GEOGLAM Work Plan:
Asia- Rice Crop Estimation and Monitoring Component (Asia-RiCE)

version 1.0

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Cover + 38 pages

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1 Introduction and Background

1.1 Introduction

This report has been prepared by an *ad hoc* team of stakeholders with an interest in the development of an Asia-Rice Crop Estimation & Monitoring (Asia-RiCE) component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative.

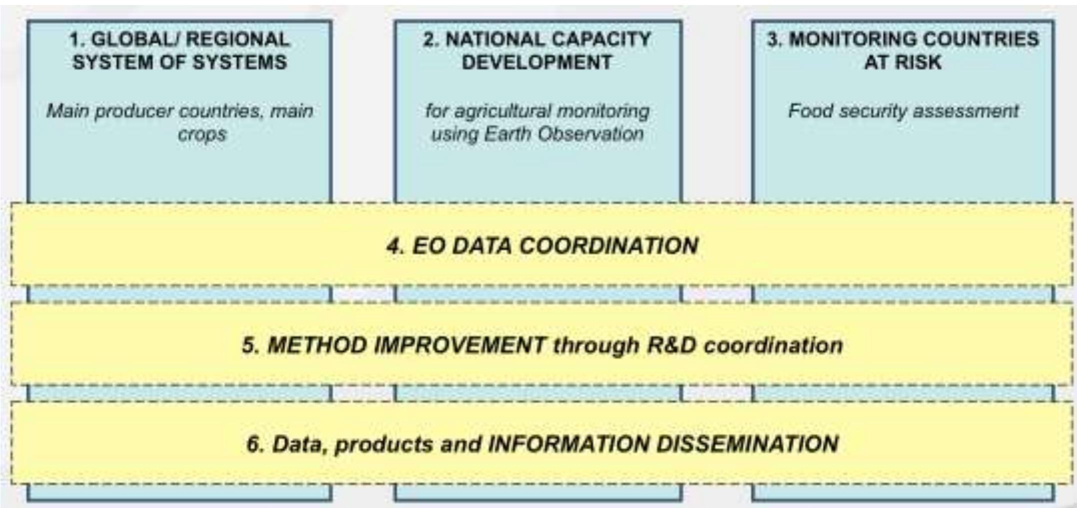
GEOGLAM

GEOGLAM 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.

GEOGLAM participants (notably the GEO Agriculture Community of Practice) have developed a high level GEOGLAM Work Plan document for the initiative that outlines the approach via 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.



The Work Plan identifies the primary activities and deliverables under each component together with the broad level of funding needed to implement them.

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 framework of GEO and the Work Plan includes a governance structure.

Importance of Rice Crop Monitoring

Rice is the staple food for more than half of humanity - with 90% of the world crop grown and consumed in Asia. Global rice production has increased continuously in the last half-century, since the Green Revolution. In the same period, the use of chemical inputs, the introduction of modern high-yielding varieties with short growing cycles, and the increased access to machinery and irrigation systems have led to a linear growth of the crop yields (+0.05ton/ha/year) according to the FAO (Food and Agriculture Organization of the United Nations 2009) as well as to an increase of the number of crops per year.

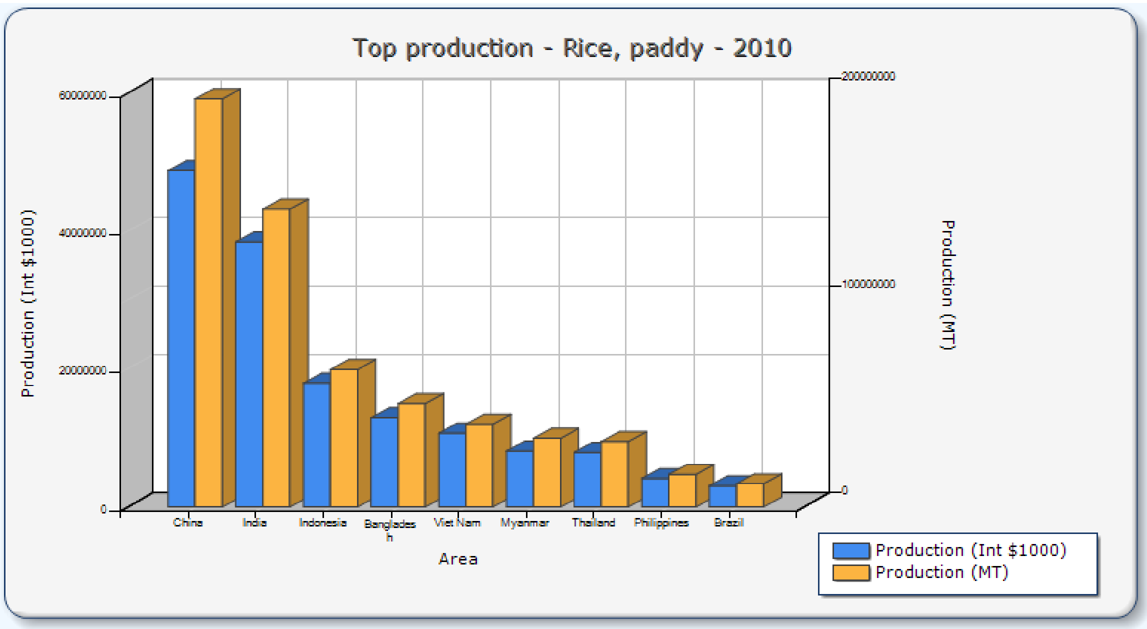


Figure 1 – Top rice producing countries by MT, 2010 (Source: FAOSTAT, http://faostat.fao.org/site/339/default.aspx)

Rank	Country	Region	Production (Gt)
1	China	Asia	197212
2	India	Asia	143963
3	Indonesia	Asia	66469
4	Bangladesh	Asia	50061
5	Viet Nam	Asia	39989
6	Myanmar	Asia	33205
7	Thailand	Asia	31597
8	Philippines	Asia	15771
9	Brazil	S. America	11236
10	USA	N. America	11027
11	Japan	Asia	10600
12	Cambodia	Asia	8245
13	Pakistan	Asia	7235
14	Republic of Korea	Asia	6136
15	Madagascar	Africa	4737
16	Egypt	Africa	4329
17	Sri Lanka	Asia	4301
18	Nepal	Asia	4024
19	Nigeria	Africa	3219
20	Lao PDR	Asia	3071

Table 1 – 2010 Top 20 Rice Producing Countries by gigatonne (Gt) (Source: FAOSTAT, http://faostat.fao.org/site/339/default.aspx)

This higher cropping intensity (from single to double or triple crop) together with the conversion of non arable land to arable land have resulted in a drastic increase of rice harvested areas in the 60s and 70s (+1.4Mha/year) which slowed down in the 80s and 90s (+0.46Mha/year) and has tended to stabilize over the last ten years as a result of approaching the limits of land use and of cropping intensity, however with a large inter-annual variability due to climatic conditions and socio-economic factors. As both the increase in yield and in planted areas will be facing limitations in the next decades, it is unlikely that rice production can keep increasing at the same rate.

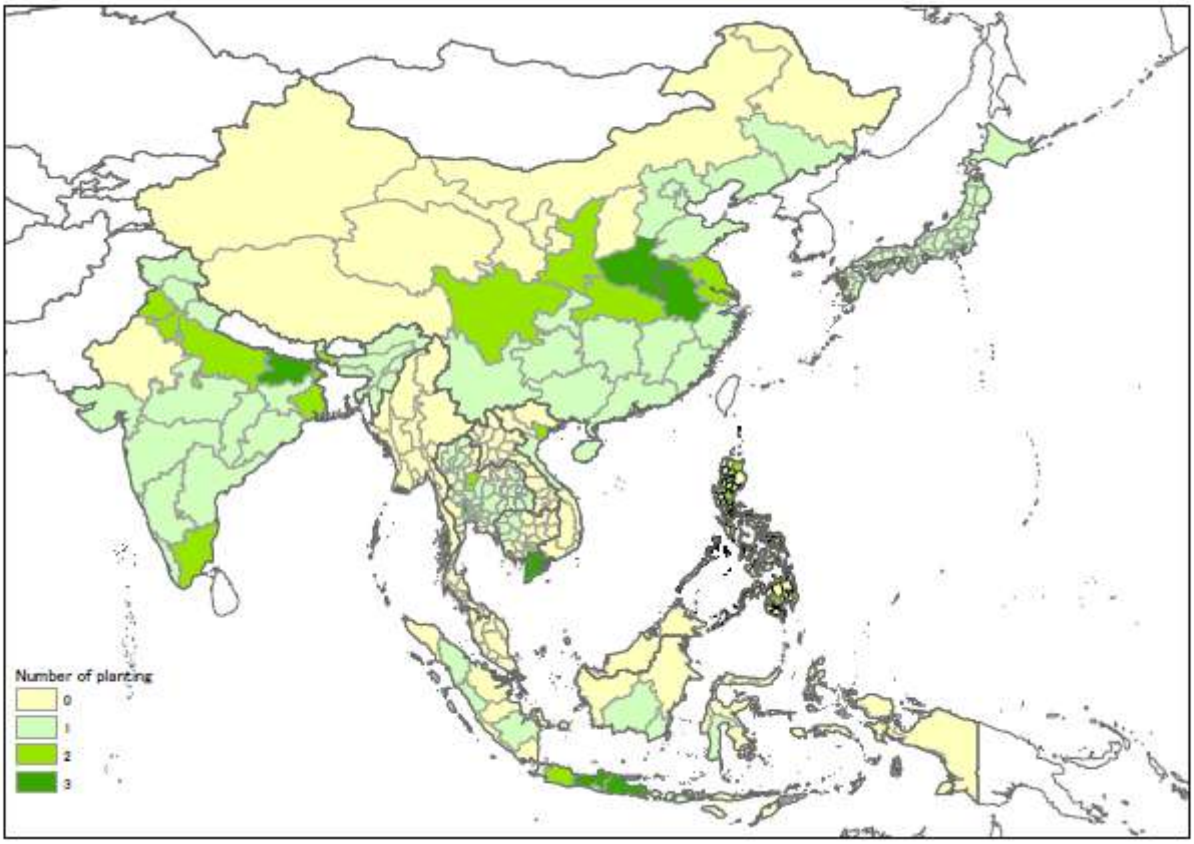


Figure 2 nA example proecut of rice cropping intensity map (cycles) in the Asian region by MODIS (Source JAXA)

Meanwhile, world population, and therefore demand for food, has increased linearly over the last fifty years (+80M/year), and is projected to keep growing until around 2050 up to 9 billion inhabitants (United Nations Department of Economic and Social Affairs, Population Division 2004). This conjuncture is prone to create tensions in food markets that could lead to world food price crises - as in 2008 when the price of rice more than doubled in only seven months - and eventually to famines. In this context of price instability and threatened food security, tools to monitor rice production in real-time are highly needed by governments, traders and decision makers.

Accurate information is needed on the spatial distribution of rice fields, water resource management, risk occurrence and annual production projections. However, most agricultural surveys rely mainly on statistics based on limited ground samplings at which data are extrapolated on a national scale. Although the census can provide statistical estimates, slow and unsystematic collection of data can limit the ability to make timely decisions.

Moreover, rice agriculture is strongly linked to environmental issues, from water management to climate change. For these reasons, longer term inter-annual monitoring is also required in order to study the production and cultural impacts of these factors. Satellite remote sensing can suppot this long term monitoring requirement at regional and global scales.

Given the importance of rice, Asian participants in GEOGLAM have formed an *ad hoc* team and taken the initiative to develop a plan for the inclusion of rice crop monitoring as an integral part of the GEOGLAM initiative.

1.2 Objectives

This document describes a work plan for the definition and development of the Asia-RiCE component for GEOGLAM. The objectives are:

- to ensure that Asian countries receive the full potential benefits of GEOGLAM, and that they are suitably engaged and prepared to do so;
- to ensure that rice crop monitoring issues are given suitable priority and attention within the scope of the full GEOGLAM initiative, including in the development of the observing requirements; and
- to establish a framework for the coordination necessary to engage, manage and support the various stakeholders.

The regional activities suggested by the Asia-RiCE Work Plan will be consistent with and undertaken within the broader GEOGLAM Work Plan and there will be a number of interdependencies and interchanges between the two Plans.

1.3 Agricultural Information Requirements

Agricultural information requirments are being gathered on behalf of GEOGLAM by an *ad hoc* group within CEOS tasked with converting the product requirements into satellite data requirements. This group participated in a GEOGLAM User Requirements meeting in July 2012, and rice-crop specific inputs to this were provided by the Asia-RiCE team.

The agricultural information needs defined by GEOGLAM cover a broad range of areas, including: monitoring and early warning systems; precision agriculture; control; and, statistical systems. These needs are summarised in Appendix A, and specific rice crop needs are summarised in Section 3.

The CEOS *ad hoc* group will translate the GEOGLAM User Requirments gathered into an analysis of the satellite scene and data volumes. The objective of this analysis will be to understand the scope and scale of the satellite data requirements. This scope and scale will then by consider by CEOS leadership, and the development of a full global acquisition strategy may be considered.

1.4 Existing and Planned Systems and Capacities

GEOGLAM will evolve as a system of systems, consistent with the overall approach of GEO in developing the GEOSS. It will leverage and coordinate existing activities and capacities wherever possible for mutual benefit of all contributing countries and programmes. The same principles and approach will apply to Asia-RiCE as a regional contribution to GEOGLAM. Asia-RiCE must connect and seek synergies with and contributions from a range of ongoing and planned activities in Asia which are relevant to its objectives.

AFSIS - The ASEAN Food Security Information System Project: Due to growing concern about food security in regional communities, the Ministers of Agriculture and Forestry of the ASEAN Member States plus China, Japan and Korea approved the Project in their meeting held in October 2002 in Lao PDR. The overall objective of the Project is to strengthen food security in the region through the systematic collection, analysis and dissemination of food security related information. The 1st Phase of the Project had a period of five years, from 2003 to 2007. It was led and coordinated by Thailand, in particular, the Office of Agricultural Economics (OAE), Ministry of Agriculture and Cooperatives. The Statistics Department (SD), Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan is the donor through ASEAN Trust Funds. Prior to the end of the 1st Phase, at the AMAF +3 Meeting in September 2005 in Philippines, the Ministers recognised the contribution of AFSIS Project to promoting the concept of regional food security and the importance of continued improvement in the details of food security data and information among Member States and regionally. Accordingly, an Implementation Plan for a 2nd Phase was prepared and endorsed by the AMAF +3 Meeting in November 2007 in Bangkok, Thailand. The 2nd Phase had a period of 5 years from 2008 - 2012 with financial support from MAFF Japan. It continued the objective to strengthen food security in the region and the main activities of the 1st Phase. The additional elements including: Early Warning Information, Agricultural Commodity Outlook and Mutual Technical Cooperation were also included in the 2nd Phase. The 3rd phase of AFSIS project plan is under discussion.

APEC food security initiatives: APEC has a range of food security objectives, including the Policy Partnership on Food formed in 2011 as the primary forum for discussing issues related to food security, the partnership brings together individuals from the private and public sector to help facilitate investment, liberalize trade and market access and support sustainable development. APEC has an Asia Pacific Food Security Information Platform website: http://www.apip-apec.com.

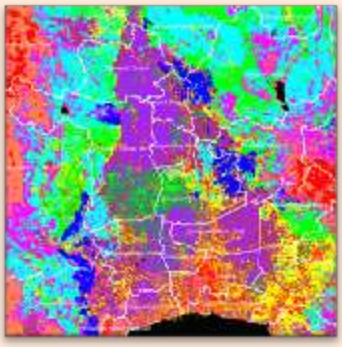
National crop monitoring systems and demonstrators are underway or planned in a number of Asian countries, including India, Thailand, China, and Indonesia; a number of bilateral development programmes are underway to explore the operationalisation of radar, optical, and passive microwave satellite data, including collaborations between Japan and Thailand, Vietnam and Indonesia.

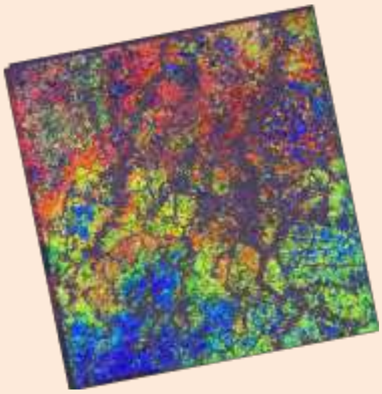
Japan's space agency (JAXA) develops and operates a web-based Earth observation information dissemination system to provide agro-weather information such as drought index, rain fall, solar radiation, land surface temperature, using Japan's satellites (GCOM-W1, TRMM, MTSAT) and others in cooperation with University of Tokyo as a one of ASEAN+3 Ministry of Agriculture and Forestry (AMAF) new project. This proposed agro-weather information system will be utilized for drought early warning not only in Indonesia and Vietnam but also in other ASEAN countries.

The goal of Asia-RiCE is to coordinate the evolution of a system of systems which will be greater than the sum of the individual parts and which will help sharing of know-how, develop capacity and support region-wide capabilities that reflect the inter-dependent nature of the food price and security challenges.

Rice Crop Monitoring in Thailand

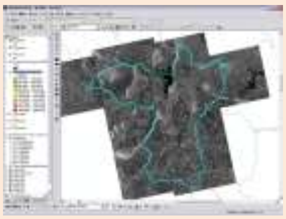
Recent work by GISTDA aimed to show the value of THEOS/ALOS data for agriculture monitoring. Target areas were chosen in Suphan Buri , Khon Kaen, and Roiet and data from ALOS, THEOS, RADARSAT, GSMaP, AMSR-E, MODIS and in-situ measurements were collected. In addition, automated 'field servers' were used to collect long time-series of data in-situ, including images of crop height for high temporal-resolution comparisons with satellite data. MODIS imagery was successfully used to produce maps of multi-crop types in central Thailand. RADARSAT-2 was used to produce a fine quad polarization map of Suphan buri that displays variations of planting date (Red – December 2010, Yellow – January 2011, Blue – February 2011). A nationwide system for rice crop yield estimation is currently under development by GISTDA and JAXA, with preliminary accuracies around 81% in the Khon Kaen area.

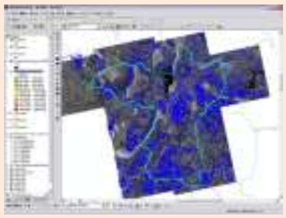




1. SAR data

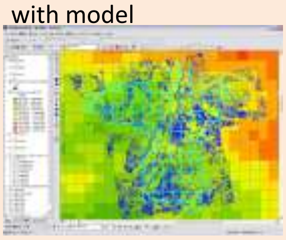
2. Cultivate area estimation

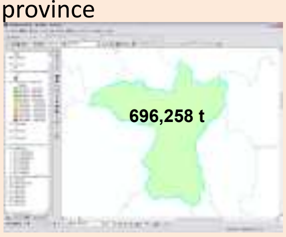




3. Derive yield per unit with model

4. Calculation of rice crop yield in a province





1.5 Stakeholders

A broad range of stakeholders are of relevance to the challenges being address by Asia-RiCE:

– **National governments** and their agencies responsible for their various rice crop monitoring and food security systems and capabilities;

– **Regional intergovernmental coordination bodies** with ambitions in this domain, including ASEAN and APEC;

– **Remote sensing organisations** and their coordination groups that can support supply of the necessary space data – these including the space agencies of Japan, China, India, Indonesia, Korea, Thailand, Vietnam and others; as well as the the regional space agency forum APRSAF and the international Committee on Earth Observation Satellites (CEOS) and its Space Data Coordination Group (SDCG);

– **FAO** and their regional activity groups; and

– **Key donor organisations**, global (World Bank), regional (ADB), and national (eg JICA and AusAid).

Participation in the *ad hoc* team which has developed this Work Plan has been predominantly by national implementing agency representatives. However the intention is to ensure that the full spectrum of stakeholders are engaged in the implementation of the Plan. Appendix D details current membership of the *ad hoc* team.

1.6 Contents

Section 2 provides more detail on the GEOGLAM work plan, and the roles of GEO and the G-20. It explains the future development and implementation schedule – as important context for the rice crop component – and how the rice crop activities will be integrated in the overall Work Plan.

Section 3 defines the information requirements related to rice crop monitoring. It discusses rice crop areas and calendars, the target products and services – and the associated requirements for data, analysis and GIS. Candidate sources of suitable space data are identified, and the role of other coordination bodies is explained.

Section 4 is the Work Plan for the Asia-RiCE component for GEOGLAM, and **section 5 discusses management**, resources, and scheduling.

2 GEOGLAM Work Plan

2.1 Background and Overview

The GEOGLAM Work Plan is a high level living document focusing on components and tasks to be undertaken within the GEOGLAM initiative and includes an estimate of the necessary level of funding to implement them. It was developed by the GEO Agriculture Task Leads, supported by the GEO Secretariat, and reviewed by the GEO Agriculture Community of Practice.

2.2 Roles of G20 and GEO

At a meeting of G20 Agriculture Ministers in Paris in June 2011, an action plan on food price volatility and agriculture was agreed. In this plan, the G20 endorsed a new initiative, the "Global Agricultural Geo-Monitoring Initiative". Following further consultation and coordination with GEO, this became known as the GEO Global Agricultural Monitoring Initiative (GEOGLAM).

The goal of GEOGLAM is to "reinforce the international community's capacity to produce and disseminate relevant, timely and accurate forecasts of agricultural production at national, regional and global scales" with the overarching goal to improve operational global and national crop production estimates using Earth observation data. This will be achieved by: 1) enhancing national agricultural reporting systems, including through a global remote sensing and geo-spatial education curriculum to ensure training of participants worldwide; 2) establishing a sustained international network of agricultural monitoring and research organizations and practitioners; and, of most relevance to space agencies (i.e. CEOS), 3) creating an operational global agricultural monitoring system of systems based on both satellite and in situ observations.

The initiative outlines the desired linkages with the 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.

GEOGLAM continues to develop under Mexico's 2012 G20 Presidency, which includes a priority focus on "Enhancing food security and addressing commodity price volatility...". Its first draft Work Plan was be provided to a G20 Agricultural Preparatory Meeting of experts in Mexico in April 2012, detailing GEOGLAM's planned implementation structure, deliverables, and governance can be found in this document.

2.3 Future Development and Implementation Schedule

The budget in the GEOGLAM work plan outlines spending of $US 45M over a 6-year timeframe. In mid-2012, a Project Manager (Pascal Kosuth) was appointed, and is also serving as Chair of the GEOGLAM Coordinating Committee. This committee is expected to further detail the timeframe for the development of GEOGLAM, and the Asia-RiCE initiative will be developed in coordination with this group.

2.4 Incorporation of Rice Crop Content and Activities

As with all GEO initiatives, GEOGLAM seeks to develop a system of systems and fosters coordination on all geographic scales. Asia-RiCE seeks to ensure a well managed regional focus for Asian engagement in GEOGLAM and to ensure that the region's most important crop, rice, is well represented in the characterisation and development of the capabilities underpinning GEOGLAM. In addition, the Asia-RiCE team intends to share its knowledge and expertise through the GEOGLAM framework.

A number of participants in the Asia-Rice *ad hoc* team are engaged in the broader GEOGLAM activities and participate in the calendar of meetings, and will take the opportunities that present themselves to report on progress as Asia-RiCE evolves and to feedback broader GEOGLAM developments to the Asia-RiCE community. However a more formalised interface is envisioned to ensure an efficient interface between GEOGLAM and Asia-RiCE, utilising a regional sub-committee to manage the interface and responsible reporting to the GEOGLAM coordination committee. Further details are explained in section 5. The mechanics of interfacing the Asia-RiCE Work Plan with the broader GEOGLAM Work Plan must be explored to ensure an effective and mutually supportive relationship.

Rice Crop Monitoring in the Mekong Delta Vietnam has been using SAR data from ERS-2, Envisat, and TerraSAR-X to map rice-cropping areas and estimate crop yields, with the goal of creating an operational system for continued rice crop inventory in the Mekong Delta, Vietnam. A test site has been selected in An Giang, an area that is heavily affected by flooding and consists of multiple different crop cycles per year. Envisat ASAR APP and Terra-SAR-X SM data has resulted in highly accurate planted rice area maps and estimates of rice yield and production have been made using multi-linear regression analysis, with reasonable accuracy.

3 Rice Crop Monitoring Information Requirements & Data Supply

3.1 Rice Crop Areas and Calendars

One of the key variables in the development of a monitoring strategy for Asian rice crops is the location and timing of crops across the region. There are several characteristics of the Asian rice growing region which distinguish it from other crop types, and other rice growing regions around the world:

- Multi season crop;
- Variable crop calendar within a season and an area;
- Diverse growing practice and co-existence with other crop types;
- Water resource dependency (water stress – irrigate, rain- fed); and
- Rainy season growth (cloud cover).

There is a lot of variation and the size of rice paddies between provincial and national cropping areas, ranging from less than 1,000,000 ha to greater than 30,000,000 ha. This includes both mono and mixed cropping patterns, and no standard crop yield information collection method covers the range. It is important to note that while most countries have a range of paddy field sizes, most of them do have large synthetic rice growing area or region, even if each individual paddy is small.

The typical growth cycle for Asian rice crops is 85-150 days, and many rice growing regions produce two or three crops a year. During a typical 120 day growth cycle, 4-5 satellite observations are generally required in order to achieve all monitoring objectives, and it is especially important to have observations at sowing and harvest times.

Main rice in Asia is cultivated in the rainy season, which drives the need to ensure coverage in the cloudy, rainy areas because of Monsoon season. The time of year when rice is grown across the Asian region also varies significantly, which means that detailed rice crop calendars by regions in a country will be required. In the rrigated riceecosystem, the rice fields require water supply for one or more crops a year. Irrigated covers a land area of 36 M ha in Asia and accounts for ~50% of global rice production. The main agronomic problems encountered in these intensive rice cultivation systemsare i) yield instability due to pests, ii) inefficient use or shortage of irrigation water, iii) misuse of fertilizers and pesticide, iv) The rainfed rice is characterised by its lack of control over the water and , frequently suffers severe damage induced by drought and floodMonitoring of rice growth and good early warning systems are required in both cases.

The Asia-RiCE team is working to provide the best available crop area maps and calendars to support the development of a global acquisitions strategy for GEOGLAM. These inputs are being provided to the CEOS *Ad Hoc* group on GEOGLAM, who are performing a volumetric analysis of observational requirements in order to assess potential future acquisition planning.

The top rice producing countries in the world are show in Figure 1, and summarised in Table 1.

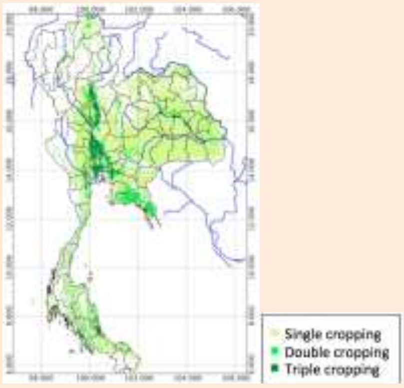
While detailed national rice crop maps and calendars are being sought, in cases where this information is not available regional rice crop, or global crop masks are being used. Inputs have been received from several key rice producing countries to date.

Country	Crop Area	Crop Calendar
Indonesia	– Crop area shape files for Indonesia at 500m – Crop area and calendar shape files for Java Island	
Vietnam	– Rice Crop Shape File	– Mekong Delta – Red River Delta
Thailand	– *Under development*	– *Under development*
India	– *Under development*	– *Under development*

Table 2 – Asia-RiCE Crop Area and Calendar Status (October 2012)

The Asia-RiCE team is working to provide consolidated rice crop area maps and calendar files to the CEOS and GEOGLAM community in a workable format (i.e. shape files) and will support those groups ensuring that full account of the unique requirements of rice crops are reflected. This product will initially be based on information provided by the USDA, and will be refined as required and as the information becomes available.

Rice yield estimation requires knowledge of cropping calendars. As rice crop calendars vary substantially over very small areas, it is necessary to have spatially high-resolution maps detailing this information. As recent studies by JAXA have shown, satellite data can be used to derive high-resolution crop calendar maps on nationwide scales. A 10-year sample of Normalized Difference Vegetation Index (NDVI) time-series data from MODIS (MOD13) was used to identify the crop calendar in all regions of Thailand. Spectral analysis techniques identified the number of cropping cycles per year and the results were mapped, as shown below. High-frequency NDVI measurements from satellites can be used to identify the crop calendar over large regions and also allow for anomalies due to meteorological conditions to be accounted for in rice yield estimations.



3.2 Target Products and Services

The core information requirements of the GEOGLAM initiative as a whole are determined by the Agricultural Market Information System (AMIS). The CEOS *Ad Hoc* group on GEOGLAM has developed a series of target information products upon which it is basing its observational requirements which is included in Appendix A.

In addition to AMIS requirements, the Asia-RiCE team is working to define the necessary observational inputs to support a variety of other data products required to forecast and monitor rice crop across Asia.

Product	Description
Crop Calendars	Timing of sowing, planting, growing and harvesting and growing status
Rice Paddy Field Maps	Cultivated area (every year) Inventory of agricultural facilities Planted area progress (every month) per Season
Early Warning	Agro- meteorology anomaly (e.g. drought,

	extreme high / low temperature,) Crop growth anomaly
Yield Estimation* and Yield Forecasting	Empirical-statstical model estimate Crop-growth simulation model estimate
Damage Assessment	Detection of flooding and other disaster impacted area Agro-meteorology Detection of drought or innundated area Detection of diseased plants, pest and diseased infestation

Table 3 – *Target Rice Crop Products (* required by AMIS)*

The Asia-RiCE team will work with GEOGLAM and AMIS experts to define the required reporting formats for the various rice crop products being developed.

3.3 Data Requirements

The information products required are being translated into remote sensing data requirements by the CEOS *Ad Hoc* group on GEOGLAM, supported in the case of rice crops by the Asia-RiCE team. The full table of satellite EO products that the *Ad Hoc* group is considering can be found in Appendix B.

These EO derived information products have been translated into satellite observational requirements which are summarised in Appedix C. While a number of data requirements apply across crops globally, requirements for SAR data are specifically related to rice crop monitoring.

Requirement	Derived Products	Coverage
50-150 m SAR dual pol. (C,L, (X))*1 per season main crops NRT products (SS/PS)*	Croplands mask Crop type area Crop Cond. Indicators Crop bioph. var. (LF, MF, SF1) Env. variables Ag. Practices /cropping systems Crop Yield	Large/Medium/Small Fields – all L Crop types diversity – rice area Calendar/Multiple cropping – entire growing seasons Cloud Coverage – high
5-20m SAR dual pol. (C,L, (X))[1] per season main crops NRT products (SS/PS)*	Crop type area Crop Cond. Indicators Crop bioph. var. Env. variables Ag. Practices /cropping systems	Large/Medium/Small Fields – L/M/S Crop types diversity – rice area Cloud Coverage – high

[1] X-Band SAR is powerful to estimate rice crop area, but may not be suitable for the estimation of rice crop growth as it saturates under heavy cloud / rainy conditions and rainfall covers large portions of the rice growing regions of Asia.

Table 4 – SAR Data Requirements for Rice Crop Monitoring

3.4 Satellite Data Sources

There are wide variety of satellite data sources required to support the rice crop monitoring component of GEOGLAM. Some of these satellite data sources house overlap with other cross types covered by GEOGLAM, for example wheat and other cereal crops, and corn. However, additional Asian rice crop requirements are driven by Asian conditions (i.e. rain) as well as crop configurations and geometries, and are unique to the region.

A preliminary set of optical and radar instruments of interest, along with some example missions, are listed in Appendix E.

3.5 Rice Crop Sampling Plan

To gather crop statistics over large areas on continent and global scales at the resultions described in Table 4 will require the use of a sampling approach. Members of the Asia-RiCE team have experience in the design of rice crop sampling plans which are based on a stratified random approach, which can use thematic maps derived from satellite image as the main source of information for stratification. The Large Area Crop Inventory Experiment (LACIE) conducted jointly by United States Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) was one of the pioneering experiments that demonstrated the feasibility of timely assessment of crop production using satellite data and a sampling scheme

Stratification of territories with remote sensing is generally cost-efficient because the same stratification can be used for several years. Existing land cover maps derived from Earth observation data often allow adequate accuracy. For crop area estimation, crop masks can be regarded as a particular case of stratification. The Crop Acreage and Production Estimation (CAPE) project (1984-2005), and FASAL project (2007 onwards) of India are examples of operational projects which used Earth observation data to gather multiple forecasts of the production of major crops at national level uses a sampling method. In this example, a sampling grid of 5 x 5 km was used, and was underpinned by agricultural stratification maps derived from MERIS data.

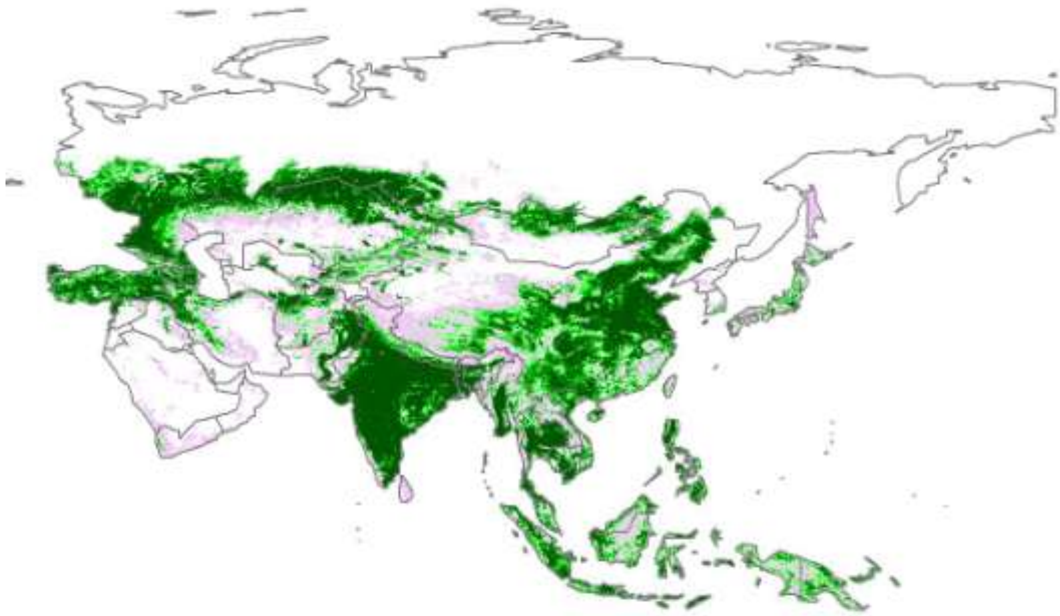


Figure 3 – Asian Agricultural Mask Generated Using MERIS Data December 2004 to June 2006 (Bicheron et al. 2008).

3.6 Image Analysis and GIS Requirements

The processing of rice crop observations into the necessary GEOGLAM, AMIS and other national/regional food security systems products will require specialised image analysis tools – largely because many of the obsevations specified for Asian rice crops require SAR data, in combination with optical and passive microwave data. In addition, a spatially explicit GIS database is required to estimate rice crop cultivated, and to represent those estimates visually. These tools need to take into account topography, land usage and other socio-economic information. They will also need to be able to integrate ground based *in situ* observations which are required inputs for rice crop growth models.

The integrated use of these tools will be very important to support visualizations of the cultivated area, and also to aggregate derived rice crop growth and yield information. To encourage wide spread generation of geospatial products, and to empower users, freeware tools should be used wherever possible.

In addition to making the required tools available, the work plan will need to consider capacity building workshops and other activities. This should also include the development of an Asia-RiCE community to facilitate knowledge sharing between participants. Capacity building activities will need to address not just the use of specialised GIS tools, but also details of satellite data processing, including advanced SAR processing techniques.

It is likely that because of the broad set of skills required to generate agricultural products, both tools and capacity building activities will need to be integrated with a number of different branches of government. The required branches would need to be identified as a part of a more detailed capacity building plan, but might include those responsible for land-use information, agriculture, as well as space and/or satellite operating agencies.

The capacity building plan should also take into account existing capacity building activities offered by agencies such as the United Nations (FAO, WMO, ESCAP), APEC, MRC, and satellite operating agencies like JAXA and USGS.

3.7 Communicating Requirements to the Community

The observational requirements developed by the Asia-RiCE team have been communitated to the GEOGLAM community, as well as the space community through CEOS. While CEOS does not currently have a formal role in support of GEOGLAM, CEOS has created an *ad hoc* group on GEOGLAM. This group is working with GEOGLAM to help translate its observation requriements to remote sensing language – and the Asia-RiCE group has communicated its observational requirements to the space community thorugh this channel.

At this time, the CEOS *Ad Hoc* group is not developing a full fledged global observations strategy, but is gathering information on behalf of CEOS on the volume and cost of data required to support GEOGLAM. They will report this information to CEOS leadership in March 2013, and will include a recommendation on next steps (if any) in CEOS support to GEOGLAM.

Should CEOS decide to formally support GEOGLAM, it is likely that the CEOS Space Data Coordiantion Group for GFOI (SDCG) would be engaged. The SDCG was established by CEOS to interpret the data requirements of the Global Forest Observations Initiative (GFOI), and develop a global obsevation strategy in response. Should CEOS agree to support acquisitions for GEOGLAM, the SDCG may be asked to expand its remit to include support for GEOGLAM (and by extension, Asia-RiCE).

Another important consideration for the engagement of both CEOS and the SDCG by GEOGLAM is that neither was setup to support operational initiatives. So if GEOGLAM (and Asia-RiCE) are to transition to an operational mode, the data coordination framework will need to be revisited.

In addition to the global coordination efforts being undertaken by CEOS and the SDCG, the Asia-RiCE group should also consider how to ensure good coordination of regional data streams. A number of key rice crop monitoring stakeholders (eg China, India, Japan, Thailand) operate significant satellite observing systems, and best use of the systems should be made where possible. There are potential roles for existing regional organizations like APRSAF facilitating regional coordination, including through activities like the APRSAF Climate Regional Readiness Review (Climate R^3) – which included a Food Security topic during its May 2012 workshop.

3.8 Technology Demonstrator Sites

In order to further develop and validate the data requirements, and to validate information accuracy and usefulness of SAR and other EO data for Asia-RiCE, a series of technology demonstrator sites are proposed. The scale of these demonstration sites should be approximately 100x100 km, or match the scale of the nearest appropriate administrative unit (i.e. provincial scale). Initially 5-7 sites from different countries should be established, ideally covering Asia-RiCE countries of interest such as Thailand, Indonesia, Vietnam, Phillipines, Lao P.D.R., India, and China. In future, the number of sites may be expanded to include Mekong River countries such as Cambodia, Myammar, as well as Banglaesh and Malaysia.

The main activity of these sites will be to execise product methodology and generation processes using both satellite and ground data streams. Satellite data streams might include:

- ALOS-2/PALSAR-2, RADARSAT-2, RISAT-1;
- Archived SAR data such as ALOS/PALSAR, ENVISAT; and
- Freely available optical sensors including MODIS and LANDSAT.

The provision of these data streams will need to be coordinated with the operating space agencies under the APRSAF Earth Observation Working Group, CEOS Space Data Coordination Group (SDCG), or other appropriate international coordination framework. The collection of ground-based data streams and statistical information will need to be coordinated with the appropriate national/regional agricultural and/or statistical authorities.

Information such as rice crop area, rice crop yield, and crop calendars should be verified using satellite and other data streams, and presented at an Asia-RICE team meeting or appropriate international conference. In addition, the results should be studied with a view to expanding rice crop area, yield and crop calendar estimation from a provincial level to the entire coutry to provide the results to national, regional and global systems such as FAO AMIS, AFSIS, etc.

The objective of these activities will be to refine and validate the Asia-RiCE data requirements. Where available, opportunities should be taken to showcase the results generated, including presentation in agricultural and EO forums and conferences such as ACRS, GEOSS-AP, APRSAF, etc. The development of these demonstrator sites should be aware of, and coordinated with any other projects and/or funding arrangements which may be ongoing or being developed in cooperation with national/regional donor agencies.

It should be a longer term goal for the Asia-RiCE team to build on these technology demonstration sites to create activity covering the cropping areas of a whole country. However, it is recognised that the most practical approach is to start with a series of demonstration sites.

An example definition of a Technology Demonstartor Site can be found in Appendix G.

4 Work Plan

4.1 Introduction & Overview

This section describes the Work Plan proposed for the definition and implementation of the Asia-RiCE component of GEOGLAM. The Work Plan aims to:

- provide a framework for the effective participation of Asian countries in GEOGLAM and to ensure that the benefits of GEOGLAM flow to the region;
- ensure representation of rice crop issues within GEOGLAM;
- provide a new focus for the underlying R&D and technical progress related to rice crop monitoring; and
- similarly, provide a new focus for regional data providers to engage and better coordinate data supply.

The proposed Work Plan is structured to be consistent with the broader GEOGLAM Work Plan and its six components; it is important that the rice crop component be fully compatible with and supportive of the GEOGLAM plans and not be in competition or conflict with it. Consistent with the GEO principles, the Work Plan also seeks to make best use of existing structures, activities and systems. Where relevant, the Work Plan will seek to coordinate regional inputs and versions of the main deliverables foreseen by GEOGLAM.

The description below follows each of the six components foreseen for GEOGLAM in order to mirror the GEOGLAM structure.

4.2 Component 1: Regional Rice Monitoring System of Systems

The relevant GEOGLAM component focuses on the major grain crops (wheat, maize, rice and soybean, total grain) for the G20 + 7 countries covered by AMIS, and aims to provide enhanced, improved and timely production forecasts to AMIS based on existing global monitoring systems, and in due course regional monitoring systems.

The rice crop component will focus on:

Activity 1-1, Development and maintenance of Asian rice crop geo-dataset: Effort is already underway to establish rice crop area and calendar information and this dataset will continue to be developed and maintained to be as comprehensive as possible. As required, the data will be expanded with information specified in the GEOGLAM plan including information on crop management (fertilization, pesticide, irrigation, etc), soil moisture, historical statistics on area and yield etc.

Activity 1-2, Ensuring regional & national monitoring systems are engaged in GEOGLAM and supporting AMIS: Recognising the significant benefits of proper engagement with GEOGLAM, existing and proposed activities of bodies such as APEC and ASEAN will be identified and connected with the GEOGLAM effort, and the regional coordination team in particular. Inputs and contributions to AMIS will be coordinated on a regional basis and inter-comparison studies of different global monitoring systems supported as appropriate.

Suitable connections and synergies with the ASEAN+3 Food Security Information System (AFSIS) project will be of particular interest. As will agro-meteorological information projects ongoing under Asian Development Bank (ADB) funding.

The leading national rice monitoring capabilities and activities will be identified and consulted, including those in Japan (and work with Thailand and Indonesia on use of SAR, MODIS, GCOM-W1, etc), India, China, and others. National monitoring system capability is essential for the system of systems approach and significant effort should be invested in support of information exchange and capacity building, as well as in methods and guidance to ensure systems are consistent and comparable.

A series of coordination and consultation events will seek to ensure good regional and national engagement.

Activity 1-3, Establish and operate a technology demonstration sites for Rice Crop:

The technology demonstration sites will be operate with the expectation that they will seek collaboration with the Joint Experiment for Crop Assessment and Monitoring (JECAM) which is an initiative of the GEO Agriculture Community of Practice and can be considered to be a testbed for techniques and coordination processes in support of GEOGLAM.

4.3 Component 2: Capacity Building

This component focuses on supporting national and regional institutions willing to develop agricultural monitoring capacities through the use of Earth observation and modeling. The Work Plan comprises a series of tasks to develop regional contributions to the relevant GEOGLAM deliverables:

Activity 2-1, Asian Rice Crop Monitoring Inventory: A regional inventory of actors, institutional frameworks, and national programmes using Earth observation in support of rice crop monitoring will be developed.

Activity 2-2, Apply GEOGLAM national capacity assessment methodology: GEOGLAM will develop and implement 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. The rice crop component will coordinate the application of this methodology, when available, to key rice crop monitoring countries in the region.

Activity 2-3, Establish capacity building priorities and promote funding opportunities: An assessment is required to determine which national systems are most likely to represent the regional building blocks of a system of system for Asia-RiCE. This should include assessment of which areas require most support and capacity building – and a set of priorities developed for collaboration and funding efforts.

Activity 2-4, Promote regional uptake of GEOGLAM-developed guidelines, standards and best practices: This activity will promote and educate regional stakeholders regarding the GEOGLAM synthesis documents of standards and best practices in support the development of national crop monitoring capabilities. Regional workshops and training sessions will help the promotion and uptake of the GEO guidelines.

4.4 Component 3: Regional System for Countries at Risk

This component focuses on engagement of and support to ongoing political processes aimed at establishing early warning information systems for countries at risk in the region. In particular the ASEAN+3 AFSIS has ambitions for the provision of Early Warning Information (EWI) through its proposed Network Centres. This component will ensure connections exist between this and the GEOGLAM effort to guarantee the necessary flow of information required for sustained and reliable early warning capabilities.

Activity 3-1, Early Warning capability development: This activity will establish engagement with existing regional efforts, in particular AFSIS and ensure that GEOGLAM and the Asia-RiCE component is suitably connected.

4.5 Component 4: Regional Coordination of Earth Observation Supply

The primary focus of GEO is to coordinate satellite and in situ observations for societal benefit. The objective of the GEOGLAM initiative is to increase the use of Earth observations to improve operational agricultural monitoring. The rice crop component work plan will focus on reinforcing regional coordination mechanisms for the supply of the necessary observations, and on ensuring engagement where necessary with the broader international efforts.

Activity 4-1, Strengthened regional space data coordination: The Asia Pacific Regional Space Agency Forum (APRSAF) is the most established of the space data related coordination mechanisms in the region. It has some heritage of success of promoting coordination of the space data assets of member countries in Asia in support of common challenges – such as for natural disasters (Sentinel Asia) and environmental applications of relevance to GEOGLAM (the SAFE initiative of APRSAF). Asian space agencies do not otherwise have a strong track record of coordination of their EO satellite programmes – despite having an increasing number of technically capable satellite systems. The regional rice crop monitoring work plan represents an opportunity to challenge APRSAF to establish itself to undertake improved coordination of space data in support of regional challenges and ambitions. This activity will explore the potential of APRSAF and other bodies to strengthen these practical coordination functions for common benefit, and will work directly with the main supply countries of India, China, Japan, Korea and Thailand, Vietnam to secure their governmental support for this purpose.

Activity 4-2, International engagement for space data coordination: The rice crop team will engage with the CEOS Space Data Coordination Group (SDCG) and other key coordination bodies to supplement the regional data sources and ensure necessary acquisition capacity is available, using EO satellites of US, Europe and others as available.

Activity 4-3, Development of rice crop monitoring space data acquisition strategy: CEOS SDCG is planning to undertake an analysis of the GEOGLAM information requirements in early 2013 and to draft a global space data acquisition strategy. The activity will ensure that the necessary information requirements, crop area maps, calendars, cloud cover information and rice crop specific information is provided to the SDCG such that the Asian rice crop needs can be fully addressed in the course of their acquisition strategy. Some dialogue may be necessary to communicate national experience as to the utility of different sensors and their observing modes (notably different SAR sensors and the different bands and polarisations) to ensure that the SDCG is well equipped to design a robust acquisition strategy.

4.6 Overview and Milestones

The Asia-RiCE component and the overarching GEOGLAM initiative will have interdependencies that will dictate the overall progress on some of the components and their contributing activities. This includes application of the national assessment methodology of GEOGLAM to determine Asian country capacities and to develop roadmaps for capacity building. Overall however, the Asia-RiCE Work Plan can proceed independently of the GEOGLAM schedule and indeed could be an example of how regional coordination can be effective in progressing GEOGLAM objectives.

A number of the component activities – such as development of the rice crop geo dataset, establishment of an inventory of capabilities and activities, and establishment of the JECAM supersite can be initiatied immediately upon approval of this work plan, and indeed some are already underway. Activities which involve external institutions and establishment of coordination mechanisms with and within other bodies such as APRSAF and ASEAN+3 will be subject to establishing agreement on a schedule with those groups and to their existing plans. The 2nd Phase of the AFSIS is due to complete in 2012 and a post-Phase 2 proposal includes the establishment of a network of National Centres, and a range of new activities and financing.

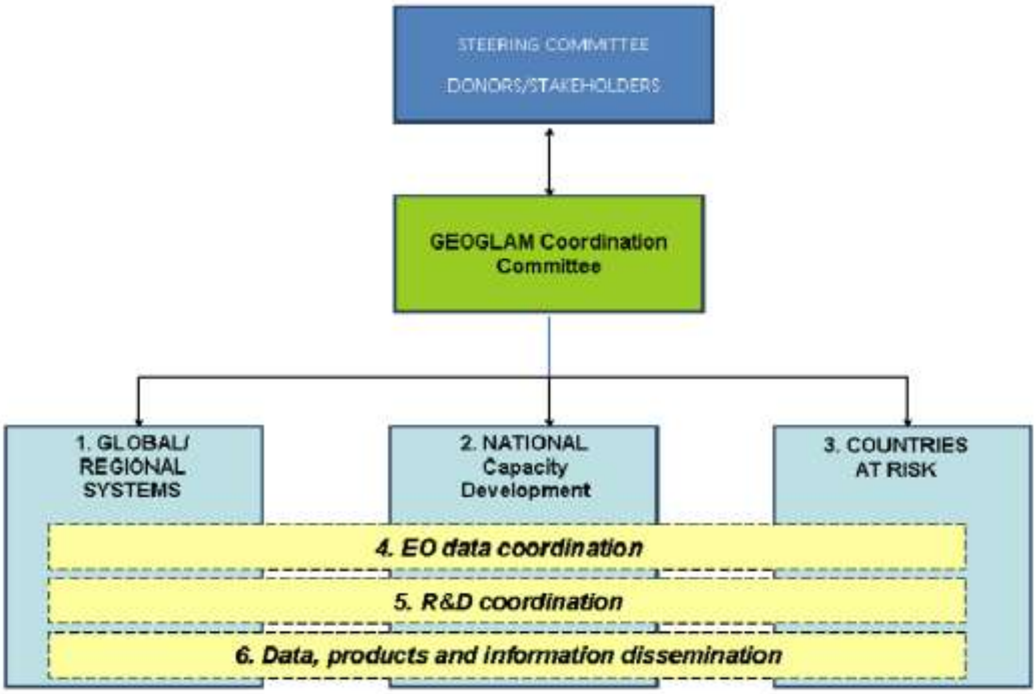
The 2013 Calendar will depend on how the Asia-RiCE management framework progresses. In any case the GEOSS-AP Symposium in India in late February will be used to further develop the regional approach. Should the EO Working Group of APRSAF be adopted as a possible home for the Asia-RiCE team, then a first full meeting could be held in connection with the EO Working Group meeting in Nagoya, Japan in May 2013.

The Indonesian National Institute of Aeronautics and Space (LAPAN) has been monitoring rice crops since 2000. The island of Java produces approximately 70% of Indonesia's rice and as a result, ensuring food security on the island is vital. LAPAN use in-situ and satellite data to assess food availability and vulnerability and to predict the productivity/yield of rice crops on Java. Food availability indicators that are derived from observations by satellite instruments such as MODIS on Terra/Aqua include crop colour, rice growth stage, growing season, drought, flood, pests and diseases in the paddy field and the harvest area. The resulting flood and drought, crop growth, and yield models have been used to support the Indonesian Ministry of Agriculture and Indonesian Statistics Bureau.

5 Management

5.1 GEOGLAM Regional Sub-Committee

The governance model which has been proposed for GEOGLAM is summarised in the figure below.



The steering committee 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 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 and, 4) institutional linkages.

It is proposed to establish a regional Sub-committee for Asia that will coordinate the implementation of the Asia-RiCE work plan and that will interface to the GEOGLAM Coordination Committee. This Sub-Committee will evolve from the *ad hoc* team of stakeholders that has assembled to develop the rice crop monitoring work plan and, will have responsibilities similar to those of the Committee (technical coordination, fund raising, reporting and linkages), but with a special focus on Asian countries and rice crop monitoring – with the aims of: providing a framework for the effective participation of Asian countries in GEOGLAM; ensuring that the benefits of GEOGLAM flow to the region; ensuring representation of rice crop issues within GEOGLAM.

The Regional Sub-Committee must ensure strong linkages to the main institutional activities within ASEAN, APEC, ADB etc and with national activities. For costefficiency the stakeholders should explore the possibility of using existing frameworks and meeting cycles (such as ASEAN, AMAF, or APRSAF) for the operation of the sub-committee and provision of an effective secretariat. The Earth Observation Working Group (EOWG) of APRSAF already features a number of relevant stakeholders and would benefit from the secretariat and mature calendar for APRSAF. This might provide a suitable framework for at least the first phase of Asia-RiCE and is consistent with APRSAF ambitions to develop as a practical data coordination body in support of regional needs.

Routine communications will be by teleconference and email, with periodic meetings convened by the sub-committee Chair, who should also provide a suitable secretariat resource. A programme website will be established as the home for all relevant documents and communications.

5.2 Resources and Funding

Participation in the Asia-RiCE activity is voluntary and should be self-funded as a default – leveraging budgets and objectives of national programmes and agencies.

Early inventory work should identify capacities and activities that are underway and planned and should provide insights as to possible donors for particular activities – eg the JECAM supersite in SE Asia may be an extension of existing work underway between govts of Thailand and Japan. The Early Warning Information activity underway within AFSIS might be the nucleus of the activity around supporting countries at risk.

Mechanisms for securing funding for individual activities will be identified, including through development grants such as those provided by the Asian Development Bank.

The initial meetings of Asia-RiCE in 2013 will focus on establishing priorities for effort to develop the regional system of systems and on identifying and engaging possible donors for the implementation of these priorities.

5.3 Future Evolution of the Asia-RiCE Work Plan

It is expected that the Asia-RiCE team will work in coordination with the GEOGLAM Coordinating Committee, as well as the Asian community and key rice crop stake holders to update this Work Plan to reflect changes and advances in circumstances. In addition to reflecting progress, and changes in circumstances, the evolution of the Plan is expected to add further implementation detail where possible.

The first update will be planned for mid-2013, following discussions at the GEOSS Asia-Pacific Symposium in late-February.

In addition, application of this work plan to rice crop producing regions in North America, Africa, and other regions as appropriate is encouraged.

Appendix A – GEOGLAM Information Products

Information type	Requirement priority			*Relevant satellite EO products*
	Timeliness	Consistency over time	Accuracy	
Monitoring and early "warning" systems				
Rainfed planted area outlook	+++	++	±	*Cultivated crop type/crop cluster map*
Irrigated crop outlook	+++	++	±	*Water availability (incl. reservoir height)*
Early acreage estimate	+++	++	±	*Early Crop Acreage statistics*
Crop condition (anomalies, stress indicator)	+++	+++	±	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Yield forecast	+++	++	+	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Early production estimate	+++	++	+	*Yield forecast & Early Crop Acreage stat.*
Precision Agriculture				
Parcel variability (for different growing stages)	++	+++	++	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Nutrients status	++	+++	++	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Weeds and pest	++	+++	++	*Pest control product*
Water status	++	+++	++	*Water stress /drought*
Control				
Damages indicator (insurance)	++	+++	++	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Illegal crop detection (poppies, etc)	+++	±	+	*Cultivated crop type/crop cluster map*
Crop and management compliance (e.g. EU CAP)	+++	±	+	*Cultivated crop type/crop cluster map*
Cropping practices control (tillage, residue, etc)	+++	±	+	*Cultivated crop type/crop cluster map*
Statistics systems				
Cropland area and change	+	+++	+++	*Cultivated crop type/crop cluster map*
Yield estimate	+	+++	+++	*Index (VI, etc), Crop variables (LAI, ET, etc)*
Crop acreage statistics	+	+++	+++	*Crop Acreage statistics*
Crop production statistics	+	+++	+++	*Yield estimate & Crop Acreage statistics*
Irrigated crop statistics	+	+++	+++	*Cultivated crop type/crop cluster map*

Appendix B – GEOGLAM Satellite EO Products

Agricultural landscapes	Coverage	Large fields - low to high crop diversity	Small fields (< 2ha) - no crop diversity	Small fields (< 2ha) - high crop diversity	Precision farming - sub-parcel level
Satellite EO products			spatial resolution and valid observation frequency		
Near real time to 'Weekly' products					
7-day (10-d) monitoring products					
Index (NDVI & other VI, WS, SAR polarisation ratio)	global croplands	100-250 m / daily	100-250 m / daily	100-250 m / daily & 5-10 m / weekly	1- 10 m / weekly
Crop variables (LAI, fAPAR, , ET, biomass, DMP)	global croplands	100-250 m / daily	100-250 m / daily	100-250 m / daily & 5-10 m / weekly	1- 10 m / weekly
Water availability (incl. reservoir height)	irrig. croplands	Radar (global monitoring or scanSAR modes, passive microwave with short repeat cycle) / Altimeter (reservoir > 300 m)	Radar (global monitoring or scanSAR modes, passive microwave with short repeat cycle) / Altimeter (reservoir > 300 m)	Radar (global monitoring or scanSAR modes, passive microwave with short repeat cycle) / Altimeter (reservoir > 300 m)	Radar (global monitoring or scanSAR modes, passive microwave with short repeat cycle) / Altimeter (reservoir > 300 m)
Hazard products					

Agricultural landscapes	Coverage	Large fields - low to high crop diversity	Small fields (< 2ha) - no crop diversity	Small fields (< 2ha) - high crop diversity	Precision farming - sub-parcel level
Crop damage area (disease, winter kill, storm,etc)	regional focus	100-250 m / daily	100-250 m / daily & 10-30m/weekly	5-10 m / weekly	1- 10 m / weekly
Water stress /drought	regional focus	100-250 m / daily	100-250 m / daily & 10-30m/weekly	10-30m / weekly (incl. SAR)	10-30m / weekly (incl. SAR)
Pest control (e.g. locust) product	regional focus	100-250 m / daily	100-250 m / daily & 10-30m/weekly	10-30m/weekly	1- 10 m / weekly
Flooding extent	regional focus	10-30m/every 3 days (mainly SAR)	10-30m/every 3 days (mainly SAR)	10-30m/every 3 days (mainly SAR)	10-30m/every 3 days (mainly SAR)
Annual products					
Early Crop Acreage statistics	global croplands or area frame sampling	100-250 m / daily & 10-30m / biweekly	100-250 m / daily & 10-30m/weekly	5-10 m / biweekly	n.a.
Cultivated crop type/crop cluster map	global croplands or area frame sampling	10-30m / biweekly (+ SAR time series)	10-30m/ biweekly (+ SAR time series)	10-30m/ biweekly (+ SAR time series)	n.a.
Crop Acreage statistics	global croplands or area frame sampling	10-30m / biweekly	10-30m / biweekly	5-10m/biweekly	n.a.
Multi-annual products					
Global cropland mask	global	10-30m/biweekly	5-10m/biweekly	5-10m/biweekly	n.a.
Global irrigated map	global	10-30m/ biweekly (incl. SAR)	5-10m/ biweekly (incl. SAR)	5-10m/ biweekly (incl. SAR)	n.a.
Global cropping intensity map (cycles)	global croplands	100-250 m / daily & 10-30m / biweekly	100-250 m / daily & 10-30m/biweekly	100-250 m / daily & 5-10m/biweekly	n.a.

Agricultural landscapes	Coverage	Large fields - low to high crop diversity	Small fields (< 2ha) - no crop diversity	Small fields (< 2ha) - high crop diversity	Precision farming - sub-parcel level
Global cropping systems map (field size, crop diversity)	global croplands	10-30m/ biweekly	5-10m/biweekly	5-10m/biweekly	n.a.

Appendix C – GEOGLAM Satellite Data Requirements

					Derived products							Global	Region specific acquisition according to agrosystems constraints (2° DB)			
Spatial resolution	Spectral range	Effective obs. freq.(cloud free)	Swath	Use (Primary/Second. Source)	Croplands mask	Crop type area	Crop Cond. Indicators	Crop bioph. var.	Env. variables (reservoir, water, soil moisture)	Ag. Practices /cropping systems	Crop Yield	agric. coverage	Large Medium Small Fields	Crop types diversity	Calendar/Multiple cropping	Cloud Coverage
2000 - 500 m	ThermalIR + optical	few per day	global	NRT products (PS)			x	x (LF)				x				
100-300m	optical+SWIR	2 to 5 per week	global	NRT products (PS)	x	x	x	x (LF)		x (LF)	x (LF)	X	all L		*	
1-15km	passive microwave	daily	global	NRT products (PS)					x			x				
50-150 m	SAR dual pol. (C,L,(X))*1	5 per season	main crops	NRT products (SS/PS)*	x	x	x	x (LF, MF, SF1)	x	x (LF, MF, SF1)	*		all L	rice area	entire growing seasons	high cloud cov.
5-20m	SAR dual pol. (C,L,(X))*1	5 per season	main crops	NRT products (SS/PS)*		x	x	x	x	x			L/M/S	rice area		high cloud cov.
20-70m	optical+SWIR	1 per month (if possible same sensor)	croplands	Annual Products (PS)	x	x							all M		all over the year focused over growing season	
Footprint	RADAR Altimetry	weekly		NRT products (PS)					x							
50-100m	Thermal	daily ?	main crops	NRT products (PS)			x						L/M/S		entire growing seasons	
20-70m	optical+SWIR	1 per week (min. 1 per 2 weeks)	main crops	NRT products (PS)			x	x	x	x			Country specific (1) L/M		entire growing seasons	

					Derived products							Global	Region specific acquisition according to agrosystems constraints (2° DB)			
Spatial resolution	**Spectral range**	**Effective obs. freq.(cloud free)**	**Swath**	**Use** (Primary/Second. Source)	**Croplands mask**	**Crop type area**	**Crop Cond. Indicators**	**Crop bioph. var.**	**Env. variables (reservoir, water, soil moisture)**	**Ag. Practices /cropping systems**	**Crop Yield**	**agric. coverage**	**Large Medium Small Fields**	**Crop types diversity**	**Calendar/Multiple cropping**	**Cloud Coverage**
5-10 m	**optical(+SWIR)*****	**1 per month (if possible same sensor)**	**croplands**	**Annual Products (PS)**	x	x							all S		all over the year focused over growing season	
5-10 m	**optical(+SWIR)*****	**1 per week (min. 1 per 2 weeks)**	**main crops**	**NRT products (PS)**			x	x	x	x			Country specific (1) S		entire growing seasons	
< 5 m	**optical**	**1 to 2 per month**	**croplands**	**Annual Products (PS)**		x				x	x		Demo. case (2 to 5 percent of croplands)		2 to 4 coverage per year	

Appendix C Table Notes:

Phase for GEOGLAM

(1)= tentatively 5 producers countries +3 at risk countries for phase 1 (3y)

(2) = adding 2 countries per year in phase 2 (3y)

* PS in regions with frequent cloud cover - Valid observation frequency expected during the ag. Season in cloudy regions

X = yes

LF = large field (>25 ha)

MF = medium field (1ha-25 ha)

SF = small field (<1 ha)

SF1 = clusters of small fields with uniform crop calendars

Meteorological parameters (snow cover, temp., rainfall, etc.) are not included in this table and will be addressed in another forum.

*** SWIR is the goal, recognizing that only SPOT 5 has these spatial and spectral resolutions

NRT : Near-Real Time in the context of monitoring crop conditions and stages means that the goal is to make data accessible to users within 48 h

[1] X-Band SAR is powerful to estimate rice crop acherage area, but may not be suitable for the estimation of rice crop growth as it saturates under heavy cloud / rainy conditions and rainfall covers large portions of the rice growing regions of Asia.

Appendix D – Membership of Asia-RiCE Team

Country	Organisation	Member
Cambodia	MRC	Hethy Sung
China	SIAT, CAS	Jinsong Chen
France	CESBO	Thuy Le Toan
India	ISRO	Jai Singh Parihar
	ISRO	Sushma Panigrahy
Indonesia	LAPAN	Agus Hidayat
	LAPAN	Parwati Sofan
	LAPAN	Dede Dirgahayu
	LAPAN	I Made Parsa
		Mahmud Raimadoya
		Muhrizal Sarwani
Japan	JAXA	Shin-ichi Sobue
	JAXA	Kei Oyoshi
	JAXA	Stephen Ward
	JAXA	George Dyke
Malaysia	Uni. Putra Malaysia	Ezrin Mohd Husin
Philippines	IRRI	Andrew Nelson
Thailand	GISTDA	Preesan Rakwatin
Vietnam	VAST	Doan Minh Chung
	VAST	Lam Dao Nguyen
	VNU	Pham Van Cu

Appendix E – Potential Satellite Data Sources

Instrument Type	Missions/Instrumens of Interest	Products
Atmospheric Sounder	NOAA (ATOVS), Metop, JPSS, NPP, FY3	
Cloud and Precipitation Radar	TRMM, Cloudsat, GPM, EarthCARE	Agro-meterology
Optical Imagers, Spectral Radiometer, VIS/IR Radiometer	ALOS-3, ANSARO, Aqua, FY-3, GCOM-C1, DMSP, EO-1, Formosat, GOES, IRS-P4, JPSS, Landsat-7/8, Meteosat, Metop, MTSAT, NOAA, PROBA, Sentinel-2, Sentinel-3, SPOT, Terra, THEOS, VHRR, VNREDSat1	Cultivated Area (every year), Inventory of agricultural facilities
Imaging Radar (SAR)	*C-Band:* RADARSAT-2, RISAT-1, Sentinel-1, RCM *L-Band:* ALOS-2, *X-Band:* COSMO-SkyMed, TerraSAR-X, Meteor	Cultivated Area (every year), Inventory of agricultural facilities
Microwave Radiometer	Aqua, GCOM-W1, TRMM, SAC-D/Aquarius, Megha-Tropiques, SMOS, GPM, FY3	

Table E1 – Asian Rice Crop Monitoring Required Instrument Types

Appendix F – Asia-RiCE Work Plan Revision History

Version	Date	Remarks
V1.0	December 2013	Initial release.

Table F1 – Asia-RiCE Work Plan Revision History

Appendix G – Example Technology Demonstartion Site Definition

Technology Demonstrator Sites should start by providing:

1) Geographic coordinates the latitude and longitudes of four corners of site. May be you can attach a Google image for reference.
2) The season when the crop is planted and harvested.

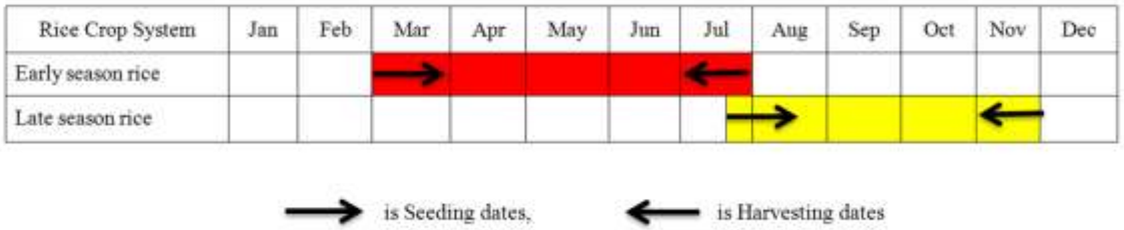
Study area

Taishan, Guangdong Province, China.

1. Geographic coordinates have shown as below.
   UL: 22°14'46.50"N, 112°27'47.06"E, UR: 22°14'44.95"N, 113° 2'58.88"E
   LL: 21°46'21.54"N, 112°24'56.16"E, LR: 21°47'25.90"N, 113° 1'39.96"E

This study area coverage of Radarsat-2 image (red box); Full polarization, incidence angle FQ10 - FQ22.

2. The season when the crop is planted and harvested; Crop Calendar



There are four major growth periods in the rice cycles (120 days) include of;

1. Sowing - Transplanting Vegetative phase (March-April, July-August)
2. Tillering vegetative phase (May, September)
3. Flowering reproductive phase (June, October)
4. Mature grain ripening phase (July, November)