

The GEO Global Agricultural Monitoring Initiative

This draft work plan was developed by the GEO Agriculture Task Leads and the GEO Secretariat and reviewed by the GEO Agriculture Community of Practice. It is being submitted to the G20 Ministries of Agriculture for their guidance, and it will be also used to support fund raising.

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EXECUTIVE SUMMARY

The Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative aims to enhance agricultural production estimates through the use of Earth observations. It was developed in response to the G20 Agricultural Ministers' concern about reducing market volatility for the world's major crops.

The initiative builds on recent advances in Earth observation technologies. These technologies have great potential to contribute to timely forecasts of crop production and early warnings of potentially significant harvest shortfalls.

The initiative's goal 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 Earth observations. The work plan for the initiative is divided into six components: 1) enhancing global agricultural production monitoring systems; 2) building capacity at the national level to utilize Earth observations; 3) supporting the monitoring of countries at risk to improve food security; 4) improving the coordination of Earth observations for agricultural monitoring; 5) coordinating research and development (R&D) in support of improved operational agricultural monitoring; and 6) disseminating data, products and information ~~dissemination~~. The work plan identifies the primary activities and deliverables under each component together with the funding needed to implement them. The funding will of necessity consist of direct and in-kind contributions from the G20 nations.

The annual budget required for fully implementing GEOGLAM is US\$7.5 million. It assumes in-kind contributions from G20 and GEO members through the sustained resourcing of their institutions, and the ~~means for estimation of costs provision~~ by space agencies of timely access to data. ~~These data will be sought from agencies based on a full and open data policy basis, as national policies allow, and through partnerships with commercial data providers.~~

The GEOGLAM initiative will require new levels of international coordination within the agricultural monitoring community. It will further develop this coordination through a series of networks and the organizations responsible for the coordination of Earth observations, such as the Committee on Earth Observation Satellites (CEOS) and the World Meteorological Organization (WMO). The initiative outlines the desired linkages with the Agricultural Market Information System (AMIS), a partner initiative launched by the G20 Agricultural Ministers and endorsed by the G20 head of states and a key beneficiary of the GEOGLAM outputs. The initiative will be implemented within the GEO framework and the work plan includes a governance structure.

Comment [TSS1]: Important to appropriately characterize the process for calculating costs of EO data provision through in-kind contributions and, where necessary, commercial procurement.

1 GEOGLAM STRATEGIC TARGETS

The objective of the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative is to reinforce the international community's capacity to produce and disseminate relevant, timely and accurate information and forecasts about agricultural production at national, regional and global scales using Earth observations from space and on the ground.

This will be achieved by:

- enhancing national agricultural reporting systems through training in the application of best practices in the field of operational agricultural monitoring;
- establishing a sustained international network of agricultural monitoring and research organisations and practitioners; and
- creating an operational global agricultural monitoring system of systems based on both satellite and in situ observations and the necessary geospatial databases.

Global success will be achieved by building on existing agricultural monitoring initiatives at national, regional and global levels and by enhancing and strengthening them through international networking and data sharing. The GEOGLAM international network will mobilize satellite and meteorological data and ground-based agricultural observations, and it will advocate for full and open data sharing. Based on state-of-the-science and continuously improved methods for crop monitoring, it will promote the dissemination and sharing of geoinformation technologies and agricultural analyses, methods and modelling techniques taking into account the established knowledge about specific regional agricultural production systems.

All of the world's agricultural regions will be involved. A number of national and regional organizations will operate as focal points for cooperation by enhancing the local networks of scientific and technical resources.

The associated international network of agricultural monitoring organisations has six primary goals:

- produce early estimates of cultivated areas and crop-type distribution at national, regional and global scales;
- produce meteorological syntheses and short-term and mid-term forecasts;
- produce agricultural monitoring syntheses and regularly updated crop-yield forecasts;
- partner with AMIS to disseminate these data;
- contribute to stakeholder awareness of the contribution of EO to meeting national needs, and to stakeholder training for their use and analysis;
- contribute to the development of improved monitoring and forecasting methods, through research development and experience sharing.

Over the past two decades, there have been major improvements in satellite monitoring capabilities around the world that have benefited agricultural monitoring. However, these systems are operated independently by national agencies and commercial entities, and no one satellite system can provide all of the information needed for agricultural monitoring. International coordination amongst space agencies to support the design and implementation of an operational satellite observing system for agricultural monitoring will be a key component of the project. The global observing system for agriculture must achieve operational standards similar to those currently used in meteorology and oceanography.

The GEO Agriculture Community of Practice will play a key role in the dynamics of this international network. This CoP includes the United States Department of Agriculture (USDA), the European Commission's Joint Research Centre (EC/JRC), China's Institute of Remote Sensing Applications (IRSA), UN agencies such as WMO and the Food and Agriculture Organization (FAO), the Consultative Group on International Agriculture Research (CGIAR), working closely with the Committee on Earth Observation Satellites (CEOS) and many national and international space agencies.

One of the ~~initiative~~ major deliverables of this initiative will be to develop capacities to monitor agriculture, using Earth observations where appropriate. It envisions a future when most nations are willing and able to generate their national statistics with the benefit of space-based sensors and techniques. (The Pakistan example described below is provided as an example of how this can be achieved). In addition, stakeholders and users should be capable of using the derived information. International coordination, transparency of information and methods, and increased awareness of the capabilities of Earth observation are key elements for realizing the following benefits:

* Improved capacities for national and global agricultural monitoring and crop-yield forecasting. The development of satellite infrastructure for Earth observation combined with advances in scientific research and international cooperation on crop monitoring methods will enable continuous technical improvements. Key technical issues include making early estimates of cultivated areas and early identification of crop types, and designing crop-yield scenarios and forecasts. The quality of crop-yield forecasts will increase as various time-series from satellite and in-situ monitoring data are integrated. In particular, Earth observation data and derived products will contribute to strengthening the development of agricultural statistics and developing a better understanding of the impacts of meteorological scenarios on crop production.

* Increased stakeholder awareness of GEOGLAM information and an increased capacity to use it. The state of agricultural monitoring varies greatly from country to country. In many cases, capacity building is needed at the national level to improve agricultural monitoring techniques and infrastructure. The GEO approach is to build networks of practitioners at the broad regional level so that they can share experiences and methods suited to local and national needs. These networks will provide critical knowledge relevant to regional agricultural systems, their production capacities, their trends and their sensitivities to meteorological and pest scenarios. Through national and regional stakeholder networks, practitioners will rapidly collect information on specific events and phenomena that can impact local or regional agricultural production (e.g. changes in practices, meteorology, pests). This will result in:

- (1) an enhanced capacity to mobilize and integrate satellite data, in-situ data, field observations, enquiries and declarations, thereby contributing to the increased quality of crop-yield forecasts;
- (2) stronger support by governments, enhanced trust, and greater regional and global collaboration;
- (3) stronger involvement of local operators and stakeholders through training, dissemination, and informed decision making;
- (4) the identification of specific global and regional information and capacity-building needs; and
- (5) increased cooperation between space agencies and enhanced Earth observation capabilities for agricultural monitoring.

* Improved crop-production transparency, international coordination and risk-management capacity. Based on improved agricultural monitoring, crop-yield forecasting, information transparency, results dissemination, and capacity building among stakeholders, actors from both public and private sectors

will be able to adapt and fine-tune their own monitoring strategies based on a comprehensive vision of the international situation.

An example: Strengthening Pakistan's agricultural monitoring system

Pakistan is a country of diverse agro-climatic regions. Agriculture plays a pivotal role as it contributes to more than 20% of the GDP and provides employment to 45% of the labour force. The cropped area of the country is around 23.7 million hectares, out of the total area of 79.6 million hectares. The major crops are wheat, cotton, rice, sugarcane and maize, while the minor crops are pulses, vegetables and fruits. These crops are sown in two cropping seasons, namely the winter-rabi-season and the summer-kharif-season. The winter crops are sown between October and December and harvested from March to May. Summer crops are sown between February and July and are harvested from August to November.

Since 1947, Pakistan has followed traditional approaches to the estimation of crops statistics through opinion surveys. Later these surveys were substituted by data gathered by the Pakistan Revenue Department. In 1970s, the Ministry of Food & Agriculture, the Federal Bureau of Statistics and provincial agriculture departments jointly devised a crop reporting system based on an area and sample frame. The system in general lacked temporal character and suffered from delays in the provision of crop information to the end users. In 2005, following a grain shortfall precipitated by an early decision to export, when in reality there was a cereal deficit, the Government of Pakistan had to import grains. Subsequently, Pakistan decided to invest in advanced technologies for collecting spatial information on agriculture. The objective was to address shortcomings of the prevalent system, including but not limited to time lags in provision of data and their quality. The Pakistan Space Agency (SUPARCO) was assigned the responsibility to develop an operational satellite-based system for crop area, yield and production estimation in collaboration with FAO and with other national stakeholders, such as the Pakistan Meteorological Department, the Federal Bureau of Statistics and Provincial Crop Reporting Services.

Subsequently, work started in earnest to develop an optimized crop area estimation and yield forecasting methodology to provide in time acreage, yield and production statistics for the whole country. From 2007 countrywide statistics, based on the integral use of Earth Observation data have been provided to decision makers and stakeholders for agriculture development, planning and policy formulation purposes.

In this period, Pakistan has effectively reduced its sample size to a manageable 317 segments covering an area of 10,000 hectares across the whole of Pakistan's cultivated area, with crop forecasts being generated every season 3 to 4 months before harvest and estimates at the time of the harvest. Results indicate a high level of concurrence with those of the Ministry of Agriculture, reducing uncertainty and gaining confidence in the estimates of crop area and yield through the use of Earth observation data. Furthermore, national capacity has been significantly and sustainably enhanced. With the Ministry of Agriculture's decentralization, federal systems have come under increasing stress and the new and robust procedures are needed at the provincial level, placing even greater emphasis on the use of the Earth observation procedures developed.

From January 2011, a monthly Pakistan satellite based crop monitoring system bulletin has been published. It provides critical and timely actionable reports to the national and international agencies involved in monitoring of agriculture. Pakistan authorities have further monitored the status of the recent floods across the country and provided detailed crop damage assessment reports produced from the integration of remotely sensed data received at the SUPARCO ground station at 2.5 m and 5 m resolution with field verification. These operational programmes would not have been possible without detailed methodological development and capacity building in the operational use of Earth observation data developed over the last 4 years.

FAO's approach to the use of remotely sensed data for area frame and multiple frame development will be carried forward in pursuit of further improvements and coverage of minor crops such as spices, horticulture, and legumes through the use of small area estimation techniques at federal and provincial level. Continued efforts to refine the system will be perpetuated through the decentralization of the approaches to the provincial level in the period 2012 to 2014 utilizing advanced training, data sharing and support systems via a cohesive effort from FAO, the University of Maryland and the USDA.

Figure 1 below is an illustration of the use of a derived Remote Sensing product (NDVI) over the Pakistan crop production area. Deviations in NDVI can be used to forecast crop productivity.

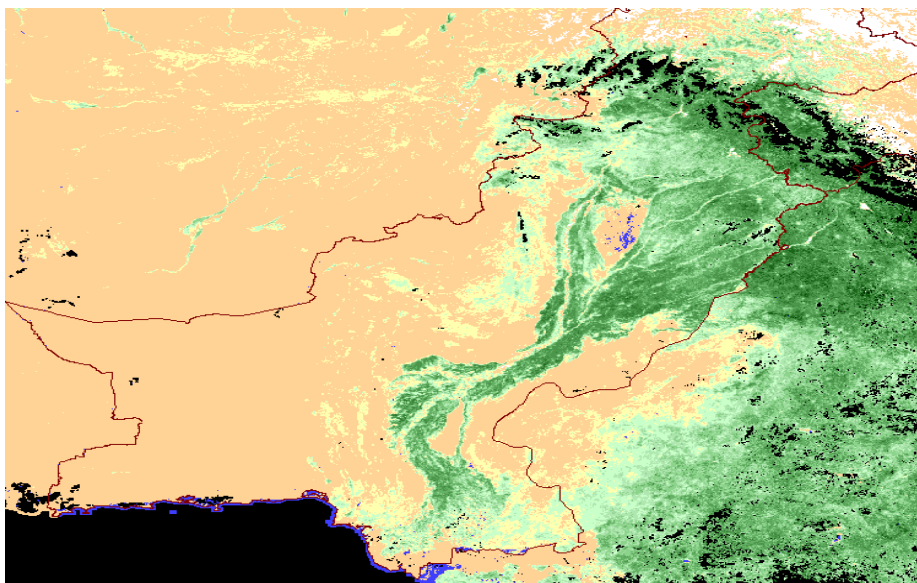


Figure 1. Normalized Difference Vegetation Index over Pakistan, August 3, 2011

2 GEOGLAM WORK PLAN COMPONENTS

The work plan is organized into six components that build on current capabilities (components 1-3) and on the need to improve satellite and in-situ data coordination, share tools, experiences and information to increase transparency, and reach out to end users (cross-cutting components 4-6):

1. Enhancing global agricultural production monitoring systems;
2. Building capacity at the national level to utilize Earth observations;
3. Supporting monitoring of countries at risk to improve food security;
4. Improved coordination of Earth observations for agricultural monitoring;
5. Coordinating R&D in support of improved operational agricultural monitoring;
6. Disseminating data, products and information.

The diagram in Figure 2 shows the implementation structure of GEOGLAM, which is described in detail below. The approach to be adopted by this initiative is to build upon existing capacities and

structures, particularly at national and regional scales, to develop new capacities where they do not currently exist, and to network them in a consistent and sustainable way.

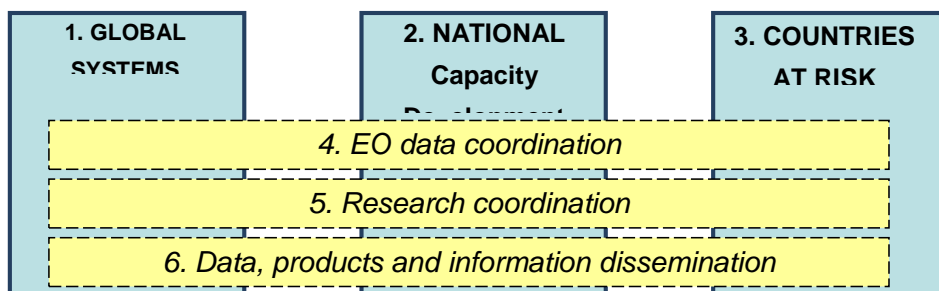


Figure 2. Diagram block of the six components of GEOGLAM

2.1 Component 1: Global Agricultural Monitoring System of Systems (main producer countries)

This component focuses on the major grain crops (wheat, maize, rice and soybean, total grain) for the G20 + 7 countries covered by AMIS, with the possible extension to other commodities (for instance sugar crops) and rangelands. It will provide enhanced, improved and timely production forecasts to AMIS based on existing global monitoring systems (i.e. USDA/FAS-CROP EXPLORER and PSDOnline, EU-MARS, IRSA-CropWatch, FAO-GIEWS).

Deliverables 1-1: Global qualitative and reliable crop production outlook, input to AMIS

Activity 1-1: Enhancement of the current global crop monitoring systems by:

building improved global geo-datasets for arable land, crop maps/masks, crop calendars and development cycles, crop management (fertilization, pesticide, irrigation, etc), soil moisture, historical statistics (> 15 years) on area and yield, breakdown at an appropriate sub-national level, between seasons (if any) or between varieties (e.g. durum soft wheat);

- a) reinforcing near real time (NRT) availability of satellite and ground meteorological data;
- b) integrating new Earth observations and Earth observation-based indicators;
- c) expanding the capability and use of MODIS GLAM and other global satellite data systems;
- d) stimulating a global NRT reporting system on crop phenology, pests and diseases;
- e) prototyping and developing multi-satellite data acquisition coordination;
- f) adding monitoring of the productivity in global rangeland and livestock; and
- g) including the regular monitoring of significant agricultural land use changes.

Activity 1-2: Input or contribution to AMIS by:

- a) providing elaborated global information to AMIS with a common global qualitative outlook (overall growing status, areas under specific agro-climatic conditions likely to impact global production and impact factors, at an appropriate frequency (for instance quarterly);
- b) in case of extreme events ~~on~~ **for any key grain-agricultural belt**, putting in place a rapid monitoring capacity with a focus and a higher frequency reporting;
- c) and/or possibly calling for an ad-hoc expert group (with global and national representatives) to analyze the situation and assess its impact.)

Comment [TSS2]: Edit provided assuming that the term "grain belt" does not apply to all crop types.

These actions will facilitate identifying AMIS information gaps and requirements, as an input to component 2 (national capacity building).

Activity 1-3: Increase confidence in crop monitoring resulting from:

- a) inter-comparison of existing global monitoring systems as concerns their results and methods for understanding discrepancies, system feedback and improvement;
- b) development of benchmarking datasets for models/methods and validation through the GEO Joint Experiment for Crop Assessment and Monitoring (JECAM);
- c) increased transparency of global crop models used by existing global systems.

Deliverables 1-2: Innovative methods and models for next generation monitoring

Activity 1-4: Development of the next generation global monitoring and food supply outlook, consisting of:

- a) a new method for food supply outlook based on a 5-year moving window production;
- b) new indicators defined by interaction with AMIS, drawn from existing systems;
- c) new methods for using these new indicators with better prospective on food supply, for instance using multi-resolution and multi-sensors Earth observation data to obtain an area-change indicator (early area estimate predictor); soil moisture for water stress; and cropping system;
- d) development of Earth observation-based crop models for global application without ground survey support.

The required budget for Component 1 is estimated as US\$1 million per year, or US\$6 million over the 6 years of the initiative. It considers that the current systems cost about US\$15-20 million a year, i.e., the extra effort would add about 5-7% to the current cost.

2.2 Component 2: National Capacity Development for Agricultural Monitoring

This component focuses on supporting national and regional institutions willing to develop agricultural monitoring capacities through the use of Earth observation and modeling. Most countries have some form of agricultural monitoring system, but the level of uptake and use of Earth observations is extremely variable. In a number of cases traditional statistical field-based methods are used and do not benefit from the synoptic information that is afforded by current Earth observation data. In many instances, there is a lack of coordination between institutions that develop and utilize remote sensing for agricultural monitoring and the agricultural ministries or statistical services responsible for operational agricultural production monitoring. There is also much to be gained by sharing experiences and approaches for the use of remote sensing between countries with similar crops and cropping systems. This component will provide technical and institutional training, training of trainers, methodological guidelines and tools, facilitated access to Earth observation including meteorological data (component 4), and expert advice and support. Open to all, the GEOGLAM

initiative will stimulate networking and the sharing of technical experience between all G20 and other countries focusing particularly on the main producers/exporters identified in relationship with AMIS or FAO, where Earth observation and crop models could improve present information.

Deliverables 2-1: Inventory of actors and institutions responsible for national agriculture monitoring; methodology for assessing national capacity, analysing requirements and defining a roadmap for capacity development.

Activity 2-1: Gathering information (for a large number of countries) about the current status of agricultural monitoring and the use of remote sensing techniques through:

- a) an inventory of actors and of institutional frameworks for agriculture monitoring;
- b) an inventory of national programmes using Earth observation in support of agricultural monitoring, and an inventory of supporting international programmes;
- c) the grouping of countries in a relevant typology depending on food balance (surplus/ exporter/importer), vulnerability to climate variability, and agriculture monitoring framework.

Activity 2-2: Developing and implementing a methodology to assess national capacities, analyze gaps and requirements and design roadmaps for capacity development for the use of remote sensing to support agricultural monitoring.

Based on case studies and experiences, this will consist of:

- a) developing and implementing methodology for the assessment of national capacities for agricultural monitoring (technical skills, institutional framework, institutions responsible/mandated for agriculture statistics creation and dissemination, infrastructure), national capacities for the use of Earth observation for agricultural monitoring (current approaches and their performances in terms of accuracy, timeliness, identification of trainee institutions);
- b) developing and implementing a methodology for analysis of requirements in terms of capacity development and design of an empowerment strategy to improve agricultural monitoring by using Earth Observation.

Deliverables 2-2: Guidelines, standards and best practices to support the development of agriculture monitoring using Earth observations at the national level

Activity 2-3: Establish synthesis documents of standards and best practices to support the development of agriculture monitoring using Earth observation at the national level. Undertaken through the Agriculture Community of Practice and JECAM global workshops and regional meetings, this activity will focus on methods for:

- a) scaling up local/district monitoring to produce national monitoring (then regional and global monitoring): sampling frameworks, remote sensing monitoring;
- b) validation and uncertainty analysis; quality framework;
- c) in situ data acquisition; knowledge about agricultural production systems;
- d) Remotely Sensed monitoring

Activity 2-4: Stimulate and coordinate research, development and experimentation to improve methods for the use of Earth observation to support agriculture monitoring at the national level.

Through JECAM R&D and collaborative studies, this activity will include developing methods for an extended variety of crops, new satellite sensors, and various crop production systems.

Deliverables 2-3: Enhanced national capacities (institutional, technical, infrastructure) and access to improved national agriculture monitoring estimates; toolkits and training programmes.

Activity 2-5: National capacity development, implemented in selected countries, by:

- a) implementing a strategy for empowerment based on the analysis of the various mechanisms: institutional, training, distance learning, networking;
- b) defining indicators to monitor the improvements and added value generated by capacity development actions;
- c) strengthening existing training institutions at national and regional levels;
- d) improving infrastructure and human capacity for collecting, accessing and processing of Earth observation data and identifying and securing an uninterrupted supply of Earth observation data, data specification, source, etc. (link with Component 4);
- e) Development of training programmes, training tools, toolkits.

This component is strategically important for GEOGLAM, as there is a consensus vision that in the future crop monitoring will be carried out comprehensively at the national level. As such, its estimated cost is US\$2.15 million per year, totaling US\$12.9 million over the 6-year timeframe.

2.3 Component 3: Global/Regional Systems for Countries At Risk: Agricultural Monitoring in Support of Food Security Assessment

This component also aims at capacity development, but with a specific focus on countries at risk, and including different crops, agricultural systems and calendars and different information needs. Agricultural monitoring in countries at risk supports timely food security assessment and early warning of potential significant food shortages. It is relevant to the three principal questions of food security assessment:

- Availability: How much food is present in-country, in the form of current production, stocks, and imports?
- Access: To what extent do market prices, or other institutional factors, prevent households from accessing available food?
- Utilization: To what extent do disease, sanitation, traditional practices, etc., prevent households from deriving full benefit from accessible food?

Many national and regional agricultural monitoring institutions in at-risk countries have a limited ability to generate agricultural production data, and they are often unable to integrate them into a broader assessment of current or near-future food security. At the same time, the avenues available to them for improving their technical capabilities for producing data and information products are limited.

A number of GEOGLAM members -- e.g. FAO's Global Information and Early Warning System on food and agriculture (GIEWS), USAID's Famine Early Warning System Network, and JRC's Monitoring Agricultural Resources unit -- are able not only to produce these products on behalf of national and regional agencies (on an interim basis), but also to help them build national and regional institutional and staff capabilities for doing so themselves. Working through the GEOGLAM structure, members can ensure the coordination of product delivery and capacity building efforts for national and regional organizations and the development of harmonized methods and tools. GEOGLAM can also promote a two-way flow of data and information between national and regional organizations on the

one hand, and international organizations on the other. This would provide a global platform from which all of these organizations could discuss how better to rationalize responsibilities and roles in order to jointly meet their complementary agricultural monitoring needs and abilities.

It should be noted that an important mechanism for building the technical capabilities of national and regional agricultural monitoring organizations should be to strengthen their linkages with those decision-makers who should be the primary users of the information they produce. It will be essential to coordinate with regional economic communities such as the Economic Community of West African States (ECOWAS), the Common Market for Eastern and Southern Africa (COMESA), the Intergovernmental Authority on Development (IGAD) in Eastern Africa, and the Central American Integration System (SICA), as well as with other continental and global bodies and initiatives dealing with food security, such as the New Partnership for African Development (NEPAD) Planning and Coordination Agency, the Food Security Information Network, the WMO-led Global Framework for Climate Services, and the Global Drought Information System. GEOGLAM members will help to develop these links through a variety of user-training mechanisms, such as regional food security forums and international policy dialogues.

Deliverable 3-1: Improved and harmonized methods and tailored agriculture monitoring products for countries at risk

Activity 3-1: Strengthen the capacity of national and regional institutions to integrate their climate and crop data collection programs with globally available Earth observation datasets and models to fill gaps and obtain new, more robust agricultural monitoring products.

These will include:

- a) gridded datasets for precipitation, temperature, evapotranspiration, soil moisture, snow water content, and vegetation condition;
- b) updated crop calendar and cropland area locations, more focused analyses of gridded products;
- c) collection of moderate and fine resolution satellite observations; and
- d) production of up-to-date area-planted statistics, supported by best available remote and on-the-ground survey numbers, to anchor year-to-year estimates of relative change in agricultural production.

Activity 3-2: Strengthen the capacity of national and regional institutions to apply improved agricultural monitoring to produce timely in-season yield and production figures to support national programs and food security early warning systems.

Actions here will include a variety of training and technology transfer workshops, data and product transmission protocols, and the establishment of frequent and routine consultative practices to reach consensus on prospects for agricultural production using a convergence-of-evidence approach.

The estimated budget for this component is US\$1.5 million per year and assumes the ongoing availability of global datasets and services like the US National Aeronautic and Space Administration's (NASA) Tropical Rainfall Measuring Mission (TRMM) and the follow-on Global Precipitation Mission (GPM), NASA Land Atmosphere Near-real-time Capability for EOS (LANCE), NOAA Global Forecast System (GFS), NASA MODIS, etc.

2.4 Component 4: Earth Observations (satellite and in situ)

The primary focus of GEO is to coordinate satellite and in situ Earth observations for societal benefit. The objective of the GEOGLAM initiative is to increase the use of Earth observations to improve

operational agricultural monitoring. As such, the GEO Partners include UN Agencies such as FAO and WMO. GEO has also initiated a requirements dialogue with the Committee on Earth Observation Satellites (CEOS), a group of the world's civil remote-sensing space agencies.

Deliverable 4-1: Improved coordination of satellite observations for agricultural monitoring

A varied set of information products is needed for effective agricultural monitoring: cropland area and change, cropping system, crop type, date of planting, crop calendar, field size and area planted, rainfall and weather conditions, crop condition, crop yield and production. The common theme for agricultural monitoring is that information needs to be timely, easily accessible and reliable, with data continuity to ensure repeatable observations. Used in synergy, satellite sensing systems with varied spatial, spectral and temporal resolutions can provide data that can help meet these information needs. Based on the high-level requirements defined in the early planning stage of GEOGLAM, it is understood that the comprehensive requirements cannot be met by a single agency or a single Earth observation satellite mission. The varied nature of the data requirements and the very high frequency of revisit required to capture essential information at the appropriate time justify the need to address agricultural user requirements under a coordinated framework.

With advances in satellite and information technologies, the various satellite systems now operating or planned for launch in the near future, and the potential for support by various space agencies at the appropriate level of funding, it is now possible to envisage the development of a coordinated "system of systems" for the agricultural monitoring community. Through a partnership approach, CEOS member agencies are capable of contributing to the development of an operational global agricultural monitoring system of systems, based on a sustained and coordinated network of Earth observation satellites. Such a system would require agency commitments to specific mission attributes (e.g., orbits, imaging swaths, sensor spatial and spectral resolution, and routine and near-real time acquisition) and open data policies.

The necessary tasks for successful implementation of an agriculture system of systems in response to the GEOGLAM needs are as follows:

Activity 4-1: Development of a coordinated observation strategy

Develop, in partnership with supporting CEOS member agencies and private-sector satellite operators, a coordinated data acquisition strategy for the systematic monitoring of agricultural areas of the world, ensuring continuous observation of these areas. This task requires the definition of a detailed set of needs by the operational agricultural monitoring community followed by an assessment of the required space operator resources to support the needs.

This activity includes:

- a) the translation of the agriculture community's needs into a satellite-based planning format to better understand the magnitude of the imaging requirements to support the GEOGLAM observation plan;
- b) the concerted and distributed definition of an multi-phase acquisition strategy that will take into consideration the monitoring needs as well as the mission capabilities and constraints of the data providers;
- c) a feasibility assessment within the context of a coordinated approach; an estimation of the costs inherent to the planning, acquisition, provision and dissemination of the satellite-based data from public and commercial missions; and finally
- d) the design of a coordinated GEOGLAM data acquisition and dissemination plan.

This activity would require new resources from both agency and commercial data providers. At the end of this activity, there should be a clear understanding of the total data requirements and related efforts and costs inherent to the implementation of GEOGLAM operations. This activity will take place during the initial implementation phase of GEOGLAM. During this initial phase, the data providers will continue to support the research needs of the agricultural monitoring community through the GEO JECAM task. It is anticipated that the data will be provided in-kind by the space data providers.

Activity 4-2: Development of tools, systems and guidelines

This activity includes the development of tools, systems and guidelines for the enhanced use of satellite data and the analysis of derived agricultural data products and information. This will also address the development of best practices and access to processing and analysis tools, the development of improved information products and the integration and assimilation of data from multiple satellite data streams. This will be done in close relation with Component 2 (National Capacity Development). Similarly these tools will be in-kind contributions over the life span of the initiative.

Activity 4-3: Implementation of the data acquisition strategy and dissemination process

The sustained acquisition and timely dissemination of data under GEOGLAM will require the involvement of several stakeholders through the process chain, all having respective capabilities and constraints. The challenge related to this activity will be to ensure an optimized use of data providers' resources, taking into account their existing capacities, existing policies (e.g., data sharing and licensing agreements), and any additional infrastructure and personnel resources required to ensure large-scale, long-term, and timely data availability. The implementation of the data acquisition strategy and dissemination process should be supported by both in-kind contributions and the availability of an operational budget to cover the costs inherent to the "non-native" elements of the data providers' core capabilities. The success of the activity will depend on the availability of a sustained source of funding sufficient to support the operations. The expected deliverable of this activity is a fully operational data acquisition plan and data dissemination process in support of the GEOGLAM operations. Under the responsibility of the GEOGLAM Project Office, this activity will be implemented by the Earth Observation Implementation team in partnership CEOS agencies and private sector satellite operators, to provide comprehensive near-real time data for the World's agricultural regions. Wherever possible these data sets should be freely and openly available not only to the GEOGLAM community, but also to the general public.

The costs of this activity include the provision of data, services, tools and infrastructures necessary to support the implementation of GEOGLAM. The costs should be covered by in-kind contributions, dedicated budgets of G20 member governments, and new funding from interested donor organizations.

Deliverable 4-2: Improved coordination of and availability of data from in situ agricultural observation networks and meteorological observation and forecasting networks

Activity 4-4: Increase regional and international coordination of agricultural, agro-meteorological and meteorological data. This will be done through a) regional FEWSNET/FAO/WMO/JRC/GEO workshops on data issues in targeted regions of the world (particularly East, West and Southern Africa, Central America and the Caribbean, and Central Asia); these meetings will involve agricultural services, national meteorological services, FAO and FEWSNET staff. They will explore how important in situ agricultural data and weather data is to (i) famine early warning and (ii) national crop FEWSNET and FAO processes, and they will seek to persuade the agencies and organizations to start reporting more agricultural data and meteorological stations. A goal of these meetings will be to have countries supply their supplementary weather data station observations directly to the GTS satellite or at least to FEWSNET / FAO to be used for their blended or gridded products.

Activity 4-5: Increase national coordination and coverage of agricultural, agro-meteorological and meteorological data. This will be done a) during national capacity-building workshops, where national meteorological services will be invited to ensure that weather data can be provided for national crop production estimates; b) by coordinating agro-meteorological datasets into the WMO Information System; c) through liaison with the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS), other observing systems (such as WIGOS), and other organizations that provide agro-meteorological data.

Activity 4-6: Explore the use of Numerical Weather Prediction (NWP) model outputs for use in crop production estimates and increase the coordination of weather and climate products. This will be achieved by a) developing demonstration projects to show the utility of NWP products for crop production monitoring and estimates; and b) gathering, through user workshops, user feedback in the development of climate products for agriculture, which will contribute to the Global Framework of Climate Service's vision of user-targeted climate products.

The total budget for component 4 is estimated at US\$1 million per year, not including estimates of significant in-kind and real costs for data acquisition that would be developed under Activity 4.1 in the early implementation phase of the initiative.

2.5 Component 5: Research coordination for monitoring enhancements

The purpose of the GEOGLAM Research Coordination is not to undertake basic research, but to provide cross-cutting coordination to drive the course of future enhancements in national and global operational agricultural monitoring systems. As such, component 5 will help guide future improvements to Global and National level monitoring systems, while informing the in situ and satellite coordination activities.

Research coordination will be achieved through the networking of existing research and experimentation efforts and the leveraging of work underway in the GEO Joint Experiments for Crop Assessment and Monitoring (JECAM). Coordination activities will result in the development of operational prototypes, standards and best practices that will establish the technological foundation for continual improvement of GEOGLAM outputs. The objective of this task is to transition selected existing state-of-the-art agricultural monitoring research undertaken by the international community to the operational environment to enhance GEOGLAM.

The JECAM network should include more countries at risk where feasible. A Mali site has recently joined JECAM but will require external support to be effective. If support for additional sites can be set aside, this could provide a mechanism to capture Mali's requirements in the development of component 5 standards and best practices.

Deliverable 5-1. Data needs documentation

Activity 5-1. Understanding the mix of agricultural practices and satellite data needs.

While there is great convergence in agricultural monitoring needs globally, the variability in landscape, climate and cultural practices results in a complex mix of satellite data needs. The GEO JECAM project currently consists of 16 research sites distributed around the world, representing most of the major agro-ecosystem types. Since 2011, JECAM has been working with CEOS to develop coordinated satellite data acquisition to support the network of JECAM research sites. This coordination effort provides, in effect, a prototype for the GEOGLAM initiative, and it provides useful insight on data requirements. The objective of this deliverable will be to leverage our understanding of JECAM data requirements to feed in to and support the definition of data requirements for GEOGLAM. The output will be a JECAM data-requirements report prepared in advance of activity 4.2. This deliverable is cross-referenced with Deliverable 4.1 and activities 4.1 and 4.2.

Deliverable 5-2. Standards and Best Practices

The GEOGLAM monitoring system of systems will be based on the best available science and technology. However, it must be recognized that science and technology are moving targets and that the creation of an operational GEOGLAM will require ongoing improvements based on emerging research and ever-improving satellite data streams and in situ data networks. The objective of this deliverable is to develop standards and best practice documentation that captures the current state of agricultural monitoring research and technology. These documents will be cross-cutting and supportive of other national and global monitoring initiatives and capacity-building tasks. The work will be achieved through thematic workshops and the results of collaborative studies that integrate existing applied agricultural monitoring research around the world. The workshops will bring together the JECAM research community and additional thematic expertise as required. Where required, GEOGLAM will also develop supporting studies, including literature reviews and discussion papers. The workshops will be held alongside planned JECAM events to increase cost effectiveness. A preliminary list of potential thematic workshops is provided below as deliverable 5-2 activities. It is anticipated that this list will evolve based on the emerging needs and priorities of GEOGLAM:

Activity 5-2. In situ data collection and minimum datasets (cross referenced to and supporting deliverable 4-2).

Activity 5-3. Best practices; optical Earth observation methods for agricultural monitoring (cross referenced to and supporting deliverables 2-2 and 3-1).

Activity 5-4. Best practices; Synthetic Aperture Radar (SAR) Earth observation methods for agricultural monitoring (cross referenced to and supporting deliverables 2-2 and 3-1).

Activity 5-5. Level 2, level 4 Earth observation data product standards (cross referenced to and supporting deliverable 4-1).

The budget for this cross-cutting coordination activity is US\$ 600,000 per year for: 1) workshops (including annual JECAM and focused thematic meetings); 2) collaborative studies focused on thematic priorities, and 3) documentation of standards and best practices.

2.6 Component 6: Data, products and information dissemination

Data and information dissemination are at the core of the GEOGLAM initiative. GEOGLAM will strongly promote timely and open sharing of the data, products and derived information from all four components.

A wide variety of data and information from multiple sources are required to effectively monitor the diverse range of agricultural systems at sub-national, national, regional and global scales. These data range from satellite and agro-meteorological observations, to cultivated-area maps, crop calendars, crop models, crop statistics, and soil-moisture measurements. Where possible, access to GEOGLAM data and information will be made openly available, recognizing that data generated through the national capacity-building component will be subject to national data policies.

GEOGLAM ~~is working~~intends to work with the satellite data providers (primarily through CEOS), the national and international agricultural monitoring agencies, meteorological agencies, and researchers to implement a phased, coordinated data and information dissemination approach.

Deliverable 6-1: Consistent data, products and information strategy.

Activities here include:

Activity 6-1: Developing a detailed inventory of data (input, intermediate and output data) and methods currently available from the existing agricultural monitoring systems. These include Earth observation data streams, derived Earth observation crop indices, in situ agricultural data and crop-condition metrics, data processing chains, analysis tools, crop maps and calendars, sub-national level statistics, crop-growth models, crop-area estimators, and meteorological station data.

Activity 6-2: Developing data processing standards, protocols and related metadata that enable the inter-use of data from various platforms.

Activity 6-3: Working with the Earth observation data providers to develop, in coordination with component 4, a centralized and/or distributed data distribution system for dissemination of the Earth observation data required by GEOGLAM. The distribution mechanism for the Earth observation data streams, in particular the high-resolution datasets, depends strongly on negotiation of agreements with the space agencies and commercial data providers. Emphasis will be placed on timely data access and open data policies.

Activity 6-4: Holding training workshops on model and data use, in coordination with component 2.

Activity 6-5: Disseminating crop condition outlooks through AMIS.

Activity 6-6: Disseminating crop production forecasts through AMIS.

The budget for this cross-cutting data and information dissemination activity is estimated at US\$250,000 per year for 1) developing a detailed data/tools inventory; 2) training workshops on methods/model and data use; 3) development and implementation of data processing standards and protocols (including community workshops); and 4) development of a data and information dissemination platform and associated tools.

3 BUDGET SUMMARY

Table 1 synthesizes the required budget per component per year as well as over the six years expected duration for the initiative. It is based on the existing resources and assumes in-kind contributions from the G20 and GEO members and participating organizations.

Table 1. Summary of the budget per component (M US\$)

Component	Annual budget	6-year budget
Global /regional systems	1.00	6.00
National capacity development	2.15	12.90
Global/Regional Systems for Countries At Risk	1.50	9.00
Earth Observations Assessment (satellite and in situ)	1.00	6.00
Research Coordination for Monitoring Enhancements	0.60	3.60
Data, products and information dissemination	0.25	1.50
Coordination	1.00	6.00
Total	7.50	45.00

4 LINKAGES TO AMIS AND OTHER RELATED PROGRAMS

AMIS is one of the key stakeholders and beneficiaries of GEOGLAM. Working together, the two initiatives will develop a close and efficient collaboration, in particular by the inclusion of an AMIS secretariat representative in the GEOGLAM Coordinating Committee. Two major links are as follows:

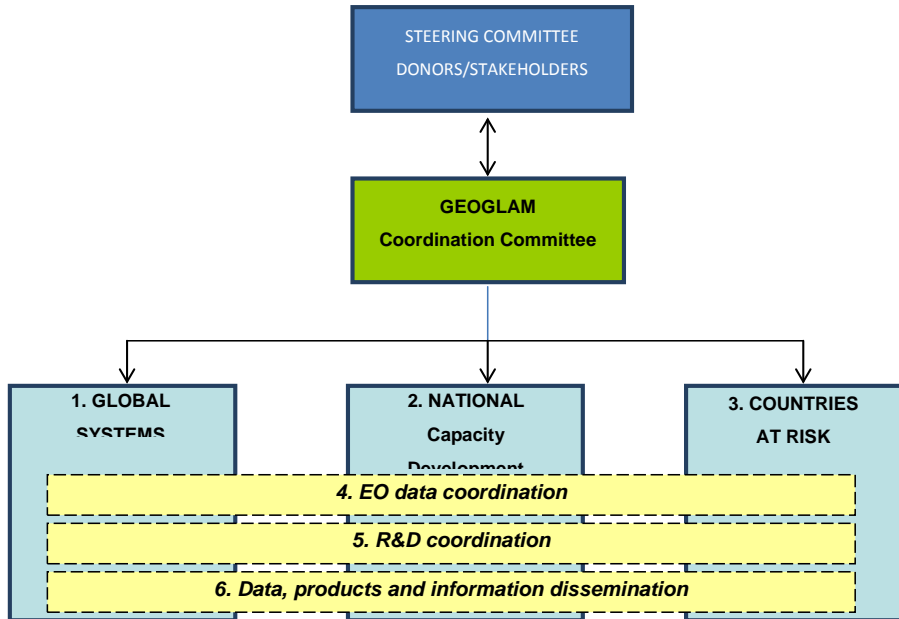
- A number of GEOGLAM deliverables are direct inputs to AMIS (see component 1) or will be better disseminated to G20+7 major producing countries through the AMIS web portal, AMIS national focal points, and ad-hoc sessions or side events at AMIS meetings;
- AMIS will contribute to defining priorities for GEOGLAM component 2 on capacity building for GEOGLAM by facilitating the availability of statistics and ground data from G20+7 countries as ~~an~~ inputs to GEOGLAM research and innovation activities.

FAO will have a specific role, both as one of the global monitoring systems (FAO GIEWS) involved in component 1 and as a contributor to all of the capacity building activities (components 2 and 3). This will ensure synergies and consistency with the World Bank's "Global Strategy to Improve Agricultural and Rural Statistics."

Component 3 of GEOGLAM, which focuses on countries at risk, will coordinate with **FAO and World Food Programme (WFP)** activities in the fields of food security early warning and vulnerability mapping, as well as with the key regional organizations according to the area of interest, such as the New Partnership for Africa Development– (**NEPAD**) or the regional economic communities (ECOWAS, IGAD, COMESA and so forth in the case of Sub-Saharan Africa).

5 THE GEOGLAM GOVERNANCE MODEL

The proposed governance model for GEOGLAM is summarized in the following block diagram. It is anticipated that the work plan will be endorsed by the G20 and adopted by the GEO Plenary.



The steering committee for GEOGLAM consists of the Executive Director of the GEO Secretariat and representatives from donors and stakeholders. Its role is to provide guidance on key issues such as objectives, budgetary control, marketing strategy and resource allocation.

The GEOGLAM Coordination Committee is formed of the task team leaders of the six components as shown above, the GEO Secretariat experts supporting the GEO Agriculture Societal Benefit Area, a Project Manager and an AMIS representative. It is chaired by the Project Manager. The roles of this group will be 1) technical coordination; 2) fund raising; 3) reporting; 4) institutional linkages; and 5) funding management and accounting.

This Committee reports to the Steering Committee for overall guidance. Being a GEO established initiative; the GEOGLAM Coordination Committee working through the Project Manager is held responsible for preparing and presenting annual reports to the GEO plenary and to the GEO Executive Committee in all its meetings or as required.