International stocktake of Activity Data Requirements and Earth Observation for Inventory Compilation

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Purpose and aim

The overall aim of this project was to evaluate critically the ability of existing or near launch Earth Observation (EO) sensors to fulfil the activity data requirements of the future integrated Agriculture, Forestry and Other Land Use (AFOLU) inventory of Greenhouse Gas (GHG) emissions. This document summarises the results obtained from an international questionnaire circulated to member countries in the Global Research Alliance (GRA) on Agricultural Greenhouse Gases.

Background

The estimation of GHG emissions from agriculture is an important part of constructing country inventories. In the context of agriculture, emissions of nitrous oxide (N_2O) and methane (CH_4) from the agricultural sector, which can contribute significantly to total emissions (Milne *et al*., 2014), are of particular concern. Furthermore, Land Use, Land Use Change and Forestry (LULUCF) activities can lead to changes in carbon stocks and anthropogenic GHG emissions. The two previously distinct sectors of LULUCF and Agriculture are combined in the AFOLU category. AFOLU inventory activity includes a range of agricultural information such as livestock numbers, fertiliser applications, and tillage practices, from a range of sources, including surveys, field observations, remote sensing and expert knowledge (Ogle *et al*., 2013).

Objectives and Approach

To support AFOLU inventory compilation by the GRA community, this project set out to learn about existing utilisation of EO and perceived strengths, weaknesses and potential for EO usage through an international stocktake. This was developed as a questionnaire that was sent out to GRA member countries with the aim of collecting information on both data requirements and EO experiences in inventory compilation. The survey broadly followed the IPCC tier 1 inventory methodology to identify requirements and priority improvements in data for specific activities. Since questions were asked for individual activities, it was seen as an opportunity for also identifying where EO had been used and access stakeholder views on EO and its potential application in these activities. While collecting information on the needs and requirements for individual activities, the survey was also used to identify any barriers and constraints to the use of EO at a high level, as well as the need for capacity building and access to resources.

International Stocktake

This international survey was ultimately completed by ten countries, which varied in land area, climate, level of development and agricultural / land usage and management types. Livestock ranching (60%), commercial grain farming (60%), dairying (80%) and specialist horticulture (70%) were identified as important agricultural types in over half of the countries which responded to the survey.

Remote sensing makes a significant contribution to GHG inventory activities around the world but usage is uneven across the different activity themes, ranging from just 7% of Land Improvement activities to 31% of Land Areas and Biomass activities (Figure 1). There is also a marked variation between respondent countries with the Unites States and Canada accounting for 52% of activities using remote sensing whilst Norway and Spain reported one use each, and Indonesia and Japan reported none.

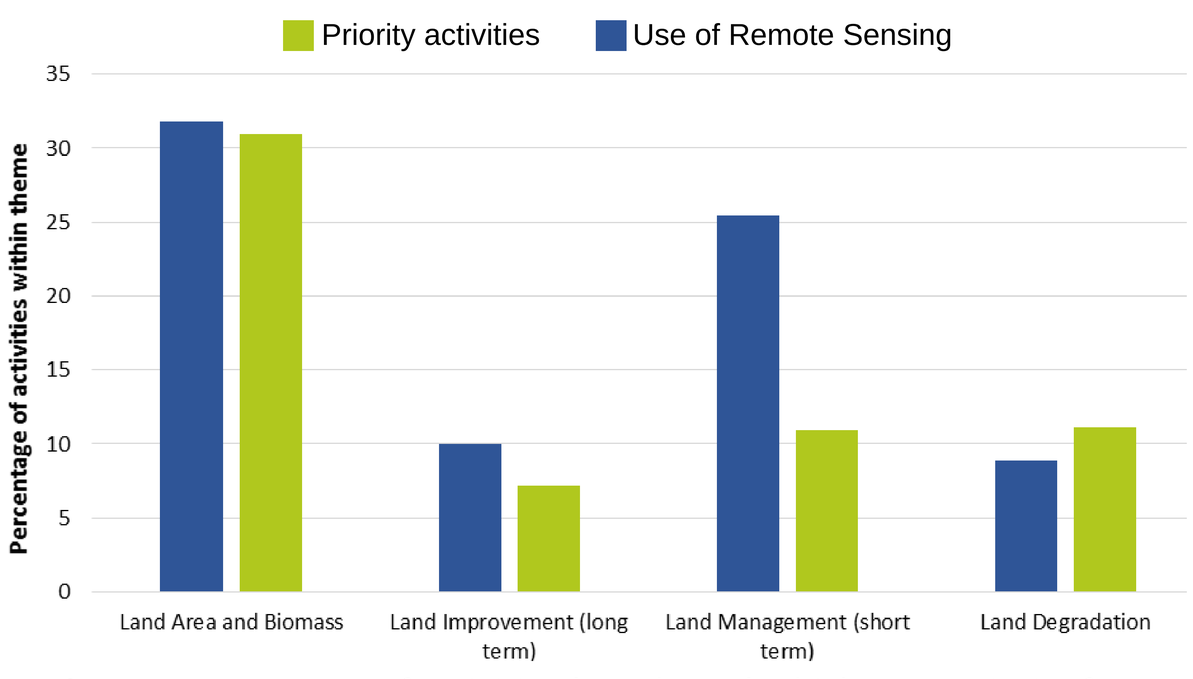

Figure 1 Percentage of activities (per theme) which are a priority for improvement or where Remote Sensing data is utilised

Use of Earth Observation

Utilisation of EO data focused on optical data (principally acquired from the Visible to Near Infra-Red part of the spectrum) with fewer activities employing Synthetic Aperture Radar (SAR). This reflects both the relative availability of these forms of data and the dominant use of vegetation indices and land cover / land use classification map products. The level of development of EO usage shows a clear gradient across the four themes of GHG inventory activities: the Land Area and Biomass themes shows a mature profile; Land Management and Land Degradation intermediate levels of development, with EO data currently being limited to R&D and exploratory use in the Land Improvement theme.

Capacity building and collaboration

Collaborative opportunities offer a way to increase the deployment of EO data for GHG inventory activities by spreading existing experience and sharing best practice amongst GRA member countries (Figure 2). Most responses on willingness to collaborate on EO utilisation and capacity building were positive but were almost exclusively confined to in-kind contributions or travel and subsistence levels of support. EO technology and infrastructure improvements also open up opportunities for EO data to further contribute to inventory activities with greater accessibility and standardisation (e.g. via GEOSS), enhanced capabilities (such as the Sentinel-2 missions) and new capabilities (such as the Soil Moisture Active Passive (SMAP), NISAR and Biomass missions).

Collaborative, infrastructure and EO technology developments mitigate most of the constraints on EO but one of the respondents most highly ranked constraints, ‘high cost of processing and data storage’, represents a challenge.

The new EO platforms and infrastructure will generate and disseminate an order of magnitude more data post-2015 than was previously the case. To meet this 'Big Data' challenge new processing paradigms, such as Near-Data Processing (NDP) (Balasubramonian *et al*., 2014), will need to be explored. With NDP, an inventory compiler could have their EO data processing procedures and algorithms hosted at an EO archive enabling them to generate and receive their GHG inventory related information on-demand through a Web interface.

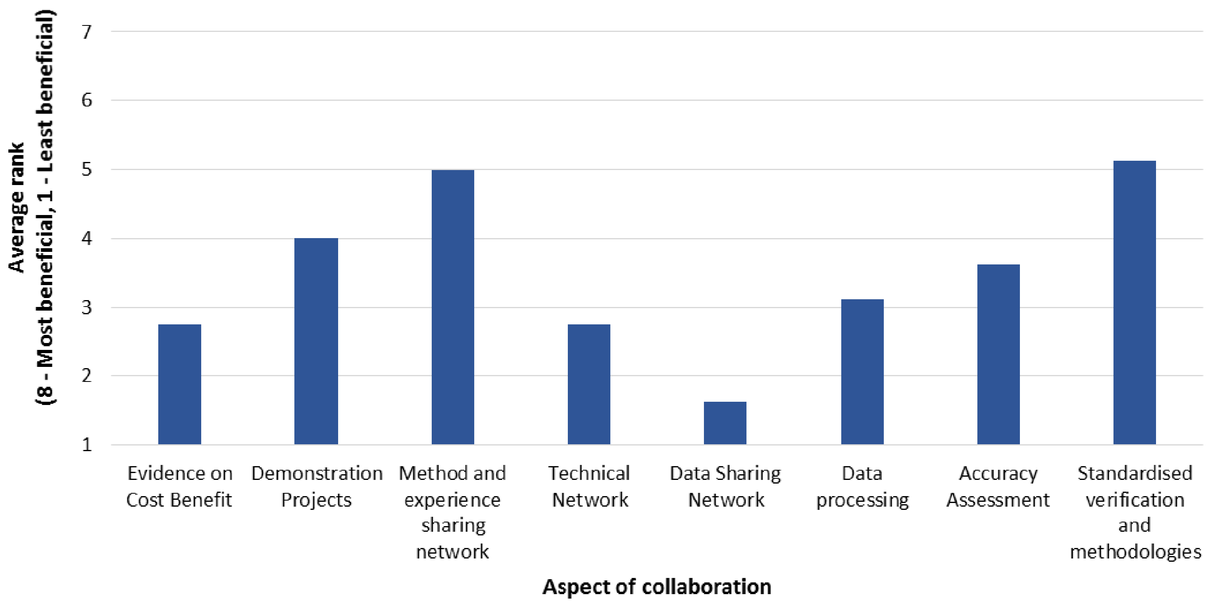

Figure 2 Average degree of benefit expected for various aspects of collaboration

Technical opportunities

Technical developments in the field of EO offer scope for improved and expanded benefits across the different inventory activity themes. The development of a Global Earth Observation System of Systems (GEOSS) is building a globally coordinated increase in observation, data dissemination and processing capacity. The initiative is also increasing harmonisation across EO data dissemination systems through the inclusion of standardisation bodies and sponsorship of interoperability demonstrators.

A range of new operational and planned missions will both enhance GHG inventory activities already using EO data and open up the potential for additional EO products to support activities where EO data has not previously been employed. The recently launched Sentinel-2 mission will take the VNIR resolution down to 10 m with an operational revisit of at least 5 days at low latitude. It also carries 20 m resolution Near-InfraRed wavebands for enhanced estimation of chlorophyll content over land surfaces and a 60 m resolution Short-Wave Infra-Red (SWIR) band.

The day-night and all weather capabilities offered by SAR missions are also being revolutionised. The European Sentinel-1 mission offers systematic data acquisition with a 20 m spatial resolution, enabling dependable repeat coverage. Where the C-band radar instrument on Sentinel-1 interacts with and images the properties of vegetation leaves, stalks and stems, missions using longer wavelengths are able to penetrate vegetation canopies further. The existing ALOS-2 L-band SAR mission and upcoming SAOCOM (2015/6) and NISAR S and L-band (2019/20) missions will reveal more information about the biomass and canopy structure of mature crops, grassland and woodland. 2019/20 will also see the launch of an even longer wavelength (P-band) SAR mission, an instrument which will return above ground forest biomass and tree structure information.

Land Improvement inventory activities and Land Area and Biomass activities that use modelling may also benefit from a new operational capability to estimate soil moisture using data from the SMAP mission which launched in 2015. The mission will determine soil moisture with a 9km spatial resolution, and 2-3 day repeat coverage. Two science value-added products, surface and root zone soil moisture and carbon net ecosystem exchange, should be of particular relevance to Land Improvement activities.

National improvement drivers and needs

Applications of EO to support the reporting of GHG emissions requires the bringing together of many different and apparently disparate disciplines, including EO specialists, air quality scientists, land scientists, modellers and policy specialists. There are many factors which have previously hindered the more widespread recognition of the potential applications of EO technologies: the cross-sector nature of this challenge; the perception that the capabilities of EO in the 1990s and 2000s may have been prematurely 'over-sold' to potential end-users; the historically high price and less ready availability of imagery; less powerful computing processing systems; more limited exploitation of radar imagery; and the relatively limited availability of process algorithms capable of interpreting imagery with consistently high accuracy.

However, from an international perspective, many countries which undertake GHG reporting are currently not exploiting EO technology to its fullest potential as recognised in the international survey undertaken in this project. To promote wider adoption, national drivers and needs include:

- Further applied research to exploit the emerging potential of EO to help characterise landscapes and land management practices
- Improved validation methodologies and procedures
- Central national hubs for coordinating the pre-processing, standardisation of image and processing algorithms, archiving and retrieval of imagery
- Assessment of the cost-effectiveness of using current and near-future EO-based sensors to support the derivation of data to underpin GHG reporting requirements

The international stocktake of GHG inventory priorities and EO experiences has found that EO data is widely used for inventory activities. There is considerable scope for better and expanded use of EO to support activities in the future through improving infrastructure, EO capabilities and coordinated collaboration and knowledge sharing / transfer. Building on the international stocktake, there is an opportunity for the GRA countries to develop such collaboration and knowledge transfer.

References

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Webinar: International Stocktake

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