Chapter 13

Earth Observation Support to the UN Framework Convention on Climate Change: The Example of REDD+

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13.1 Background

Forests present a significant global carbon stock accumulated primarily through growth of trees and an increase in soil carbon. While sustainable management, planting, and rehabilitation of forests can conserve or increase forest carbon stocks, deforestation, degradation, and poor forest management result in reductions. According to estimates from the Global Forest Resources Assessments (FRA) of the Food and Agriculture Organization of the United Nations (FAO) (FAO 2016), global forest biomass stocks decreased at an estimated average rate of 2.5% per year during the period 1991–2015, with about 2% resulting from deforestation and 0.5% from forest degradation (Federici et al. 2015).

The large contribution of greenhouse gas emissions from deforestation and forest degradation—in particular from non-Annex-I (developing) countries—is recognized in international climate negotiations. In 2005 the term “REDD”, standing for “Reducing emissions from deforestation and forest degradation” was introduced to the UNFCCC following an initiative by the governments of Papua New Guinea and Costa Rica (UNFCCC 2005). During subsequent refinement of the concept at UNFCCC COP meetings (Bali, Poznań, Copenhagen, Cancun, Warsaw, Paris), it became commonly known as “REDD+” because of a broadening of scope. Since the Cancun COP, REDD+ comprises five specific activities for which results-based incentives for participating countries can be made:

- Reducing emissions from deforestation;
- Reducing emissions from forest degradation;
- Conservation of forest carbon stocks;
- Sustainable management of forests;

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- Enhancement of forest carbon stocks.

Countries participating in REDD+ (on a voluntary basis) are required to report their national estimates of carbon dioxide and other greenhouse gas emissions and removals resulting from significant REDD+ activities to the UNFCCC on a biennial basis, following an agreed transparency framework for Measurement, Reporting, and Verification (MRV) (United Nations Climate Change Secretariat 2014). They are requested to utilize Intergovernmental Panel on Climate Change (IPCC) guidance and guidelines and to establish National Forest Monitoring Systems (NFMS) to estimate anthropogenic emissions and removals, using a combination of remote sensing and ground-based data.

The potential of remote sensing technology to support UNFCCC was first assessed more than a decade and a half ago (Rosenqvist et al. 2003), recognizing the significant potential of satellite-based techniques to monitor the state and changes of forest and land cover over extensive areas. Operational uptake of the technology has been slower than anticipated, with relatively few developing countries using satellite data as a tool for national forest monitoring in the first decade following the assessment (the most prominent exception being Brazil). The inertia of major space agencies and satellite data operators in recognizing and responding to the opportunity was probably at least part of the reason for the slow progress. Restricted/commercial data policies in particular have long been a key obstacle to widespread operational uptake of the technology. The US decision in 2008 to release all Landsat satellite data for unrestricted use was a major game-changer for Earth observation, prompting other countries to realize the advantages of free and open data access.

Many developing countries are now actively engaged (through REDD+) and are making use of ever-increasing remotely sensed datasets thanks to global systematic acquisition strategies and free and open access to a number of key Earth observation satellites. Such data assist in defining the extent of human activity causing emissions and removals from forest lands including historical impacts in the development of Forest Reference [Emission] Levels (FRELs/FRLs).¹

13.2 GFOI Goals and Objectives

The Global Forest Observations Initiative (GFOI) has been established to facilitate the supply and use of Earth observation data to countries as part of developing national forest monitoring systems for the purposes of REDD+. Through collaborative action, the initiative seeks to foster forest monitoring and assessment that is

¹Benchmarks are expressed in tonnes CO₂ equivalent per year for assessing each country's performance in implementing REDD+ activities.

robust, reliable, and achievable at reasonable cost and supports planning for national development priorities including climate change mitigation and adaptation.

GFOI was founded under the intergovernmental Group on Earth Observations (GEO). First initiated as a demonstration activity—the Forest Carbon Tracking (FCT) Task—in 2008, the first GFOI Implementation Plan was approved by the GEO Plenary in 2011, followed by long-term governance arrangements established in 2013. The GFOI is led by a Lead Team consisting of FAO, CEOS, Australia,² Norway³ and the U.S.,⁴ with support from other governments and institutions. It benefits from advisory committees with representatives from the UNFCCC, the IPCC GHG inventory program, the World Bank Forest Carbon Partnership Facility (FCPF), Global Observation for Forest Cover and Land Dynamics (GOFC-GOLD), and various other institutions and experts.

GFOI sets out to facilitate widespread implementation of REDD+. It aims to support countries that are developing and implementing NFMS and associated emissions MRV systems to take full advantage of Earth observation technology, by encouraging the use and assuring sustained availability of satellite observations required for forest monitoring; engaging space agencies and satellite data providers; developing methods and protocols on the combined utilization of remotely sensed and ground data for transparent assessment and reporting; developing capacity building programs to provide sustained assistance and guidance; and promoting directed research and development on high priority topics where further development is needed (e.g. forest degradation, above-ground biomass, satellite data synergy).

Reporting greenhouse gas emissions and removals to the UNFCCC is the responsibility of the countries that voluntarily opt to participate in REDD+. GFOI aims to *support* countries developing their national forest monitoring systems, not to conduct monitoring on their behalf. Countries are engaged on equal terms and hold full ownership over their NFMS and associated capacities.

The sections below provide a brief summary of some early achievements and challenges of the four components of GFOI: Satellite Data Coordination; Methods and Guidance; Capacity Building; and Research & Development Coordination.

²Australian Department of the Environment.

³Norwegian International Climate and Forest Initiative (NICFI), Ministry of Climate and Environment (Klima- og miljødepartementet).

⁴SilvaCarbon—technical cooperation program of the U.S. Agency for International Development (USAID), the U.S. Forest Service within the Department of Agriculture (USFS), the U.S. Geological Survey of the Department of Interior (USGS), the U.S. Environmental Protection Agency (EPA), the U.S. Department of State, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration within the Department of Commerce (NOAA), and the Smithsonian Institution.

13.3 Achievements and Challenges

13.3.1 Data Coordination

The Committee on Earth Observation Satellites (CEOS) coordinates civil space-borne observations of the Earth and leads the GFOI Data Coordination component. A dedicated Space Data Coordination Group for GFOI (SDCG) was established by CEOS and charged with developing and coordinating the satellite data acquisition strategies required in support of countries participating in REDD+. A key strength of SDCG is the broad support and active participation it enjoys from the national space agencies and data providers that are operating the key satellite missions of relevance for REDD+ (Table 13.1).

Restricted data policies and inconsistent data archives have long been major obstacles to operational utilization of satellite data over national scales (Reiche et al. 2016; Rosenqvist et al. 2003). In order to avoid creating a dependency on commercial satellite data for reporting, SDCG primarily focuses, as a matter of principle, on the coordination of freely available, sharable, and accessible global data. Data from the US Landsat series is currently most commonly used by countries, with data from the European Sentinel satellite constellation—also publicly open—expected to grow in importance as the satellites (first unit launched in 2014) and ground segment become fully operational. As an indication of the significance of these open data policy missions, SDCG is jointly chaired by USGS and ESA.

Table 13.1 Participating space data providers and corresponding satellite missions (as of May 2016)

Satellite mission	Type	Data policy	Agency/Data provider	Country
Landsat 7/8	Optical	Public open	USGS (NASA)	U.S.
Sentinel-1	Radar	Public open	ESA/European commission	Europe/EU
Sentinel-2	Optical	Public open	ESA/European commission	Europe/EU
CBERS-4	Optical	Public open*	INPE and CRESDA	Brazil and China
COSMO-SkyMed	Radar	PPP**	ASI	Italy
Pléiades	Optical VHR	PPP**	CNES	France
Radarsat-2	Radar	PPP**	CSA	Canada
TerraSAR-X/TanDEM-X	Radar	PPP**	DLR	Germany
ALOS-2	Radar	PPP**	JAXA	Japan
SPOT-6/7	Optical	Commercial	Airbus Defence & Space	Europe

* CBERS—public open from INPE, ** PPP Public-Private Partnership, VHR Very-High Resolution

Agencies with semi-commercial or Public–Private Partnership (PPP) missions also contribute to GFOI by making data available to the GFOI R&D program (see Sect. 13.3.4). As all aspects of national forest monitoring cannot be fully addressed solely with Landsat and Sentinel-type data, including priority REDD+ topics still in the research realm, the additional information provided by the very-high resolution and long-wavelength radar sensors operated by these agencies can often be part of the solution.

SDCG is not primarily about data provision per se. One of its main functions is to support CEOS with strategic solutions to better meet the requirements of REDD+ reporting. REDD+ countries commonly face different challenges compared to other users that CEOS agencies traditionally aim to support. These challenges include poor Internet connectivity, limited data processing capacity, and incomplete data archives, made more challenging by the possible requirement to handle large volumes of data covering national territories at a high temporal frequency.

SDCG actively promotes the implementation of systematic satellite data acquisition strategies to CEOS agencies to assure that *all* forested regions on the Earth are covered with sufficient temporal frequency and with as many different sensor types as possible.

To address Internet infrastructure issues and reduce data complexity, SDCG is, in collaboration with FAO and a number of pilot countries, developing cloud-based processing and analysis solutions and storage of preprocessed ready-to-use satellite data (also referred to as Analysis-Ready Data, ARD) in seamless “Data Cubes”. It is hoped that novel concepts such as these will contribute to reducing the current obstacles to the uptake and application of satellite data in REDD+ countries and increase their ownership of the process, and they can also be expected to provide innovative solutions on how space agencies can handle the increasing amount of satellite data more efficiently in the future.

13.3.2 *Methods & Guidance Documentation*

The GFOI Methods & Guidance Documentation (MGD)⁵ provides methodological advice on the joint use of remotely sensed and ground-based data to estimate and report greenhouse gas emissions and removals associated with forests in a manner consistent with the greenhouse gas inventory guidance from the IPCC. This is required by decisions of the UNFCCC for voluntary implementation of REDD+ activities.⁶

⁵Available in English, French and Spanish at <http://www.gfoi.org/methods-guidance/>.

⁶The REDD+ activities as listed in the Cancun Agreements (UNFCCC Decision 1/CP.16 para 70) are: (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; (e) Enhancement of forest carbon stocks.

The document is written by a team of internationally renowned experts and stakeholders specializing in forest information systems and the observations underpinning those systems, as well as experts in the assessment of forest carbon emissions and removals. The MGD is complementary to the IPCC Good Practice Guidance (GPG) and the GOFC-GOLD REDD Sourcebook (GOFC-GOLD 2015).

The second edition of the MGD, entitled *Integrating remote sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance (MGD) from the Global Forest Observations Initiative*, was released in 2016. The MGD is available for free from the GFOI website.

The MGD has been well received by both participating REDD+ countries and key stakeholders and has contributed to:

- Building a bridge between the decisions of the UNFCCC and operational decisions made by countries opting to estimate GHG emissions and removals from REDD+ activities;
- Systematically describing how IPCC Emissions Inventory methods can be used to make REDD+ estimates, activity by activity, using a combination of remotely sensed and ground-based data;
- Defining a foundation for consistent methodological advice, training, technical support, and communication provided to countries through GFOI engagement;
- Providing a link to freely available satellite data sets (via the GFOI Space Data Coordination Component); and,
- Communicating REDD+ country methodological requirements and data needs to the research and development community.

A key to success for the MGD has been the close linkage (facilitated by GFOI) to the relevant policy, implementation, funding, methodology, and research organizations involved in the REDD+ process (e.g. UNFCCC, IPCC, World Bank, SilvaCarbon, NICFI, UN-REDD, and GOFC-GOLD). Interactions between these key REDD+ support agencies combined with government partners working bilaterally on REDD+ initiatives have enabled the MGD to respond to REDD+ countries' methods and guidance needs.

Additionally, feedback from users on the utility of the MGD (received through FAO and SilvaCarbon capacity building workshops) has led to a number of innovations designed to address the challenges of effectively communicating technical guidance in a dynamic and rapidly emerging sector to a multilingual global audience with specific national needs.

These innovations include:

- Publication of rapid response guidance modules that expand on guidance presented in MGD in topical areas such as forest reference emission levels and the use of global data sets; and

- Release of REDDcompass, a web application providing access to the MGD in an interactive online framework (GFOI 2016). REDDcompass enables users to progressively work through the key themes, concepts, and actions of REDD+ NFMS for MRV, gaining access to a suite of GFOI methods and guidance, space data resources, training materials, and tools along the way.

The MGD builds on the foundation of the first edition and enhances and extends guidance on institutional arrangements, the use of global data sets, forest reference emission levels, safeguards, integration methods, extended systematic statistical advice on emission and removal factors and activity data, and reporting and verification requirements and processes. All methods and guidance materials and supporting references and tools are available through REDD compass.

13.3.3 Capacity Building

The GFOI Capacity Building component provides the interface between GFOI and the REDD+ countries that are its target users. The US SilvaCarbon program manages the Capacity Building component of GFOI in collaboration with FAO/UN-REDD.

SilvaCarbon implements capacity building efforts at both national and regional levels. At national levels, it works with countries to develop country-specific work plans ranging from technical assistance to intensive technical training sessions, workshops, and study tours. They are provided by experts from the U.S. SilvaCarbon institutions, and often in collaboration with other GFOI organizations and affiliated partners from industry and academia. The regional work plans are developed to reach out to a larger number of countries that share some common attributes or interests (e.g. in Central America, the Andean Amazon region, Central Africa and South/Southeast Asia). They typically include activities such as hands-on or showcase workshops on a range of topics related to monitoring and managing forest and terrestrial carbon in the regions.

FAO, through UN-REDD, supports national REDD+ readiness efforts in partner countries through direct support to the design and implementation of UN-REDD National Programs, as well as through complementary support to national REDD+ actions through common approaches, analyses, methodologies, tools, data, and best practices. Both SilvaCarbon and FAO have an active presence in partner countries and are well positioned to serve as links between countries and the other components of GFOI as they relate to capacity building needs. Both use and promote the GFOI MGD in training events and in turn provide comments and feedback from country representatives to the MGD team. There is also close cooperation with the Data Coordination component, to report user needs to CEOS space agencies and data providers, as well as to prepare and provide satellite data for training and NFMS development.

Long-term engagement is a prerequisite to building and maintaining technical capacity in a region. Workshops are never one-time events, but undertaken on a regular basis over several years and on a range of specialized topics. In the Americas region for example, SilvaCarbon events often engage the same core group of participants from the relevant organizations in the countries, which gradually build up sustained capacity on different aspects of the REDD+ process. Importantly, the events also stimulate personal and institutional networking between participants and organizations in the region. Regional collaboration and support is of mutual benefit for all parties.

There are naturally huge challenges in building up capacity in a large number of countries in a relatively short period of time and with finite staffing and financial resources. Sustained in-country engagement is in most cases not feasible. The level of basic technical infrastructure and competence—including familiarity with Earth observation techniques—can also vary greatly between countries and regions, posing an additional difficulty to regional capacity building efforts. Language is still a complication, despite publication of the MGD in three languages. While workshops in the Americas region are commonly undertaken partly or fully in Spanish, most training events in Africa and Asia are undertaken in English.

From an organizational point of view, both SilvaCarbon and FAO/UN-REDD are independent undertakings, with objectives, timelines, and budgets formally separate from GFOI. Coordination between SilvaCarbon, FAO, and the different GFOI components facilitates the success of the GFOI Capacity Building component in helping increase the use and awareness of Earth observation techniques for the REDD+ process. In 2016, GOFC-GOLD (with the support of the Forest Carbon Partnership Facility) started coordinating training workshops with SilvaCarbon and the FAO. Such joint efforts improves the cost-efficiency of the activities.

13.3.4 Research and Development Coordination

The GFOI R&D Coordination (RDC) component is led by the GOFC-GOLD Land Cover Office, with support from ESA. The RDC component covers focused R&D actions addressing immediate needs for NFMS, rather than more long-term, basic research activities in the forest monitoring domain. The primary objective of the RDC component is to support the MGD component by advancing select topics of priority for REDD+ implementation to reach a technical readiness level sufficient for inclusion in the MGD. The RDC component also supports the development of training materials. Key research needs have been prioritized in a peer-reviewed report (GFOI 2013), addressing priority R&D topics such as methods for mapping forest degradation and particular forest types (e.g. mangrove, peat forests, woodlands), vegetation biomass estimation, and satellite sensor synergy.

To capitalize on the significant forestry-related research that is already underway worldwide, the RDC component is engaged in two main activities: the organization of dedicated Expert workshops and the management of an R&D program for GFOI.

The Expert workshops are typically focused on one or two selected priority topics and seek to identify the main obstacles to their widespread/operational implementation. In case the challenges are related to satellite data (e.g. lack of adequate time series, cost of data, or sensor shortcomings), comments and recommendations are channeled back to CEOS and SDCG. For challenges of a methodological nature, the workshops provide opportunities to pool capacity and brainstorm alternative solutions. SDCG coordinates access to a wide range of public and commercial test data for high value research areas to support experts in the development of new solutions.

The RDC is set up to engage external research groups and help focus their activities towards the GFOI Priority R&D Topics and dedicated country needs. It is supported by the SDCG space agencies, which provide dedicated satellite data—also from commercial and PPP missions—to progress priority research and development of related novel Earth observation techniques.

The main challenge to GFOI R&D is financial. GFOI funds are limited to management and coordination only, with no budget allocation to support R&D per se. This leads to reliance on external R&D efforts, which may only partly overlap with the goals and timelines of the GFOI. Nevertheless, recent research calls (e.g. Innovators from ESA) have been based on the recommendations from the RDC component. One can anticipate more research calls will be based on the GFOI activities in the future. The RDC setup with Expert workshops and a “data-for-research” R&D program is a solution that nonetheless has proven valuable.

13.4 Conclusions

The GFOI constitutes an example of how Earth observation data can be used to support Multilateral Environmental Agreements (MEA), such as the UNFCCC, or the new Sustainable Development Goals (SDGs). While it is too early to assess the full impact of GFOI on REDD+ implementation, the initiative is certainly in a good position with active participation by developing countries and multilateral organizations, including those providing funding. With the backing and active engagement of CEOS space agencies, key organizations and stakeholders engaged in REDD+, national governments, and technical and scientific experts on remote sensing and forestry, circumstances can hardly get better. The stars are aligned. It is now or never to prove the worth of Earth observation.

Acknowledgements The views expressed are those of the author who is grateful to the late Jim Penman, Carly Green, Sylvia Wilson, Frank Martin Seifert, Eugene Fosnight, Thomas Harvey, and Brice Mora for reviewing the manuscript.

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Author Biography

Ake Rosenqvist is CEO of solo Earth Observation (soloEO), an SME providing scientific consulting in the field of satellite-borne environmental monitoring and mission planning. He joined the Swedish Space Corporation (SSC) in 1990 and was the first foreign national invited to join the National Space Development Agency of Japan (NASDA) in 1993, where he became involved in the development of the JERS-1 applications program. He spent 6 years at the EC Joint Research Centre in Ispra, Italy, and was awarded the ISPRS President's Honorary Citation in 2000 for promotion of Earth observation applications to the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol. As senior scientist at the Japan Aerospace Exploration Agency (JAXA), he developed the concept of systematic data observations, which was adopted by JAXA and implemented for the ALOS and ALOS-2 missions. Dr. Rosenqvist founded soloEO in 2009 and is currently supporting JAXA, the Argentinian Space Commission (CONAE), and the

European Space Agency (ESA) with planning for the ALOS-2, SAOCOM-1, and SAO-CS radar missions. On behalf of JAXA and the Norwegian Space Centre (NSC), soloEO has supported the development of the Global Forest Observations Initiative (GFOI) since its establishment in 2008.

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