivity assessments

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.6.1 Change in the extent of water-related ecosystems over time

Monitoring of indicator with EO: Land use / land cover mapping and monitoring

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

EO contribution to achieving target: Solar, wind, hydropower and biofuel potential assessment and monitoring of performance

7.1.1 Proportion of population with access to electricity

7.1.2 Proportion of population with primary reliance on clean fuels and technology

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.2.1 Renewable energy share in the total final energy consumption

EO contribution to achieving target: solar, wind, hydropower and biofuel potential assessment and monitoring of performance

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

EO contribution to achieving target: Mapping of energy utilities and access to electricity

8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programs on Sustainable Consumption and Production, with developed countries taking the lead

EO contribution to achieving target: Mapping and monitoring environmental degradation and environmental impact of extractive industries.

8.4.1 Material footprint, material footprint per capita, and material footprint per GDP

Monitoring of indicator with EO: Data input for footprint calculations (same as 12.2.1)

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

9.1.1 Proportion of the rural population who live within 2 km of an all-season road

Contribution to target and monitoring of indicator with EO: Mapping, monitoring and analysis of rural settlements and roads

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities

EO contribution to achieving target: Mapping and monitoring of infrastructure (projects) and vulnerability assessment of infrastructure

9.4.1 CO_2 emission per unit of value added

Monitoring of indicator with EO: Measuring CO_2 in atmosphere and climate modelling

10 Reduce inequality within and among countries

EO contribution to achieving target: Combination of actions for SDG-1 – 9 with emphasis on vulnerability.

10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies

EO contribution to achieving target: Mapping and monitoring migration patterns (refugee camps, settlements)

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums

11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing

Monitoring of indicator with EO: Mapping and monitoring of slum extent and housing quality

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

11.3 By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

EO contribution to achieving target: Assessment of sustainable urban planning through a combination of actions for 1.4, 1.5, 3.6, 3.8, 3.9, 4.2, 4.3, 5.4, 5.6, 7.b and 9.1

11.3.1 Ratio of land consumption rate to population growth rate

Monitoring of indicator with EO: Mapping and monitoring of urban sprawl and impervious surfaces; land use / land cover mapping and monitoring

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage

EO contribution to achieving target: Mapping and monitoring of cultural and natural heritage sites and identification of threats

11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations

EO contribution to achieving target: Risk assessment and simulation models; forecasting and early warning; monitoring of disasters and damage assessment

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

EO contribution to achieving target: Mapping of waste sites and assessment of impact of urban expansion on the environment

11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)

Monitoring of indicator with EO: Air quality monitoring

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

Monitoring of indicator with EO: Urban monitoring and change detection, including green and public spaces

11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning

EO contribution to achieving target: Mapping and monitoring of land use, land cover and urban processes

11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

EO contribution to achieving target: Mapping and monitoring of urban housing

12.2 By 2030, achieve the sustainable management and efficient use of natural resources

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse

EO contribution to achieving target: Mapping and monitoring of use of natural resources (agriculture, water, forests, fishing, mining, energy, air, environment, etc.)

12.2.1 Material footprint, material footprint per capita, and material footprint per GDP

Monitoring of indicator with EO: Data input for footprint calculations (same as 8.4.1)

12.8 By 2030, ensure that everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature

EO contribution to achieving target: Overarching purpose of EO in combination with mobile and web applications

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population

EO contribution to achieving target: Support to modelling for prevention, early warning and monitoring of disasters (storms, floods, earthquakes, volcanic eruptions, landslides, industrial disasters); mapping and monitoring of actions for rehabilitation and strengthening of resilience

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

14.1.1 Index of coastal eutrophication and floating plastic debris density

Monitoring of indicator with EO: (Surface) water quality monitoring and oil spill detection

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches

Contribution to achieving target and monitoring of indicator with EO: Ecosystem mapping and monitoring; coastal land use / land cover mapping and monitoring

14.3 Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

EO contribution to achieving target: Monitoring of ocean acidity

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics

14.4.1 Proportion of fish stocks within biologically sustainable levels

EO contribution to achieving target: Identification, monitoring and analysis of potential fishing zones & detection of harmful algal blooms

14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information

EO contribution to achieving target: Assessment of impact of economic activities on protected coastal and marine areas

14.5.1 Coverage of protected areas in relation to marine areas

Monitoring of indicator with EO: Mapping and monitoring of marine protected areas extent

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organisation fisheries subsidies negotiation

14.6.1 Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing

EO contribution to achieving target: Detection and tracking of fishing vessels

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

EO contribution to achieving target: Mapping and monitoring of tourism infrastructure, environmental impact and access to markets for fisheries and aquaculture; identification, monitoring and analysis of potential fishing zones & detection of harmful algal blooms

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

EO contribution to achieving target: Mapping and monitoring of ecosystems, including forests, wetlands and drylands and mapping and monitoring of phenomena that may affect these ecosystems (land degradation, urbanisation, economic activity, disasters, etc.)

15.1.1 Forest area as a proportion of total land area

Monitoring of indicator with EO: Forest cover mapping and monitoring

15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type

Monitoring of indicator with EO: Ecosystem and natural habitat mapping and monitoring

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

15.2.1 Progress towards sustainable forest management

Monitoring of indicator with EO: Mapping and monitoring of forests, including forest degradation, rehabilitation and recovery

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

15.3.1 Proportion of land that is degraded over total land area

Monitoring of indicator with EO: Land degradation monitoring; land use / land cover mapping and monitoring

15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development

15.4.1 Coverage by protected areas of important sites for mountain biodiversity

Monitoring of indicator with EO: Ecosystem and natural habitat mapping and monitoring

15.4.2 Mountain Green Cover Index

Monitoring of indicator with EO: Ecosystem and natural habitat mapping and monitoring

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

15.5.1 Red List Index

Contribution to achieving target and monitoring of indicator with EO: Natural habitat and biodiversity mapping and monitoring

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020

Monitoring of indicator with EO: Ecosystem, natural habitat and biodiversity mapping and monitoring

16.1 Significantly reduce all forms of violence and related death rates everywhere

EO contribution to achieving target: Monitoring of conflicts (bombing, military presence) and humanitarian efforts (refugee camps) from space

16.2 Substantially reduce corruption and bribery in all their forms

EO contribution to achieving target: Mapping and monitoring of properties and illegal constructions and activities (deforestation, mining, disturbance protected areas)

16.6 Develop effective, accountable and transparent institutions at all levels

EO contribution to achieving target: Mapping and monitoring of spatial dimension of public spending, such as infrastructure

16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels

EO contribution to achieving target: Overarching purpose of EO: increasing visibility of environmental and societal processes and monitoring of changes over time

17.1 - 17.5 Finance

17.1 Strengthen domestic resource mobilisation, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection

EO contribution to achieving target: Mapping and monitoring of properties and illegal constructions and activities (deforestation, mining, disturbance protected areas) spatial dimension of public spending, such as infrastructure

17.6 - 17.8 Technology & 17.9 Capacity building

EO contribution to achieving target: Mapping and monitoring of effects of technology transfer, such as improved air quality, reduction environmental pollution, sustainable cities, environmental management, etc.

17.10 - 17.12 Trade

EO contribution to achieving target: Mapping and monitoring of agricultural production, industrial activity and transport characteristics

17.16 - 17.17 Multi-stakeholder partnerships

EO contribution to achieving target: Mapping and monitoring of transboundary issues and public-private issues (sustainable use of natural resources, environmental pollution, extractive industries, fisheries)

17.18 - 17.19 Data, monitoring and accountability

17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts

17.18.1 Proportion of sustainable development indicators produced at the national level with full disaggregation when relevant to the target, in accordance with the Fundamental Principles of Official Statistics

Monitoring of indicator with EO: Portfolio of EO applications that support natural wealth accounting (environmental accounting, ecosystem accounting and footprint calculations)

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

Contribution of EO to achieving target: Mapping and monitoring of infrastructure and economic, environmental and societal processes

Annex 3 Examples of easily accessible datasets

GEOSS data portal – all kinds of free and open geospatial datasets: http://www.earthobservations.org

Global Human Settlement Layer (GHSL) – population database to assess vulnerability to disasters (JRC): http://ghsl.jrc.ec.europa.eu

Open readiness data toolkit – disaster management:
http://data.worldbank.org/about/open-government-data-toolkit/readiness-assessment-tool

Open data for resilience GFDRR – disaster management: http://gfdrr.org/opendri

INFORM user guide - tool for risk assessment and risk management: http://www.inform-index.org/

GEOGLAM – global agricultural monitoring: https://cropmonitor.org/ & https://www.earthobservations.org/geoglam.php

Global Open Data for Agriculture and Nutrition (GODAN): http://www.godan.info/

Global Agro-Ecological Zones (GAEZ) - initiative of IIASA and FAO for assessing agricultural resources and potential: http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/

WAter Productivity through Open access of Remotely sensed derived data (WaPOR, FAO): http://www.fao.org/in-action/remote-sensing-for-water-productivity/wapor/en/#/home

Africa Water Atlas – modelling of Africa's surface waters (UNEP): https://na.unep.net/atlas/africaWater/downloads/africa_water_atlas.pdf

Global Runoff Data Centre (GRDC) report series: hydrologic information – metadata; UML model of available catalogues: http://www.bafg.de/GRDC/EN/Home/homepage_node.html

Global surface water explorer (water occurrence change intensity, JRC), based on Landsat (time series):
https://global-surface-water.appspot.com/

A new map of standardised terrestrial ecosystems of Africa - overview of integrated and comprehensive ecosystem mapping exercise: http://www.aag.org/cs/publications/special/map_african_ecosystems

Land cover datasets – overview: http://worldgrids.org/doku.php/wiki:land_cover_and_land_use
GlobCover (ESA): http://due.esrin.esa.int/page_globcover.php,
GlobeLand30 (China): http://www.globallandcover.com/GLC30Download/index.aspx
GOFC-GOLD - focuses on land cover in relation to ECVs, GFOI, REDD+ and FAO FRA: http://www.gofcgold.wur.nl/

Essential climate variables (ECV; GCOS)
http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables
http://www.fao.org/gtos/topcECV.html

The state of soil in Europe (JRC, EEA) - update on soil of "the European environment"
https://www.eea.europa.eu/data-and-maps/data/external/the-state-of-soil-in-europe

Global Biodiversity Information Facility (GBIF) data portal: http://www.gbif.org

FAO forest resource assessment: http://www.fao.org/forest-resources-assessment/en/

RETScreen international (Natural Resources Canada) – renewable energy database http://www.retscreen.net

Solar and wind energy resource assessment (SWERA) – dataset to identify high potential areas for solar and wind energy: http://en.openei.org/wiki/Solar_and_Wind_Energy_Resource_Assessment_(SWERA)

OneGeology – geological maps for more than 70 countries: http://www.onegeology.org

TIGGE weather data: http://www.ecmwf.int
data archive available at http://apps.ecmwf.int/datasets/data/tigge/

Global Urban Footprint (GUF), by DLR, based on TerraSat (only one point in time): http://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-9628/16557_read-40454/

Open digital elevations models: http://www.opendem.info/

Annex 4 Overview of SDG targets and indicators, selected by EO4SDG, but not used for this report

Number of SDG Target or Indicator	Reason why not used for this report
2.c	Relation considered to be too indirect
3.4	Relation considered to be too indirect
3.d	Relation considered to be too indirect
5.a.1	Considered too difficult to measure with EO
6.3.1	Considered too difficult to measure with EO
6.a	Relation considered to be too indirect
6.b	Relation considered to be too indirect
7.3	Relation considered to be too indirect
7.a	Relation considered to be too indirect
9.5	Relation considered to be too indirect
9.a	Relation considered to be too indirect
11.b	Relation considered to be too indirect
11.2.1	Considered too difficult to measure with EO
12.a	Relation considered to be too indirect
12.a.1	Financial indicator
12.b	Relation considered to be too indirect
13.2	Relation considered to be too indirect
13.3	Relation considered to be too indirect
13.b	Relation considered to be too indirect
15.7	Relation considered to be too indirect
15.8	Relation considered to be too indirect
16.8	Relation considered to be too indirect
17.2	Relation considered to be too indirect
17.3	Relation considered to be too indirect

Annex 5 Earth observation for SDGs - General

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Mapping of land use and developments, base mapping for land administration, assessment of compliance with land use regulations and property rights, infrastructure mapping (for market access and access to basic services)	Cost saving by limiting need for field inspections; improved visualisation of phenomena	Mostly international	Affordable data and data processing; expert knowledge; in-situ validation	Land use database of the Netherlands – LGN (WUR)
1.4.2	Proportion of total adult population with secure tenure rights to land, with legally recognised documentation and who perceive their rights to land as secure, by sex and by type of tenure	Mapping for verification of land tenure rights	Cost and time saving by limiting need for detailed in-situ measurements	International	Sufficient resolution; participatory approach; acceptance of quick solutions in cases where there is no conflict	Social tenure domain model (Kadaster, ITC)
1.5	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Risk assessment and simulation models; forecasting and early warning	Reduction of damage and lives lost (estimated at 10% of total potential loss)	National and international	Affordable data and data processing; expert knowledge; buy-in of stakeholders	Risk city (ITC), Eagle (GEODAN); North African coastal cities address natural disasters and climate change (World Bank, ESA; 2011) studies on adaptation to climate change with respect to natural disasters for Alexandria, Tunis, Casablanca and the Bouregreg area
3.3, 3.3.3 & 3.3.5	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases Malaria incidence per 1,000 population Number of people requiring interventions against neglected tropical diseases	Early warning systems for vector-borne diseases	Better insight into cause-effect relations; improved preparedness; reduction of incidences and loss of life	International	Further development; expert knowledge; in-situ data; scaling up; advocacy	Malaria early warning system (MEWS, ECMWF)
3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents	Base mapping for the identification of roads and the assessment of road conditions (paved, unpaved)	Quick first analysis; base layer for field inspections	International	High resolution data; affordable data processing; additional field inspections	
3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all	Infrastructure and population density mapping to assess access to basic services (health facilities) disaggregated by population group; base map for planning of creation of health facilities	Better insight in actual situation; better informed decision-making and planning	International	High resolution data; additional data on population and health service provision;	Global human settlement layer – GHSL (JRC)
3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Air quality and water quality monitoring systems; mapping of potentially dangerous infrastructure (waste management facilities, industry, mining, nuclear facilities, etc.)	Near-real time information; improved vulnerability assessment and insight into cause-effect relations	National and international	Further development; expert knowledge; additional in-situ data	

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
3.9.1	Mortality rate attributed to household and ambient air pollution	Air quality monitoring and early warning systems	See 3.9	See 3.9	See 3.9	
3.9.2	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)	Surface water quality monitoring	See 3.9	See 3.9	See 3.9	
4.2 & 4.3	By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university	Infrastructure and population density mapping to assess access to educational services (schools) disaggregated by population group; base map for planning of creation of schools	Better insight in actual situation; better informed decision-making and planning	International	Time series of sufficient resolution; additional data on population and education;	Global human settlement layer – GHSL (JRC)
5.4, 5.6 & 5.a	Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Program of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	Assessment of access to health facilities, arable land, infrastructure, schools. etcetera in terms of travel time (throughout the year)	Better insight in actual situation; better informed decision-making and planning	International	Time series of sufficient resolution; combination with in-situ observations	Global human settlement layer – GHSL (JRC)
7.b	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programs of support	Mapping of energy utilities and access to electricity	Better insight in actual situation; better informed decision-making and planning	International	Time series of sufficient resolution; combination with in-situ observations	Night-time light satellite data (CIESIN)
9.1 & 9.1.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all Proportion of the rural population who live within 2 km of an all-season road	Mapping, monitoring and analysis of rural settlements and roads	Cost saving by reducing need for in-situ observations	International	Time series of sufficient resolution; combination with in-situ observations	Global human settlement layer – GHSL (JRC)

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
10	Reduce inequality within and among countries	Combination of actions for SDG-1 – 9 with emphasis on vulnerability.		International		
10.7	Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies	Mapping and monitoring migration patterns (refugee camps, settlements)	Cost saving by reducing need for in-situ observations; coverage of unsafe areas	International	Time series of sufficient resolution	
11.1 & 11.1.1	By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums Proportion of urban population living in slums, informal settlements or inadequate housing	Mapping and monitoring of slum extent and housing quality	Cost saving by reducing need for in-situ observations; coverage of unsafe areas	International	Time series of sufficient resolution; expert knowledge	Studies of ITC with UN-HABITAT
11.2 & 11.3	By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Assessment of sustainable urban planning through combining actions for 1.4, 1.5, 3.6, 3.8, 3.9, 4.2, 4.3, 5.4, 5.6, 7.b and 9.1				
11.3.1	Ratio of land consumption rate to population growth rate	Mapping and monitoring of urban sprawl and impervious surfaces; land use / land cover mapping and monitoring	Cost saving by reducing need for in-situ observations; increased accuracy	International	Affordable data and data processing; expert knowledge; in-situ validation	
11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Mapping and monitoring of cultural and natural heritage sites and identification of threats	Cost saving by reducing need for in-situ observations; earlier identification of threats	International	Affordable data and data processing; expert knowledge; in-situ validation	
11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Risk assessment and simulation models; forecasting and early warning; monitoring of disasters and damage assessment	Reduction of damage and lives lost (estimated at 10% of total potential loss)	National and international	Affordable data and data processing; expert knowledge; buy-in of stakeholders	Risk city (ITC), Eagle (GEODAN)
11.6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Mapping of waste sites and assessment of impact of urban expansion on the environment	Near-real time information; improved vulnerability assessment and insight into cause-effect relations	National and international	Further development; expert knowledge; additional in-situ data	
11.6.2	Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	Air quality monitoring	Near-real time information; improved vulnerability assessment and insight into cause-effect relations	National and international	Further development; expert knowledge; additional in-situ data	

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
11.7 & 11.7.1	By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	Urban monitoring and change detection, including green and public spaces	Cost saving by reducing need for in-situ observations	National and international	High resolution images; time series; expert knowledge	
11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Mapping and monitoring of land use, land cover and urban processes	As with 10	As with 10	As with 10	
11.c	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Mapping and monitoring of urban housing	Cost saving by reducing need for in-situ observations; coverage of unsafe areas	International	Time series of sufficient resolution; expert knowledge	
14.1 & 14.1.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution Index of coastal eutrophication and floating plastic debris density	(Surface) water quality monitoring and oil spill detection	Cost saving by reducing need for in-situ observations; increased detection rate	National and international	High resolution and high frequency imagery: expert knowledge	
16.1	Significantly reduce all forms of violence and related death rates everywhere	Monitoring of conflicts (bombing, military presence) and humanitarian efforts (refugee camps) from space	Integration of different layers of information; access to areas that are difficult to reach	International	High resolution and high frequency imagery: expert knowledge	
16.2	Substantially reduce corruption and bribery in all their forms	Mapping and monitoring of properties and illegal constructions and activities (deforestation, mining, disturbance protected areas)	Improved visualisation and compliance	International	Further development; high resolution imagery; expert knowledge	
16.6	Develop effective, accountable and transparent institutions at all levels	Mapping and monitoring of spatial dimension of public spending, such as infrastructure	Improved visualisation and compliance	International	Further development; high resolution imagery; expert knowledge	
16.7	Ensure responsive, inclusive, participatory and representative decision-making at all levels	Overarching purpose of EO: improved visualisation of environmental and societal processes and monitoring of changes over time				
17.1	Strengthen domestic resource mobilisation , including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	Mapping and monitoring of properties and illegal constructions and activities (deforestation, mining, disturbance protected areas) and spatial dimension of public spending, such as infrastructure	Improved visualisation and compliance	International	Further development; high resolution imagery; expert knowledge	
17.6 – 17.9	Technology and capacity building	Mapping and monitoring of effects of technology transfer, such as improved air quality, reduction environmental pollution, sustainable cities, environmental management, etc.	Add spatial dimension to demonstration of cause-effect relationships	International	Further development; high resolution imagery; time series; expert knowledge	

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
17.10 – 17.12	Trade	Mapping and monitoring of agricultural production, industrial activity and transport characteristics	Integration of different layers of information; insight into cause–effect relationships; early identification of potential risks	International	Further development; high resolution imagery; time series; expert knowledge	
17.16 – 17.17	Multi-stakeholder partnerships	Mapping and monitoring of transboundary issues and public-private issues (sustainable use of natural resources, environmental pollution, extractive industries, fisheries)	Integration of different layers of information; insight into cause–effect relationships; early identification of potential risks	International	Further development; high resolution imagery; time series; expert knowledge	

Annex 6 Earth observation for SDGs - Food security

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	Agricultural knowledge and information systems, crop health and yield monitoring, market access, agricultural land rights, agricultural market information, site evaluation, tackling pest and diseases, fertiliser advice, crop calendars	Increased production and productivity, improved access to markets, reduction of post-harvest losses, increased resilience; specific attention to smallholder farmers	Mainly international	Further development of products and expert knowledge; increased cooperation with other actors, including aggregators; scaling up; advocacy	Projects funded by the G4AW Facility[1]; App to reduce post-harvest losses and to improve (labour-intensive) road work (Cheetah)
2.3.1	Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size	Parcel identification and crop monitoring	Cost saving by reducing need for field inspections	National and international	High resolution imagery; time series; expert knowledge; in-situ validation	GeoCAP (European parcel identification and crop monitoring system)
2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	See 2.3 + drought early warning, agricultural insurance, market access and infrastructure analysis, climate adaptation scenarios	Improved information provision, leading to increased income and resilience	Mainly international	Further development of products and services; expert knowledge; increased cooperation with other actors, including aggregators; scaling up; advocacy	Selection of projects funded by the G4AW Facility that give attention to drought, insurance or climate adaptation[2]
2.4.1	Proportion of agricultural area under productive and sustainable agriculture	Land use / land cover mapping and monitoring	Cost saving by limiting need for field inspections; improved visualisation of phenomena		Affordable data and data processing; expert knowledge; in-situ validation	Land use database of the Netherlands – LGN (WUR); GOFC-GOLD activities (WUR)
12.8	By 2030, ensure that everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Overarching purpose of EO in combination with mobile and web applications				
14.4 & 14.4.1	By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics Proportion of fish stocks within biologically sustainable levels	Identification, monitoring and analysis of potential fishing zones & detection of harmful algal blooms	Achieving sustainable fishing yield	National and international	Affordable data and data processing; expert knowledge; in-situ validation	Web-based provision of potential fishing zone information and ocean state forecast in the Indian Ocean (ODIS, INCOIS); Satellites support sustainable fishing (Copernicus)

(Footnotes)
1. https://g4aw.spaceoffice.nl/en/projects/g4aw-project-leaflets/
2. https://g4aw.spaceoffice.nl/en/projects/g4aw-project-leaflets/

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
14.6 & 14.6.1	By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organisation fisheries subsidies negotiation Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	Detection and tracking of fishing vessels	Cost saving by reducing need for in-situ inspection; increased detection of illegal activities	National and international	Affordable data and data processing; expert knowledge; in-situ validation	MyOcean: marine safety, marine resources, coastal & marine environment, weather & seasonal forecasting
14.7	By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	Mapping and monitoring of tourism infrastructure, environmental impact and access to markets for fisheries and aquaculture; identification, monitoring and analysis of potential fishing zones & detection of harmful algal blooms	Integration of different layers of information; see also 14.5	International	Affordable data and data processing; expert knowledge; in-situ validation	

Annex 7 Earth observation for SDGs - Water

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Assessment and monitoring of available water resources for drinking water	Cost saving by reducing need for in-situ observations; improved accuracy and change detection	International	Time series of data and data processing; expert knowledge	WaterAid: framework and practical tools (WaterPointMapper) to improve water supply and sanitation in poor areas
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Assessment of proximity to and availability of drinking water, sewerage and drainage systems and wastewater treatment plants (utility mapping)	Cost saving by reducing need for in-situ observations	International	High resolution data; combination with in-situ observations	WaterAid: framework and practical tools (WaterPointMapper) to improve water supply and sanitation in poor areas
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Water quality monitoring	Cost saving by reducing need for in-situ observations; improved accuracy and change detection	National and international	Time series of data and data processing; expert knowledge; in-situ validation	Evaluating the feasibility of systematic inland water quality monitoring with satellite remote sensing (CSIRO study for Australia); Real-time monitoring of water quality parameters (Blueleg): handheld monitoring as complement to EO
6.3.2	Proportion of bodies of water with good ambient water quality	(Surface) water resources monitoring and water quality monitoring	Cost saving by reducing need for in-situ observations	National and international	Time series of data and data processing; expert knowledge; in-situ validation	Methodology tested in pilot countries (UNESCO-IHE)
6.4, 6.4.1 & 6.4.2	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity Change in water-use efficiency over time Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Water resources assessment and monitoring; input for water accounting and water productivity assessments	Cost saving by reducing need for in-situ observations; improved accuracy and change detection	National and international	Time series of data and data processing; expert knowledge; in-situ validation; buy-in of stakeholders for water accounting	Methodology tested in pilot countries – 6.4.1 (UNESCO-IHE); Ladder approach (Deltares, eLeaf, CBS); Water availability analysis for the Upper Indus, Ganges, Brahmaputra, Salween and Mekong river basins (study by FutureWater)
6.5 & 6.5.1	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate Degree of integrated water resources management implementation (0-100)	See 6.4	See 6.4	See 6.4	See 6.4	
6.6 & 6.6.1	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes Change in the extent of water-related ecosystems over time	Land use / land cover mapping and monitoring	Cost saving by reducing need for in-situ observations; improved accuracy and change detection	National and international	Time series of data and data processing; expert knowledge; in-situ validation	Methodology tested in pilot countries – 6.6.1 (UNESCO-IHE)

Annex 8 Earth observation for SDGs - Sustainable landscape management

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
12.2, 12.4 & 12.5	By 2030, achieve the sustainable management and efficient use of natural resources By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimise their adverse impacts on human health and the environment By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	Mapping and monitoring of use of natural resources (agriculture, water, forests, fishing, mining, energy, air, environment, etc.)	Cost saving by limiting need for field inspections; improved visualisation of phenomena	Mostly international	Affordable data and data processing; expert knowledge; in-situ validation	
12.2.1	Material footprint, material footprint per capita, and material footprint per GDP	Data input for footprint calculations (same as 8.4.1)	Increased accuracy and reliability of footprint calculations	International	Time series of sufficient resolution; expert knowledge; advocacy	Water footprint research (UT)
14.2 & 14.2.1	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans Proportion of national exclusive economic zones managed using ecosystem-based approaches	Ecosystem mapping and monitoring; coastal zone land use / land cover mapping and monitoring	Cost saving by limiting need for field inspections; improved visualisation of phenomena	National and international	Affordable data and data processing; expert knowledge; in-situ validation	
14.3	Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	Monitoring of ocean acidity	Increased amount of data for analysis	International	Further development; expert knowledge	
14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	Assessment of impact of economic activities on protected coastal and marine areas	Integration of different layers of information	National and international	Affordable data and data processing; expert knowledge; in-situ validation	Census of Marine Life
14.5.1	Coverage of protected areas in relation to marine areas	Mapping and monitoring of marine protected areas extent	Cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	
15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	Mapping and monitoring of ecosystems, including forests, wetlands and drylands and mapping and monitoring of phenomena that may affect these ecosystems (land degradation, urbanisation, economic activity, disasters, etc.)	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	
15.1.1	Forest area as a proportion of total land area	Forest cover mapping and monitoring	Cost saving by reducing need for in-situ observations; access to data on areas that are difficult to reach	Mainly international	Affordable data and data processing; expert knowledge; in-situ validation	Global forest watch; forest resource assessment – FRA (FAO); global forest observation initiative (GFOI)

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
15.1.2	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	Ecosystem and natural habitat mapping and monitoring	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	GEO biodiversity observation network (GEOBON)
15.2 & 15.2.1	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally Progress towards sustainable forest management	Mapping and monitoring of forests, including forest degradation, rehabilitation and recovery	Cost saving by reducing need for in-situ observations; access to data on areas that are difficult to reach	Mainly international	Further development, affordable data and data processing; expert knowledge; in-situ validation	Global forest watch; forest resource assessment – FRA (FAO); global forest observation initiative (GFOI)
15.3 & 15.3.1	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 Proportion of land that is degraded over total land area	Land degradation monitoring; land use / land cover mapping and monitoring	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	
15.4, 15.4.1 & 15.4.2	By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development Coverage by protected areas of important sites for mountain biodiversity Mountain Green Cover Index	Ecosystem and natural habitat mapping and monitoring	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	GEO biodiversity observation network (GEOBON)
15.5 & 15.5.1	Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species Red List Index	Natural habitat and biodiversity mapping and monitoring	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	GEO biodiversity observation network (GEOBON)
15.9 & 15.9.1	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020	Ecosystem, natural habitat and biodiversity mapping and monitoring	Integration of different layers of information; cost saving by reducing need for in-situ observations	National and international	Affordable data and data processing; expert knowledge; in-situ validation	GEO biodiversity observation network (GEOBON)

Annex 9 Earth observation for SDGs - Climate

Number SDG Target or Indicator	Description SDG Target or Indicator	Earth observation application	Benefits (which problem does it solve?)	NL and/or international?	What is required to make it a success?	Examples
7.1, 7.1.1, 7.1.2, 7.2 & 7.2.1	By 2030, ensure universal access to affordable, reliable and modern energy services Proportion of population with access to electricity Proportion of population with primary reliance on clean fuels and technology By 2030, increase substantially the share of renewable energy in the global energy mix Renewable energy share in the total final energy consumption	Solar, wind, hydropower and biofuel potential assessment and monitoring of performance	Cost saving by limiting need for in-situ observations; increased accuracy	National and international	Expert knowledge; scaling up; advocacy	
8.4	Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programs on Sustainable Consumption and Production, with developed countries taking the lead	Mapping and monitoring environmental degradation and environmental impact of extractive industries	Better insight in actual situation; better informed decision-making and planning	International	Time series of sufficient resolution; expert knowledge; advocacy	
8.4.1	Material footprint, material footprint per capita, and material footprint per GDP	Data input for footprint calculations (same as 12.2.1)	Increase accuracy and reliability of footprint calculations	International	Time series of sufficient resolution; expert knowledge; advocacy	A carbon map for Kalimantan and Sumatra (biomass mapping exercise, IfW); Water footprint research (UT)
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Mapping and monitoring of infrastructure (projects) and vulnerability assessment of infrastructure	Better insight in actual situation; better informed decision-making and planning (see also 1.5)	International	Time series of sufficient resolution; expert knowledge; buy-in of stakeholders (see also 1.5)	North African coastal cities address natural disasters and climate change (World Bank, ESA; 2011) studies on adaptation to climate change with respect to natural disasters for Alexandria, Tunis, Casablanca and the Bouregreg area
9.4.1	CO_2 emission per unit of value added	Measuring CO^2 in atmosphere and climate modeling	Synoptic view, year-round data collection, cost saving by reducing the need for in-situ observations	National and international	Data from CO_2 monitoring satellites; expert knowledge	GEOCARBON
13.1 & 13.1.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	Support to modeling for prevention, early warning and monitoring of disasters (storms, floods, earthquakes, volcanic eruptions, landslides, industrial disasters); mapping and monitoring of actions for rehabilitation and strengthening of resilience	Reduction of damage and lives lost (estimated at 10% of total potential loss)	National and international	Affordable data and data processing; expert knowledge; buy-in of stakeholders	See 9.4

Annex 10 Main benefits of the use of Earth observation for SDGs

As derived from Annexes 5 - 9:

Saving of costs and time
- Cost saving by limiting need for field inspections / in-situ observations;
- Base layer for field inspections;
- Quick first analysis;
- Near-real time information; and
- Synoptic view, year-round data collection.

Quality improvement
- Improved visualisation of phenomena / better insight in actual situation;
- Increased accuracy;
- Increased amount of data for analysis;
- Integration of different layers of information;
- Better insight into cause-effect relations (add spatial dimension);
- Increased accuracy and reliability of environmental accounting and footprint calculations;
- Better informed decision-making and planning;
- Increased production and productivity, improved access to markets, reduction of post-harvest losses, increased resilience; and
- Achieving sustainable fishing yield.

Improved process control
- Improved vulnerability assessment;
- Earlier identification of threats and potential risks;
- Reduction of damage and lives lost (estimated at 10% of total potential loss);
- Improved preparedness; reduction of incidences and loss of life;
- Coverage of unsafe and/or inaccessible areas;
- Increased detection rate (of illegal activities); and
- Improved compliance.

Annex 11 Main challenges for the use of Earth observation for SDGs

As derived from Annexes 5 – 9:

Data-related
- High or sufficient resolution imagery (spatial resolution);
- High frequency imagery (temporal resolution);
- Affordable data and data processing;
- In-situ validation;
- Additional in-situ data;
- Additional data on population, health services and education; and
- Time series.

Knowledge and skills-related
- Further development; and
- Expert knowledge.

Marketing-related
- Increased cooperation with other actors, including aggregators;
- Scaling up;
- Buy-in of stakeholders; and
- Advocacy.

It is worth noting that with respect to data, not only temporal and spatial resolution are important, but also wavelength. Examples are LiDAR, radar, multi-spectral and hyper-spectral. Most of the potential applications of these technologies (still) need further development to become fully operational and generally applicable. Another consideration related to further development is that it should not take place in isolation, but in cooperation with stakeholders outside the Earth observation community.

In addition to what is stated above, capacity building is needed, especially in developing countries. Timing is also of the essence: GEOCARBON offers a full operational system by 2030, but by 2030 the SDGs should already have been achieved and in consequence this is too late to provide a real contribution. A challenge for scaling up is that, although based on general data layers, Earth observation solutions are usually highly context-specific and location-specific.

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Mark Noort, HCP International, June 2017

Contact
Email: G4AW@spaceoffice.nl

Visitors Address
Prinses Beatrixlaan 2 | 2595AL The Hague

G4AW
GEODATA FOR AGRICULTURE AND WATER

Netherlands Space Office

Ministry of Foreign Affairs of the Netherlands

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