Asia-RiCE

Phase 4 Work Plan Rev C

Asia-RiCE Work Plan Rev C
Asian Rice Crop Estimation and Monitoring Component of GEOGLAM

March 2025
Cover + 18 pages

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1. Introduction and Background

1.1. Introduction

This 2025 update of the Asia-RiCE Work Plan Rev C has been prepared to reflect the latest status of Asia-RiCE. The main update of this version is to make "Evaluation of Methane Emission from Paddy Rice" one of the main pillars of the activity (see the Activity Area #3).

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). This also increased the number of crops per year in countries that had not reached the potential yield (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 seasonal 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 and relevant decisions.

Rice agriculture has been considered one of the main emission sources of atmospheric methane (CH4), with methane emissions from paddy rice estimated to make up about 8 .7% of total global anthropogenic emissions (IPCC 6th Assessment Report-AR6). Rapidly reducing methane emissions is regarded as an effective strategy to help mitigate global warming in the near term, since methane has a global warming potential much higher than CO2 (1kg of CH4 is equivalent to 34 kg of CO2) , and a shorter lifetime in the atmosphere (about 9-12 years) than carbon dioxide (IPCC-AR6). Specific reductions of methane emissions would, in the short term, contribute significantly to the efforts of limiting warming to 1.5°C or 2°C. In addition, reductions of methane would have substantial co-benefits, improving air quality and therefore limiting effects on human health.

For these reasons, water management monitoring is also required in order to study the impacts of rice cultivation practices on methane emissions, where appropriate water management can reduce methane emission from paddy fields. Satellite remote sensing, especially SAR, can support this requirement at local scales to identify water inundation status of individual paddy fields. This can in turn contribute to climate change and greenhouse gas mitigation by supporting Monitoring, Reporting, and Verification (MRV) of methane emission from paddy fields, and helping to enable carbon credit training.

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. Its goal is to foster the widespread use of EO for 'wall-to-wall', whole of 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. It also seeks to promote monitoring rice cultivation practices, in particular, water management for reducing GHG emission from paddy fields.

1.2. Objectives

Asia-RiCE has two main objectives:

- **Enhancing regional food security** by improving rice crop monitoring and yield estimation using Earth observation data; and,
- **Promoting and supporting sustainable agriculture** through efficient resource use and reducing environmental impact through advanced remote sensing technologies.

This includes efforts to:

- Promote the use of EO data for wall-to-wall rice crop monitoring in cooperation with Asia-RiCE team members and international donors;
- Promote the use of new generation tools for big EO data analysis, such as the VEDAS, Open Data Cube, Google Earth Engine (GEE) and cloud-based systems with available data sources and tools (such as INAHOR, GEORice, and VEDAS);
- 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 and other crop outlooks in Asia using agromet information from Japan (JASMIN, JASMAI) and India (VEDAS) and utilisation of rice planted area map for the improvement of rice statistics; and,
- Promote the use of EO data for monitoring water management of paddy fields to the methane MRV including carbon credit trading.

1.2.1. Stakeholders

Asia-RiCE aims to coordinate the evolution of a system of systems which will be robust and resilient, 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;
- **Key donor organisations** including global (e.g., World Bank), regional (e.g., Asian Development Bank), and national bodies (e.g., JICA); and,
- **Private companies** for agriculture and carbon credit related businesses utilising Asia-RiCE capabilities and methodologies.

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.

1.3. 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.a. P1, P3, and P4 (highlighted in red) are considered the **core** Asia-RiCE products. In addition to these items, P6 in Table 1.b. reflect products that support sustainable agriculture, and reducing methane emission from paddy fields.

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	Crop intensity, 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, product/information of yield modelling using AI (machine learning & deep learning)

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

ID	Product/Information	Description
P1	**Rice Planted/Harvested Area and Mapping (same as Table1.a)**	Cultivated area (every cropping season); planted area progress (every month) during the growing season.
P2	Crop Calendars/Crop Growth **(same as Table1.a)**	Crop intensity, Timing of sowing, planting, growing and harvesting; growth status (phenological stage if possible).
P6	**Water management**	**Water condition (inundation or non-inundation) of individual fields**

Table 1.b – Target Rice Crop Products for the methane emission from paddy fields (Sustainable Agriculture)

2.2. Essential Agricultural Variables

Asia-RiCE aims to harmonise the Asia-RiCE products with GEOGLAM Essential Agricultural Variables (EAVs) listed in Appendix B. Asia-RiCE members represented the rice crop monitoring community in the process of defining 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 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, GOSAT-1/2/GW, OCO-2, Sentinel 5P TROPOMI
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, THEOS-1/2
Imaging Radars (SAR)	C-Band: RADARSAT-2, RCM, RISAT-1A, Sentinel-1A/1C/1D, L-Band: ALOS-2 (PALSAR-2), ALOS-4 (PALSAR-3), NISAR X-Band: LOTUSat-1, TerraSAR-X/TanDEM-X
Passive Microwave Radiometers	GCOM-W (AMSR-2), GPM (GMI), DMSP (SSM/I), GOSAT-GW (AMSR-3)

Table 2 – List of potentially relevant missions and instruments for Asian rice crop monitoring

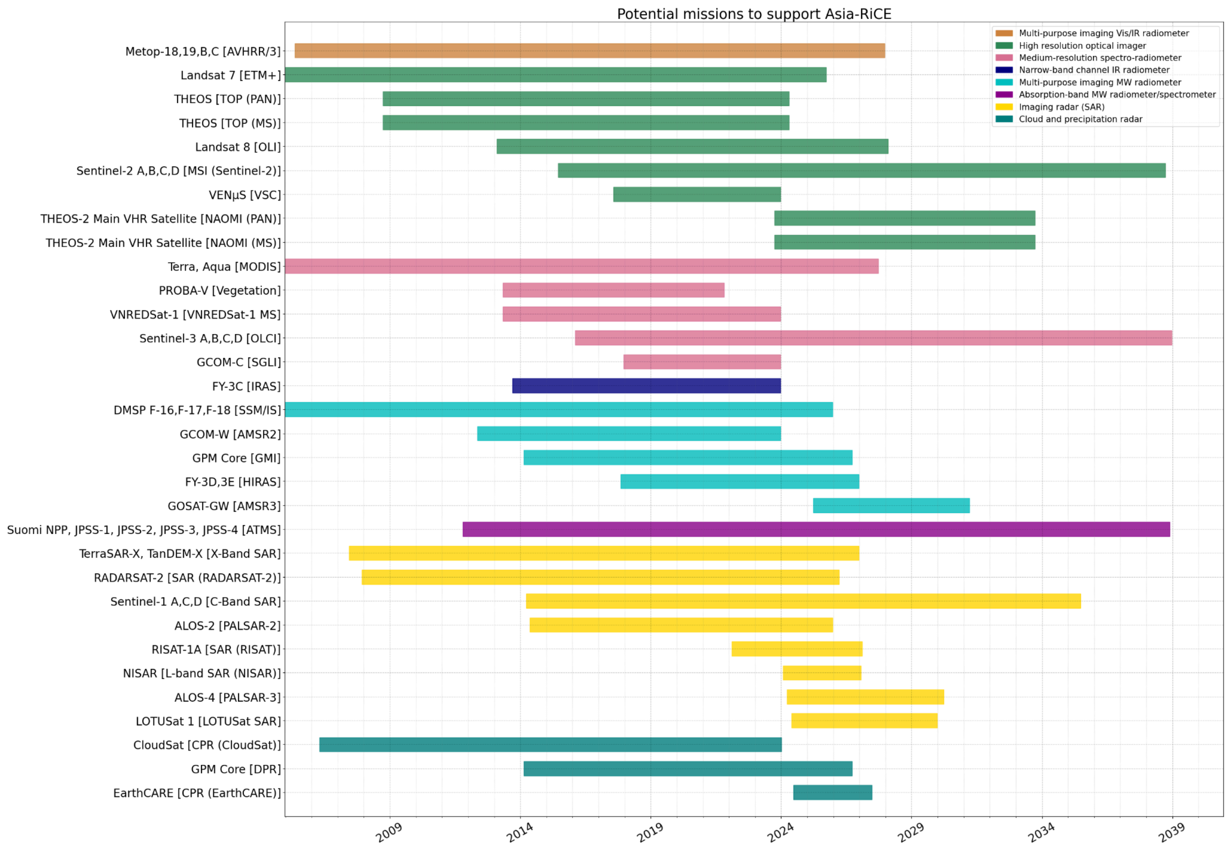

Figure 1: Timeline of potentially relevant missions for Asia-RiCE

3. 2025 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 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 information from Japan (JASMIN, JASMAI) and India (VEDAS); and,
- Encourage broad ground data collection and sharing between countries, agencies, and projects.

These activities will be conducted in close collaboration with:

- APRSAF SAFE (Asia-Pacific Regional Space Agency Forum- Space Applications for Environment) Project on rice crop monitoring and CH4Rice;
- GEORice, including the Sentinel-1 reference site collaboration with GEORice, VAST-VNSC, ESA, CNES, JAXA, and local universities; and,
- GEOGLAM's Joint Experiment of Crop Assessment and Monitoring (JECAM), including the establishment of new reference sites for Asia-RiCE purposes.
- Japan-ASEAN Integration Fund（JAIF works to support and improve the monitoring of meteorological information for rice crop outlooks, such as precipitation, temperature, soil moisture, and vegetation index in the ASEAN region through capacity building using Earth observation satellite products (2019-2022), and this project has been successfully completed. A new project on rice mapping using SAR for improving rice-cultivated area statistics has been approved- in 2024, running 2024-2026.
- The CNES-Space Climate Observatory VietSCO project aims to investigate the links between climate change and rice agriculture, with a specific focus on methane emissions from rice cultivation.

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 Analysis Ready Data, 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/GlobEO, ISRO, TASA, 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, Sentinel-1, 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 JASMAI (originally developed by JAXA and currently operated by MAFF/Japan) and VEDAS (ISRO) agro-meteorological information tool. Products generated from GCOM-C will be available through JASMAI. 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. This activity will be expanded to maize outlook in 2025.

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

Activity 2-1 – Asia-RiCE Inputs to CEOS ARD: Undertake a comprehensive review of the CEOS ARD Product Family Specifications and provide feedback on the edits (if needed) to make CEOS ARD 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 CEOS ARD 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).

ALOS-2 ScanSAR L2.2 data (slope corrected and ortho-rectified) processed in accordance with CEOS ARD have been open to the public via JAXA G-portal and GEE.

Activity 2-2 – EAVs Definition: Coordinate Asia-RiCE inputs to the GEOGLAM effort to define the EAVs, working with national agricultural ministries. Connect researchers and space agencies to this GEOGLAM process through Asia-RiCE. Currently, the CEOS LSI-VC GEOGLAM subgroup is working on coordinating EAV inputs, and the group is currently seeking membership from CEOS agencies interested in contributing. In addition, the subgroup will be supporting the GEOGAL EAV Stocktake workshop (13-15 May 2025), and this may be the best channel for JAXA to engage the EAV process.

3.4. Activity Area #3: Evaluation of Methane Emission from Paddy Rice

To assess methane emissions from rice fields on a national scale for MRV, and on a local scale for the implementation of attenuation measures, Earth Observation (EO) data are utilised to provide activity data (rice area, rice growth, rice inundation status, rice cropping density). This data is then used with emission factors and scale factors in the IPCC Tier 1 approach, or with emission measurements at experimental sites (Tier 2). C/L-band SAR data is employed to monitor rice growth, while L-band SAR is utilised to monitor inundation status. Additionally, for regional assessment, greenhouse gas missions (GOSAT-1/2/GW, OCO-2, Sentinel 5P TROPOMI) are considered.

Activity 3-1 – Water management monitoring:

Asia-RiCE will work to use EO data, to monitor planted area, crop calendar and water inundation/non-inundation for estimating methane emissions from paddy fields. This is achieved through the sharing of satellite data and knowledge, and coordination of ground data collection in the study sites in the Asian region. This activity is in close collaboration with the SAFE CH4Rice Project, and AOGEO Task Group 5.

Activity 3-2 – Integrated use of ground-based observation and EO data: Asia-RiCE will collect ***in situ* data (**Water-level, methane concentration/flux etc.) measured by IoT equipments and manual observation for the development, fine-tuning and validation of water inundation/non-inundation monitoring by EO data.

Activity 3-3 – CH4Rice Special Edition of Open Access Journal "Remote Sensing": All Asia-RiCE to consider submissions to a special edition of Open Access Journal, Remote Sensing highlighting their work and sharing best practice of methane monitoring for rice crops, as well as application of low methane emission alternative water management strategies such as Alternate Weting and Drying (AWD) irrigation.

Activity 3-4 – Promote Dialogues with Stakeholders for Applications: Dialogue with stakeholders both public and private sectors for utilizing EO data for guidelines on the carbon credit mechanisms (both public and volunteer, e.g. Joint Credit Mechanism, Verra, Gold Standard etc.) on methane emission from paddy fields. Also, fostering published papers as scientific evidence to utilize EO data for these guidelines.

3.4.1. SAFE CH4Rice Project

In 2022, the Methane emission evaluation SAFE project, CH4Rice was approved at APRSAF-28 with the aim to accurately assess methane emissions for sustainable rice cultivation. The work plan for the implementation of CH4Rice activities was confirmed at the SAFE Executive Board Meeting in 2023. The selected supersites include Subang in Indonesia, Suphan Buri in Thailand, Nawagam in India, Miyagi in Japan, Rajshahi in Bangladesh, and Mekong Delta in Vietnam.

Ongoing activities focus on water inundation monitoring (Alternate Wetting and Drying, AWD, water management to reduce methane emissions) using L-band SAR and *in situ* data, alongside the selection and finalisation of study areas and data sharing for collaborations. Automatic water-level measurements have been installed in some sites (e.g. Bangladesh, Japan, Indonesia, Vietnam, Thailand, etc.), and some are being installed.

The project will implement methane MRV using satellite and *in situ* data for climate change mitigation for a sustainable rice-producing system. Water will be managed efficiently through irrigation methods that result in lower methane emissions, such as AWD. Additionally, the project will promote and participate in regional and global sustainable agriculture related initiatives, such as SDG 2, GEOGLAM/Asia-RiCE and AOGEO and JAXA CEOS SIT Chair Initiative (2024-25).

The project has initiated the CH4Rice project implementation process in the selected sites of each country. Prepare and install *in situ* water level measurements at designated study sites, and conduct field surveys.

The project has several planned activities. One such activity is data, tool and knowledge sharing, and capacity building for multilateral collaborations. Satellite data, such as ALOS-2 (both full-pol and ScanSAR dual), NISAR, etc., will be shared, and methodologies and tools will be shared on platforms such as ISRO's VEDAS, GEE, and Open Data Cube (ODC).

The project also aims to promote dialogue with stakeholders and end-users by presenting results. It will engage with relevant agencies, such as agriculture, environmental, and water management-related ministries in each country. It will contribute to international initiatives like the Asia-RiCE/GEOGLAM, CEOS, AO-GEO and ASEAN SCOSA. Building collaborations with international initiatives related to methane emissions, such as UNEP and the International Methane Emissions Observatory (IMEO), is also part of the project's plan.

3.5. Activity Area #4: Stakeholder Engagement

Activity 4-1 – 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 4-2 – 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 4-3 – 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 4-4 – 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 projects.

Activity 4-5 – Communicate Best Practices from SAFE Project 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 Project to a broader audience. For 2025, this includes sharing recent discussions and results from the Asia-RiCE team at the AO-GEO Symposium in September 2025.

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. 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 6m spatial resolution for the improvement of planted area, phenology, and water management monitoring. And also, combined use of L-band fleets, ALOS-2/4 and NISAR.

5. Governance

5.1. Structure

- Lead: Dr. Shinichi Sobue (JAXA);
- Vice-Leads: Dr. Thuy Le Toan (CESBIO/GlobEO), Dr. Kei Oyoshi (JAXA); 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 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. In addition, Asia-RiCE is expanding its activities from food security to sustainable agriculture to help mitigate climate change by monitoring methane emissions from paddy rice fields, which would be also used in the private sector for carbon credit training and contribute to the space economy.

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

Alice Laborte (IRRI)
Bimal Bhattacharya (ISRO)
Bingfang Wu (RADI)
Cheng-Ru Chen (NCU)
Chi-Farn Chen (NCU)
Dede Dirgahayu (BRIN)
Ezrin Mohd Husin (UPM)
George Dyke (SYMBIOS)
Horng-Yuh Guo (TARI)
Kei Oyoshi (JAXA) *
Lam Dao Nguyen (VAST/VNSC)
Matthew Steventon (SYMBIOS)
Osamu Ochiai (JAXA)
Okumura Toshio (RESTEC)
Panu Nueangjumnong (GISTDA)
Parwati Sofan (BRIN)
Rajeev Jaiswal (ISRO)
Rashid Shariff (UPM)
Rizatus Shofiyati (BRIN)
Rokhis Khomarudin (Research Center for Geoinformatics, BRIN)
Shin-ichi Sobue (JAXA) *
Shoji Kimura (SEAA research LLC)
Son Nguyen-Thanh (NCU)
Suk Young Hong (Korea)
Teoh Chin Chuang (MARDI)
Thatheva Saphangthong (MAF, Lao)
Thuy Le Toan (CESBIO/Globeo) *
Tsang-Sen Liu (TARI)
Yih Yeon Kim (Korea)
Yi-Ting Zhang (TARI)
Youg-Sin Cheng (NCU)

Past Members
Lal Samarakoon (CanAsia)

(indicates Leads/Vice-Leads)*

Appendix B – Land Use and Productivity EAVs (by GEOGLAM)

EAV	Definition
Crop Type Area Estimate	A quantitative determination of the horizontal projection of the area under identified crop types.
Reference Crop Calendars	Identification of the typical or usual planting and harvesting dates or windows per crop per region.
Crop Condition Assessment	Qualitative indicator of crop health status relative to short-term reference* (*definition must be declared)
Precipitation	Integration of solid and liquid precipitation rates reaching the ground over several time intervals. The reference requirement refers to integration over 24 hours.
Crop Yield Forecast	Within season, pre-harvest forecast of harvestable weight* of commodity per unit area* (*definitions must be declared
Crop Yield Estimation	End of season harvestable weight* of commodity per unit area* (*definitions must be declared)