# Asia-RiCE

## Phase 4 Work Plan

# Asia-RiCE Work Plan

## Asian Rice Crop Estimation and Monitoring Component of GEOGLAM

Asia-RiCE
Crop Estimation and Monitoring

GEOGLAM
Global Agricultural Monitoring

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Cover + 14 pages

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# 1. Introduction and Background

## 1.1. Introduction

This 2020 update of the Asia-RiCE Work Plan has been prepared to reflect the latest status of Asia-RiCE.

### GEOGLAM

Asia-RiCE is the rice monitoring component of the Group on Earth Observations Global Agricultural Monitoring 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.

### 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) as well as to an increase of the number of crops per year (Food and Agriculture Organization of the United Nations, 2012).

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 (methane emission). For these reasons, long term inter-annual monitoring is also required in order to study the production and cultural impacts of these factors. Satellite remote sensing can support this long-term monitoring requirement at regional and global scales.

Given the importance of rice, Asian participants in GEOGLAM formed an *ad hoc* team to ensure the appropriate representation of rice crop monitoring in the GEOGLAM initiative.

The goal of Asia-RiCE is to foster the widespread use of EO for 'wall-to-wall', whole country, timely and accurate forecasts of rice production at national, regional, and global scales, as an input to the GEOGLAM Crop Monitor and AMIS Market Monitor.

## 1.2. Objectives

Asia-RiCE aims to:

- Promote the use of EO data for wall-to-wall rice crop monitoring in cooperation with GEORice and Asia-RiCE team members and international donors;
- Promote the use of new generation tools for big EO data analysis, such as the Open Data Cube and cloud-based systems with available data sources and tools (such as INAHOR and GEORice);
- Promote outcomes, output applications, research results, and progress at international conferences such as the ESA Living Planet Symposium, IGARSS, ACRS, etc.;
- Continue to promote the generation of rice crop outlooks in Asia using agromet information from Japan (JASMIN) and India (MOSDAC).

## 1.3. Stakeholders

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

A broad range of stakeholders are of relevance to 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, such as ASEAN. Asia-RiCE works with the ASEAN Food Security Information System (AFSIS) to provide crop condition overview information and outlooks to the GEOGLAM Crop Monitor and AMIS.
- **Remote sensing organisations** and their coordination groups that can support supply of the necessary space data – these include the space agencies of Japan, China, India, Indonesia, Korea, Thailand, Vietnam and others; as well as the regional space agency forum APRSAF, SERVIR Mekong, and the international Committee on Earth Observation Satellites (CEOS);
- **UN agencies** and their regional activity groups, such as FAO and ESCAP; and,
- **Key donor organisations** including global (e.g., World Bank), regional (e.g., Asian Development Bank), and national (e.g., JICA) bodies.

Participation in the *ad hoc* team has to date been predominantly by national implementing agency and space agency representatives. However, the intention is to ensure that the full spectrum of stakeholders are further engaged in implementation of Asia-RiCE. Appendix A details the current membership of the *ad hoc* team.

## 1.4. Contents

**Section 2** defines the target products and information requirements related to rice crop monitoring. **Section 3** is the work plan for Asia-RiCE. Some research and development suggestions are presented for consideration in **Section 4**. Governance is covered in **Section 5**. A conclusion is presented in **Section 6**.

# 2. Rice Crop Monitoring Products & Data Supply

## 2.1. Required Products and Services for Rice Crop Monitoring

Crop and agricultural products required for rice crop monitoring are summarised in Table 1. P1, P3, and P4 (highlighted in red) are considered the **core** Asia-RiCE products.

| ID | Product/Information | Description |
|---|---|---|
| **P1** | **Rice Planted/Harvested Area and Mapping** | **Cultivated area (every cropping season); planted area progress (every month) during the growing season.** |
| P2 | Crop Calendars/Crop Growth | Timing of sowing, planting, growing and harvesting; growth status (phenological stage if possible). |
| **P3** | **Crop Damage Assessment** | **Detection of flooding and other disaster impacted areas; agro-meteorology; detection of areas impacted by drought or saline water intrusion; detection of pest and disease infestation.** |
| **P4** | **Agro-meteorological Information** | **Agro-meteorology anomaly (e.g., precipitation, solar radiation and max/min temperature); crop growth anomaly for early warning, growth outlook, and impact on future yield.** |
| P5 | Yield/Production Estimation* and Forecasting | Empirical-statistical model estimates; crop-growth simulation model estimates. |

*Table 1 – Target Rice Crop Products (* required by AMIS)*

## 2.2. Essential Agricultural Variables

The products listed in Table 1 are expected to be harmonised with the Essential Agricultural Variables (EAVs) which will be developed in GEOGLAM (see Activity 2-3). Asia-RiCE members will represent the rice crop monitoring community in the process to define the EAVs, ensuring the monitoring needs are reflected in these requirements that are expected to provide key guidance for observing systems (e.g., satellites operated by space agencies).

## 2.3. Satellite Data Sources

There are a wide variety of satellite data sources required for the generation of these products. Asian rice crop monitoring is heavily dependent on SAR, driven by unique Asian conditions (i.e., rain, consistent cloud cover) as well as the unique signal response characteristics of rice which facilitates growth stage analysis. A set of instruments of interest, along with some example missions, are listed below.

*Please note: data policies differ between missions. For example Aqua, Terra, Landsat, and Sentinel data are free and open; a certain amount of additional SAR data are available for free for R&D purposes, regional initiatives, or under MoUs such as for the Joint Experiment for Crop Assessment and Monitoring (JECAM) (for RADARSAT-2) and Asian-Pacific Regional Space Agency Forum (APRSAF) Space Applications for Environment (SAFE) or MoU for governmental use (for ALOS). A small number of products must be acquired on a commercial basis (e.g., TerraSAR-X/TanDEM-X).*

| Instrument Type | Missions/Instruments of Interest |
|---|---|
| Atmospheric Sounder | MetOp, JPSS, Suomi NPP, FY-3 |
| Cloud and Precipitation Radar | CloudSat, GPM (DPR), EarthCARE |
| Optical Imagers, Spectral Radiometer, VIS/IR Radiometer | Aqua/Terra (MODIS), GCOM-C, DMSP, JPSS, Landsat-7/8, MetOp, NOAA AVHRR/3, PROBA-V, Sentinel-2/3, Venus, VNREDSat-1, ALOS-3 |

| | |
|---|---|
| Imaging Radars (SAR) | C-Band: RADARSAT-2, RISAT-1A/1B, Sentinel-1A/1B<br>L-Band: ALOS-2 (PALSAR-2), ALOS-4 (PALSAR-3)<br>X-Band: TerraSAR-X/TanDEM-X |
| Passive Microwave Radiometers | GCOM-W (AMSR-2), GPM (GMI), DMSP (SSM/I) |

*Table 2 – List of potentially useful instruments for Asian rice crop monitoring*

# 3. 2020 Asia-RiCE Work Plan

## 3.1. Introduction & Overview

This section describes the work plan of Asia-RiCE, which aims to:

- Promote the use of EO data for wall-to-wall rice crop monitoring in cooperation with GEORice and Asia-RiCE team members and international donors;
- Promote the use of new generation tools for big EO data analysis, such as the Open Data Cube and cloud-based systems with available data sources and tools (such as INAHOR and GEORice);
- Promote outcomes, output applications, research results, and progress at international conferences such as the ESA Living Planet Symposium, IGARSS, ACRS, etc.;
- Continue to promote the generation of rice crop outlooks in Asia using agromet information from Japan (JASMIN) and India (MOSDAC).
- Encourage broad ground data collection and sharing between countries, agencies, and projects.

These activities will be conducted in close collaboration with:

- APRSAF SAFE Evolution activities on rice crop monitoring and agromet;
- GEORice, including the Sentinel-1 reference site collaboration with GEORice, VAST-VNSC, ESA, CNES, JAXA, and local universities;
- The Joint Experiment of Crop Assessment and Monitoring (JECAM), including the establishment of new reference sites for Asia-RiCE purposes.
- Japan-ASEAN Integration Fund（JAIF）work to support and improve the monitoring of meteorological information for crop outlooks, such as precipitation, temperature, soil moisture, and vegetation index in the ASEAN region through capacity building using Earth observation satellite products.

## 3.2. Activity Area #1: Towards Operational Use

***Activity 1-1 – Data for Whole Country Rice Crop Monitoring*:** Asia-RiCE will work with CEOS and others to ensure the necessary data (preferably CEOS ARD), data distribution mechanisms, and ground data collection coordination is available to support whole country rice-planted area and production estimations.

***Activity 1-2 – Data Platforms and Tools:*** Asia-RiCE will work to enhance the utility of data platforms for rice crop monitoring, in cooperation with CEOS, APRSAF SAFE activities, VAST-VNSC, GA, CSIRO, ESA/CNES/CESBIO, NSPO, and JAXA. Priorities will be streamlining data distribution and management for whole-country rice crop monitoring and the development/porting of tools and algorithms (e.g., INAHOR, GEORice algorithms).

In addition, Asia-RiCE will seek to establish an online cloud-based collaborative platform on which space agencies and in-country agencies can share software, methodologies, ALOS-2 data (with access restrictions), archives of ground truth data for supervised learning, and

storage for other countries' satellite data and products (output rice maps, etc.), and on which users can generate products of interest using the aforementioned inputs.

***Activity 1-3 – Rice Crop Outlooks:*** Continue serving as the focal point for the development of regular Asian rice crop outlooks for the GEOGLAM Crop Monitor and AMIS Market Monitor and continue providing access and updates to the JASMIN agro-meteorological information tool. Agromet products generated from GCOM-C will be available through JASMIN. This activity will be undertaken in collaboration with the ASEAN Food Security Information System (AFSIS) and the ministries of agriculture in the participating Asian countries.

### 3.3. Activity Area #2: Standardisation of Rice Crop Monitoring

***Activity 2-1 – Cross-Validation of Agriculture and Agromet Variables:*** Asia-RiCE will communicate the results of and connect the international community (e.g., GEOGLAM, CEOS) to the bilateral activities taking place under SAFE Evolution to compare rice crop masks and agro-meteorological data generated by different datasets and algorithms. Products will include various outputs from the bilateral activities being undertaken by ISRO, JAXA, and GISTDA through SAFE Evolution.

***Activity 2-2 – Asia-RiCE Inputs to CEOS Analysis Ready Data for Land (CARD4L):*** Undertake a comprehensive review of the CEOS Analysis Ready Data for Land (CARD4L) Product Family Specifications and provide feedback on the edits (if needed) to make CARD4L datasets suitable for operational rice crop monitoring at national scale.

The aspects to be covered include primarily geometric and radiometric pre-processing of the images. Geometric rectification including geolocation is needed for the use of *in situ* and multi-source EO data. Relative radiometric calibration is required for classification and mapping, whereas absolute calibration is necessary for detection of anomalies and for the retrieval of biophysical parameters. For optical data, correction of atmospheric and BRDF effects, and for SAR data, reduction of speckle noise or incidence angular effect are the main operations.

Asia-RiCE could also pilot the end-to-end application of CARD4L for rice crop monitoring, from data distribution to final results, and provide feedback to CEOS to show the utility and value of these datasets (ideally via the analysis platform mentioned in Activity 1-2).

***Activity 2-3 – Essential Agricultural Variables (EAVs) Definition:*** Coordinate Asia-RiCE inputs to the GEOGLAM effort to define the Essential Agricultural Variables (EAVs), working with national agricultural ministries. Connect researchers and space agencies to this GEOGLAM process through Asia-RiCE.

### 3.4. Activity Area #3: Stakeholder Engagement

***Activity 3-1 – Close Communication and Capacity Building with End User Agencies:*** Undertake capacity building efforts in Asia in cooperation with available training centres such as ARTSA, IIRS, CSSTEAP, and in collaboration with existing projects such as APRSAF SAFE, GEORice, etc., and using the Japan ASEAN trust fund (JAIF) for ASEAN projects.

***Activity 3-2 – Continue International Engagement via CEOS for Space Data Coordination:*** Asia-RiCE will continue to engage with key CEOS groups to explore opportunities to

supplement regional data sources and ensure that the necessary acquisition capacity is available, using EO satellites of the U.S., Europe, and others, as available. Asia-RiCE has a key role in communicating observation requirements to space agencies. Asia-RiCE will also continue advocating for the production and distribution of CEOS ARD.

***Activity 3-3 – Establish Improved Links to Stakeholders and Donor Agencies:*** Asia-RiCE requires strong institutional support to ensure continued activity into the future. Asia-RiCE will seek to establish closer linkages to and support from the World Bank, Asian Development Bank, JICA, AFSIS, ESCAP, Mekong River Commission, APRSAF, and SERVIR Mekong, among others.

***Activity 3-4 – Coordination of Ground Data Collection and Sharing:*** Asia-RiCE will work with various stakeholders including countries' ministries of agriculture to improve the availability of ground data for the purpose of improving machine learning algorithms (e.g., INAHOR-NEO) and validating output products – including via the analysis platform mentioned in Activity 1-2. Asia-RiCE will consider how to implement a regional sharing agreement for this data.

Asia-RiCE recognises that GEOGLAM is faced with the same problem, as noted in the work plan of this GEO Flagship:

*In general, open sharing of in-situ data is a challenge for the GEOGLAM community. At the national level, this data is often protected under law to prevent the disclosure of price information. At best this data can be accessed externally within projects only, under data sharing agreements. The same types of restrictions often occur when commercial EO data sources are utilized. The best examples of data sharing occur within the JECAM inter-comparison projects. Here in-situ data and commercial EO data is shared between participating research sites in order to test methods towards the development of best practices. Also, in a promising development ESA has recently launched the Sens4Stats project with the intent to develop tools to extract in-situ data to support EO analysis while preserving the confidentiality of the data sources. GEOGLAM believes these efforts will help to move the bar on in-situ data sharing, but much is still to be done to realize universal open sharing.*

As such, this task should be undertaken in coordination with GEOGLAM, as well as the SAFE Evolution projects.

***Activity 3-5 – Communicate Best Practices from SAFE Evolution to the International Community:*** Asia-RiCE will use its linkages to the international community via GEOGLAM, GEORice, JECAM, ASEAN/AFSIS, and others to communicate the best practices developed under SAFE Evolution to a broader audience.

# 4. Research and Development Suggestions

These tasks are presented here as suggestions for future research topics, based on what would be most helpful for the field of rice crop monitoring using space-based Earth observations.

## 4.1. Data Fusion

Investigate methods (including machine learning techniques) for integrating different sources of optical and multi-frequency SAR data/ARD (C/L/X-band) for use in rice crop monitoring (specifically planted area, condition, and phenology studies).

## 4.2. Yield (Production) Estimations

Create a rice crop yield estimation model by integrating satellite data, numerical models (statistical models or crop growth simulation models), and in situ yield/production data (both crop cutting and statistical data).

## 4.3. Methane Emission Evaluation

Investigate options for evaluating methane emissions from Mekong Delta paddy fields (a key source of emissions) using SAR, optical, microwave radiometers and dedicated greenhouse gas missions (e.g., GOSAT-1/2, OCO-2, Sentinel-5P TROPOMI).

## 4.4. Dual/Full-Polarimetry with High-Revisit and Spatial Resolution Data Analysis

Investigate the benefits of frequently observed full-polarimetric SAR data (e.g., ALOS-2 for a supersite every 14-days with dual or full-polarimetry 10m spatial resolution toward ALOS-4 mission) for the improvement of planted area, phenology, and inundation monitoring.

# 5. Governance

## 5.1. Structure

- Lead: Dr. Shinichi Sobue (JAXA);
- Vice-Leads: Dr. Thuy Le Toan (CESBIO), Dr. Kei Oyoshi (JAXA);
- General Secretariat: Dr. Lal Samarakoon (AIT); and,
- Secretariat: Mr. Matthew Steventon (Symbios for JAXA).

## 5.2. Responsibilities

The Lead and Vice-Leads have the following responsibilities, which are supported by in-kind agency contributions:

- Coordinate the Asia-RiCE crop team activity as described in this work plan;
- Participate in the GEOGLAM Implementation Team to coordinate and promote Asia-RiCE crop team activities including rice crop growth estimation using SAR and optical data, as well as the monthly rice crop outlooks;
- Participate in the CEOS *ad hoc* Working Group on GEOGLAM to coordinate Asia-RiCE crop team data and system requirements;
- Coordinate Asia-RiCE face-to-face team meetings; and,
- Coordinate the publication of joint papers, the hosting of conference sessions, and other outreach activities with related organisations.

The General Secretariat and Secretariat have the following responsibilities, also supported by in-kind agency contributions:

- Host Asia-RiCE team teleconferences (chair, minutes, action items, etc.);
- Host and maintain the Asia-RiCE website; and,
- Maintain the Asia-RiCE Work Plan and other documents.

## 6. Conclusion

Asia-RiCE has demonstrated the great utility of the initiative, with substantial amounts of CEOS data flowing from space agencies to in-country agricultural agencies and researchers – an achievement that would not have been possible without the collective efforts of the group and its connections to both GEOGLAM and CEOS. As a result of Asia-RiCE, improved rice production estimates are being generated at national and regional scales – valuable inputs to the GEOGLAM Crop Monitor and AMIS Market Monitor that would not otherwise be present.

The Asia-RiCE Leads thank all partners and data providers for their continued support of the initiative.

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# Appendix A – Asia-RiCE Membership

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*(* indicates Leads/Vice-Leads)*