Asia-RiCE

Phase 4 Work Plan Rev B

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

February 2024
Cover + 16 pages

List of Contents

1. Introduction and Background

1.1. Introduction

This 2024 update of the Asia-RiCE Work Plan Rev B 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 increased the number of crops per year in countries that had not reach 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.

Moreover, rice agriculture is strongly linked to climate change. Rice is mostly grown under flooded soil conditions, uses more water and has higher greenhouse gas (GHG) emissions than most crops. Rice agriculture has been considered one of the main emission sources of atmospheric methane concentration. Rapidly reducing methane emissions from paddy rice is regarded as the single most effective strategy to reduce global warming in the near term.

For these reasons, long term inter-annual monitoring is also required in order to study the impacts of rice cultural practices on methane emissions. 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 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, 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 outlooks in Asia using agromet information from Japan (JASMIN, JASMAI) and India (VEDAS).

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

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

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
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, RISAT-1A, Sentinel-1A/1C/1DL-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 useful instruments for Asian rice crop monitoring

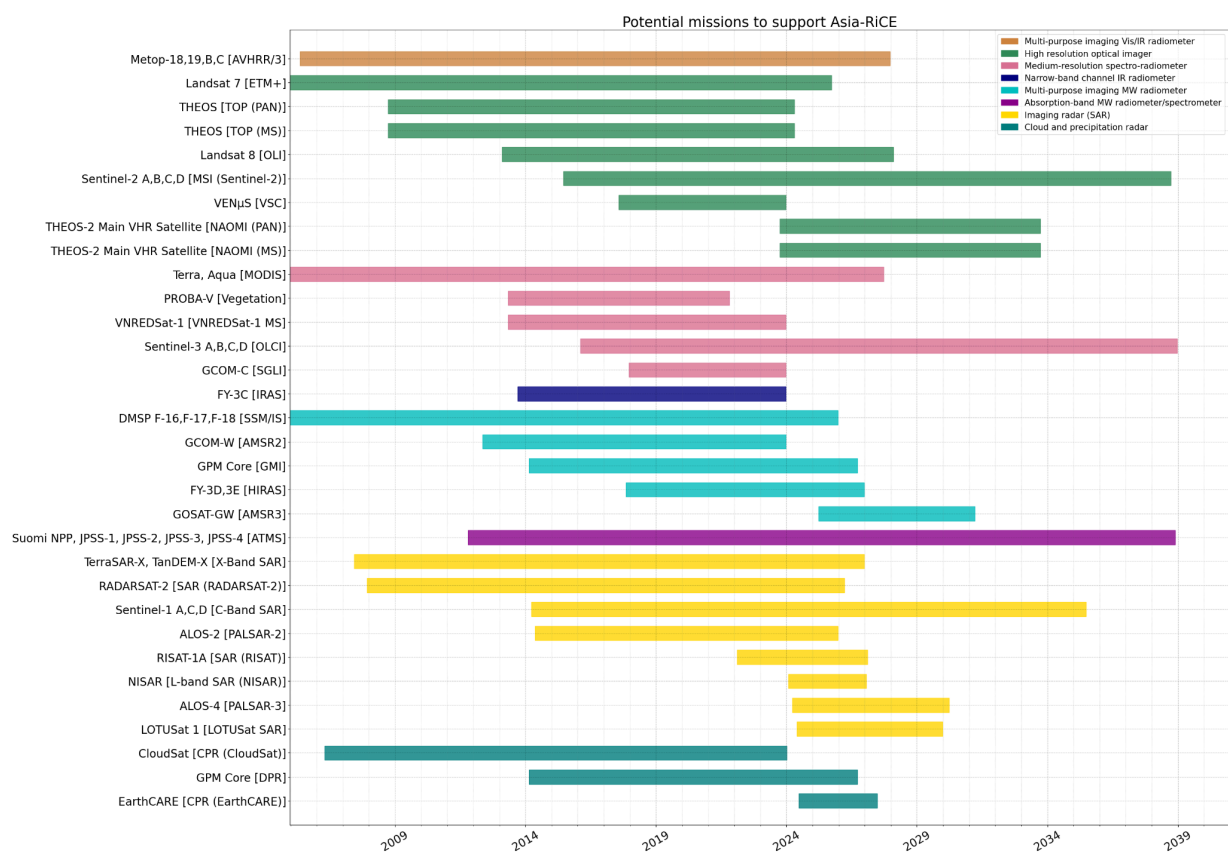*Figure 1: Timeline of potentially useful missions for Asia-RiCE*

3. 2024 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 agromet information from Japan (JASMIN, JASMAI) and India (VEDAS).

- 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) Evolution activities on rice crop monitoring, CH4Rice and agromet project;

- 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 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). A new project on rice mapping using SAR for improving rice-cultivated area statistics is currently being coordinated with the ASEAN secretariat.

- 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 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 JASMIN/JASMAI and VEDAS 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 (CEOS-ARD): Undertake a comprehensive review of the CEOS Analysis Ready Data (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 2-3 – 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

To assess methane emissions from rice fields on a national scale for Monitoring, Reporting, and Verification (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). 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-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.

SAFE CH4Rice Project

In 2022, the Methane emission evaluation SAFE project, CH4Rice was approved at APRSAF-28 with the aim to accurately assess CH4 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 (for AWD: Alternate Wetting and Drying water management to reduce CH4 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 etc.), and some are being installed.

The project will implement CH4 Monitoring, Reporting and Verification (MRV) using satellite and in-situ data for climate change mitigation through a sustainable rice-producing system. Water will be managed efficiently through irrigation methods that result in lower CH4 emissions, such as Alternate Wetting and Drying

(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 will initiate 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, Google Earth Engine (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 CH4 emissions, such as UNEP and the International Methane Emissions Observatory (IMEO), is also part of the project's plan.

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/GlobEO), Dr. Kei Oyoshi (JAXA);

− General Secretariat: Dr. Lal Samarakoon (CanAsia for 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 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

Alice Laborte (IRRI)
Bimal Bhattacharya (ISRO)
Bingfang Wu (RADI)
Cheng-Ru Chen (NCU)
Chi-Farn Chen (NCU)
Dede Dirgahayu (BRIN)
Ezrin Mohd Husin (UPM)
Horng-Yuh Guo (TARI)
Kei Oyoshi (JAXA) *
Lal Samarakoon (CanAsia)
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)

(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)