Asia-RiCE

2018 Implementation Report

Asia-RiCE has been organised to develop the rice crop estimation and monitoring component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative. GEOGLAM aims to enhance agricultural production estimates through the use of Earth observations, and Asia-RiCE seeks to ensure that the observational requirements for Asian rice crop monitoring are reflected in the GEOGLAM priorities.

This report summarises the activities and achievements of Asia-RiCE in 2018. This document also aims to acknowledge and highlight the impact of contributions from data providers, and the role of the Asia-RiCE initiative in facilitating these inputs.

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Introduction

Background

The Asia-RiCE initiative has been organised to develop the Asian Rice Crop Estimation and Monitoring (Asia-RiCE) component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative. GEOGLAM aims to enhance agricultural production estimates through the use of Earth observations, and Asia-RiCE seeks to ensure that the observational requirements for Asian rice crop monitoring are reflected in the GEOGLAM priorities.

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.

Target crop and agricultural products are summarised in Table 1. It is expected that these products will be generated with national resources as input to crop forecasting systems.

Table 1 – Target Products for Asia-RiCE

Product	Description
P1: Rice Crop Area Estimates/ Maps	Cultivated area (every year). Inventory of agricultural facilities.
P2: Crop Calendars/Crop Growth Status	Timing of sowing, planting, growing and harvesting/growing status. Identification of growth stages. Planted area progress (every month) per season. Crop growth anomaly.
P3: Crop Damage Assessment	Detection of flooding and other disaster impacted area. Detection of drought or inundated area. Detection of diseased plants, pests and diseased infestation.
P4: Agro-Meteorological Information Products	Early warning. Anomaly detection (drought, extreme temperatures). Crop growth anomaly.
P5: Yield Estimation And Forecasting	Empirical-statistical model estimate. Crop-growth simulation model estimates.

Asia-RiCE & The Phased Approach

Asia-RiCE has leveraged existing agricultural monitoring programs and initiatives at local levels to develop, exercise, and refine processes, and now moves on to full implementation and product generation using SAR (i.e., radar) and other Earth observation data for practical rice crop monitoring.

This activity (being implemented in phases) will contribute to Goal 2 and other Goals of the SDGs by improving rice crop productivity and reducing environmental impacts.

Phase 1 (2013 – 2015)

Phase 1A (2013-2014) consisted of four demonstration sites in three countries: Indonesia, Thailand, and Vietnam). Each of these was focused on the development of provincial-level rice crop area estimations.

Note: Phase 1A only covered rice area statistics, maps, and yield estimates. In Phase 1B (2014-2015), additional technical demonstration sites in Chinese Taipei, Japan, and Malaysia were added.

Phase 2 (2016 – 2018)

Following the successful demonstration of the core functionality of Asia-RiCE, the initiative moved into Phase 2, which covered:

- Scaling-up rice crop monitoring using SAR (adding rice growth outlooks for Laos, Cambodia, and Myanmar);
- Expanding from provincial-level to

country/ region-level estimates (Vietnam & Indonesia);

- Expanding rice growth outlooks using satellite-derived agro-meteorological data;
- Continuing rice growth outlooks for FAO/ AMIS and related agencies via GEOGLAM in collaboration with AFSIS (ASEAN+3 Food Security Information System) project; and,
- Wall-to-wall observation of selected countries to implement national monitoring systems.

Phase 3 (April 2019 – March 2021)

Asia-RiCE is now in its third phase – expected to run from April 2019 to March 2021. Phase 3 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);
- Continue to promote the use of the Open Data Cube in Vietnam, Cambodia, and Chinese Taipei in cooperation with VNSC, GA, ESA/CNES, NSPO, and JAXA;
- 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 the agro-met information from Japan (JASMIN) and India (MOSDAC).

In addition to these practical aspects, the following research topics are also priorities:

- Research around creating ARD time series from SAR and optical data for rice crop monitoring using Open Data Cube;
- Rice crop models for yield estimation;
- Methane emission from paddy fields;
- Standardization of field surveys for validation of results at national and regional scales (in cooperation with GEORICE);
- The practicality of potential integration of operational systems such as FASAL (India);
- Capacity building in Asia in cooperation with available training centres such as ARTSA, IIRS, CSSTEAP.

Specific details of the work to be undertaken in Phase 3 can be found in the Asia-RiCE Phase 3 Work Plan, which is available at:

http://asia-rice.org/

Asia-RiCE has linkages with major international frameworks such as the 2030 Agenda for Sustainable Development (SDGs 1, 2, 3, 6, 10, 13 & 15), the Sendai Framework for Disaster Risk Reduction 2015-2030 (impact of drought and flood on agriculture, JASMIN agro-met system), and the Paris Climate Agreement (paddy field methane).

UN World Conference on Disaster Risk Reduction
2015 Sendai Japan

SUSTAINABLE DEVELOPMENT GOALS

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

2018 Asia-RiCE Highlights

Asia-RiCE works to connect in-country agricultural agencies, space agencies, and global agricultural initiatives. Its activities are therefore broad. Some highlights are presented here.

Research and Development Activities

- Demonstration at Technical Demonstration Sites (TDS) in India, Japan, Malaysia, Philippines, Thailand, Taiwan (Chinese Taipei), Cambodia, and Myanmar from 2016.
- Demonstration at regional/national scale: wall-to-wall in Vietnam and top 10 rice production provinces in Indonesia.
- APRSAF (Asia Pacific Regional Space Agency Forum) SAFE Initiative with ALOS-2 and INAHOR for Cambodia, Indonesia, Myanmar and Vietnam (Mekong Delta).
- ESA-GEORice using Sentinel-1 for Vietnam.
- ADB project using ALOS-2 (with INAHOR) for Laos, Philippines, Thailand and Vietnam (Red River).
- Ongoing research using SAR (L/X/C-band) and optical (Sentinel-2/Landsat/Venus/Formosat) data for rice yield and methane emission estimates at TDS and JECAM sites.

Towards Operational Services

- Setting up pre-operational services for rice crop monitoring using ALOS-2 ScanSAR and Sentinel-1 and other satellites in Indonesia and Vietnam.

Data Coordination & Supply

The Committee on Earth Observation Satellites (CEOS) and its agencies are critical partners for Asia-RiCE. Asia-RiCE works with these space agencies to secure the data required by in-country teams for development of target products as well as other research activities.

A key feature of the coverage being provided by CEOS agencies is the multiple band SAR (C/L/X), which facilitates important intercomparison studies.

In early 2019, JAXA provided further ALOS-2 PALSAR-2 ARD to Vietnam – covering Cambodia, Laos, and Thailand – for the Mekong Data Cube project (the VAST-VNSC 2019 CEOS Chair Initiative), which has a focus on rice products. CNES/CESBIO integrate Sentinel-1 SAR ARD with the Vietnam Data Cube for rice monitoring.

Open Data Cube & SAR ARD

Open Data Cube arranges data as a multi-dimensional (space, time, data type) stack of spatially aligned pixels ready for analysis.

The powerful time series functionality of the Data Cube platform makes it very useful for agricultural studies, including for rice.

Critical for the Data Cube is Analysis-Ready Data (ARD). CEOS, through its Land Surface Imaging Virtual Constellation (LSI-VC) has developed the concept of CEOS Analysis-Ready Data for Land (CARD4L) – satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets. JAXA is a co-lead of the SAR CARD4L specifications.

http://ceos.org/ard/

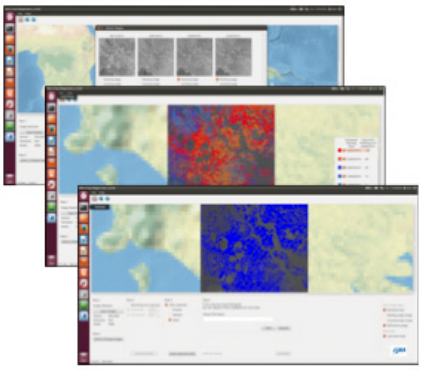
ALOS-2 PALSAR-2 ARD is supplied by JAXA to Vietnam and Indonesia for their Data Cube projects.

INAHOR

JAXA/RESTEC continued development of the INAHOR (INternational Asian Harvest mOnitoring system for Rice; crop planted area estimation software) and JASMIN (agro-met information provision system for outlook) tools.

INAHOR estimates rice crop acreage and production using space-based Synthetic Aperture Radar (SAR) from the ALOS series, RADARSAT-2 and Sentinel-1.

In 2018, JAXA/RESTEC successfully ported the INAHOR algorithm to the Open Data Cube platform and also developed a machine learning version of the software (see page 11).



JASMIN

JASMIN provides satellite derived agro-meteorological information including precipitation, drought index, soil moisture, solar radiation, land surface temperature, and vegetation index. The tool is able to generate two types of product for each parameter – current condition, and anomaly, which is the deviation from past year's averages. JASMIN can generate either a map of the whole country or time series graphs at a number of pre-defined locations. The outputs assist the ASEAN Food Security Information System (AFSIS) and target country agricultural statistics experts in preparing AMIS outlooks for Asia-RiCE.

With the 2017 launch of GCOM-C, agro-met related GCOM-C products with higher spatial resolution (solar radiation, land surface temperature, vegetation index) will be available on JASMIN after cross-calibration with the current MODIS products.

Reporting

Asia-RiCE continued its work with the ASEAN Food Security Information System (AFSIS) to provide crop condition overview information and outlooks to the GEOGLAM Crop Monitor for AMIS.

The following sections, separated by country, highlight some results from Asia-RiCE team members.

Indonesia

Objective: develop and upscale remote sensing based models of paddy growth stage using satellite data (optical and SAR).

These models are used by the Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD) and the Indonesian Agency for Agricultural Research and Development (IAARD).

In 2016, the Indonesian rice crop monitoring initiative was expanded to cover the top 10 'high priority' rice crop areas (in part because the East-West extent of the country means a larger number of satellite passes would be required to cover all areas).

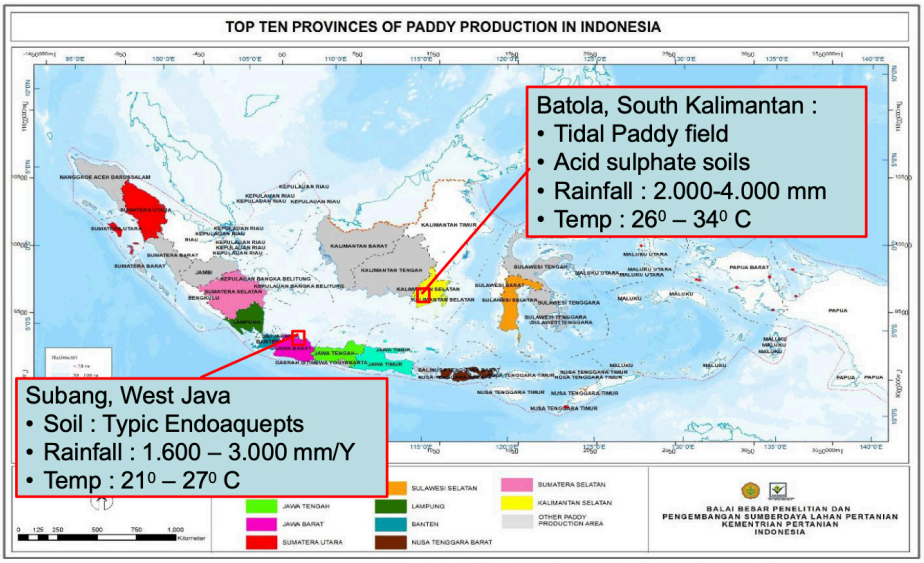
Conclusions

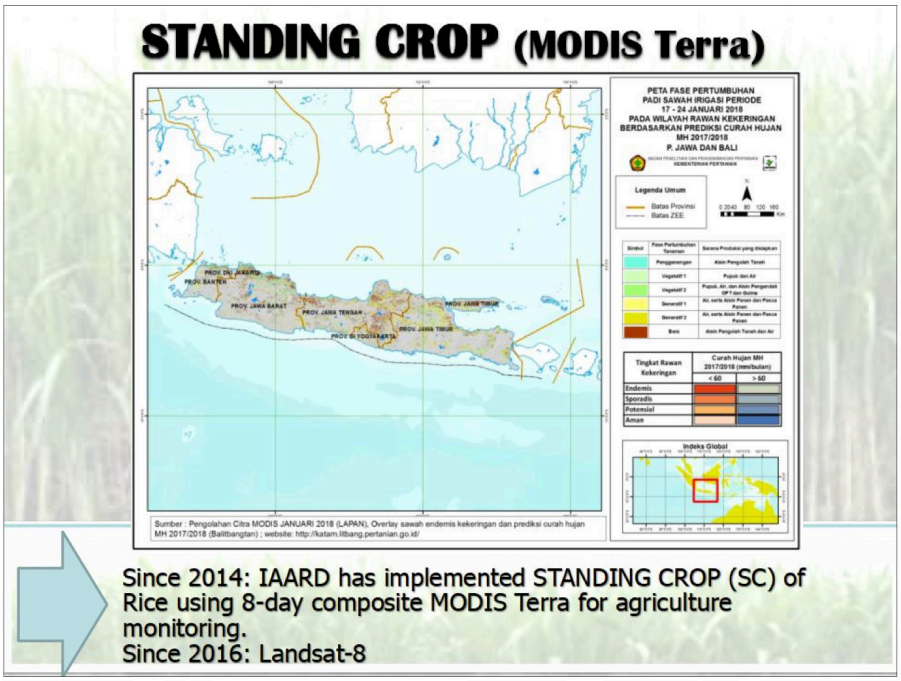
• The role of remote sensing technology is very important as an information base to formulate land management and agriculture policy to support food security.

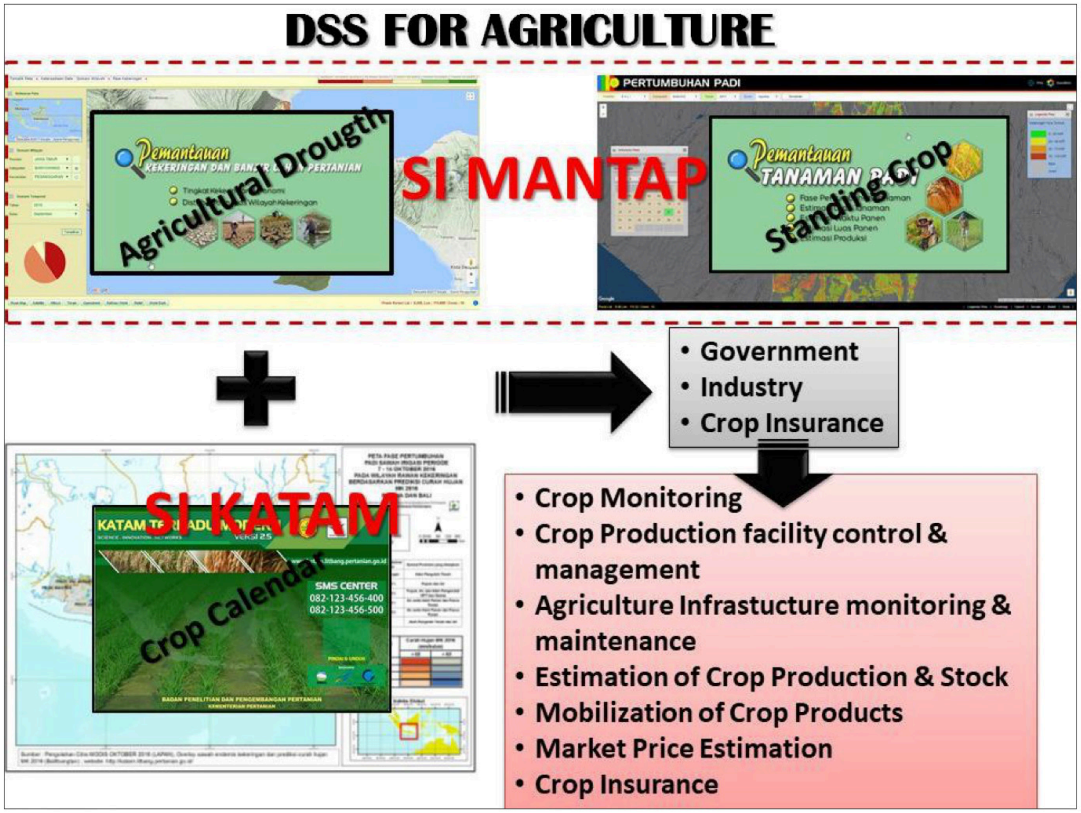
• Since 2014, a remote sensing-based information system has been implemented in Indonesia for crop monitoring to help policy makers in agricultural management.

• Improvement of the model is required to achieve the expected accuracy level as input reference for policy makers.

Selected 10 top provinces for upscaling of SAR modeling of paddy




STANDING CROP (MODIS Terra)
PETA FASE PERTUMBUHAN PADI SAWAH IRIGASI PERIODE 17 - 24 JANUARI 2018 PADA WILAYAH RAWAN KEKERINGAN BERDASARKAN PREDIKSI CURAH HUJAN MH 2017/2018 P. JAWA DAN BALI
Since 2014: IAARD has implemented STANDING CROP (SC) of Rice using 8-day composite MODIS Terra for agriculture monitoring.
Since 2016: Landsat-8


DSS FOR AGRICULTURE
Agricultural Drought
SI MANTAP
PERTUMBUHAN PADI
Standing Crop
SI KATAM
Crop Calendar
• Government
• Industry
• Crop Insurance
• Crop Monitoring
• Crop Production facility control & management
• Agriculture Infrastucture monitoring & maintenance
• Estimation of Crop Production & Stock
• Mobilization of Crop Products
• Market Price Estimation
• Crop Insurance

Vietnam

Ho Chi Minh City Vietnam National Space Center (VNSC) / Vietnam Academy of Science and Technology (VAST) performs surveying, process and analyse data, and develop tools and models, supported by Centre d'Etudes Spatiales de la BIOsphère (CESBIO), France.

VNRice (2017-2020)

This is a state-level VNSC applied research project on the use of multi-temporal, multi-resolution optical and radar remote sensing data for rice planted area monitoring and rice yield/production estimation in the Mekong and Red River Deltas.

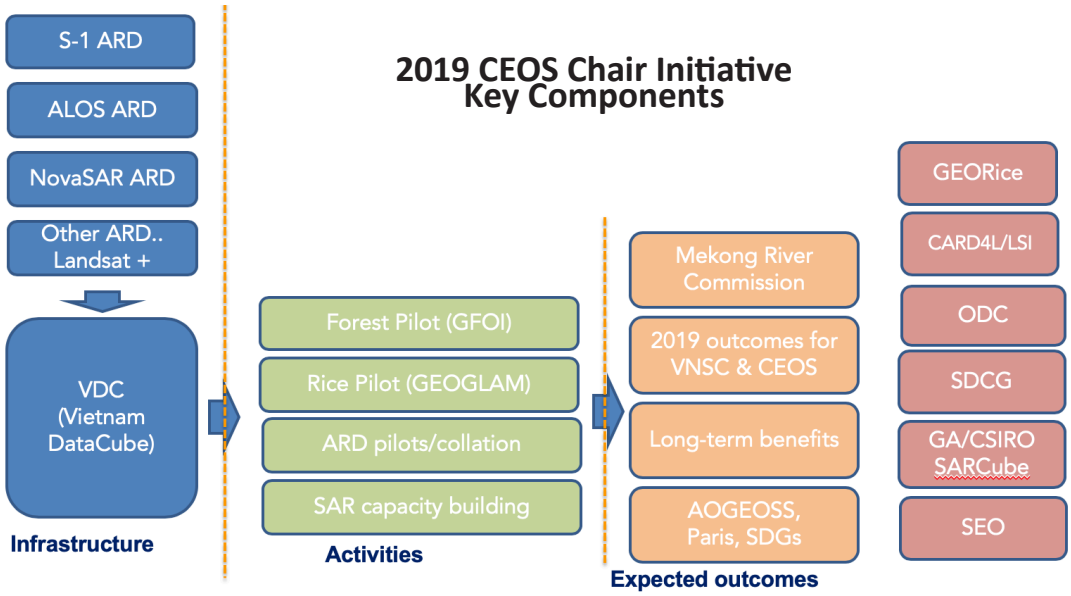
Vietnam Data Cube & 2019 CEOS Chair Initiative

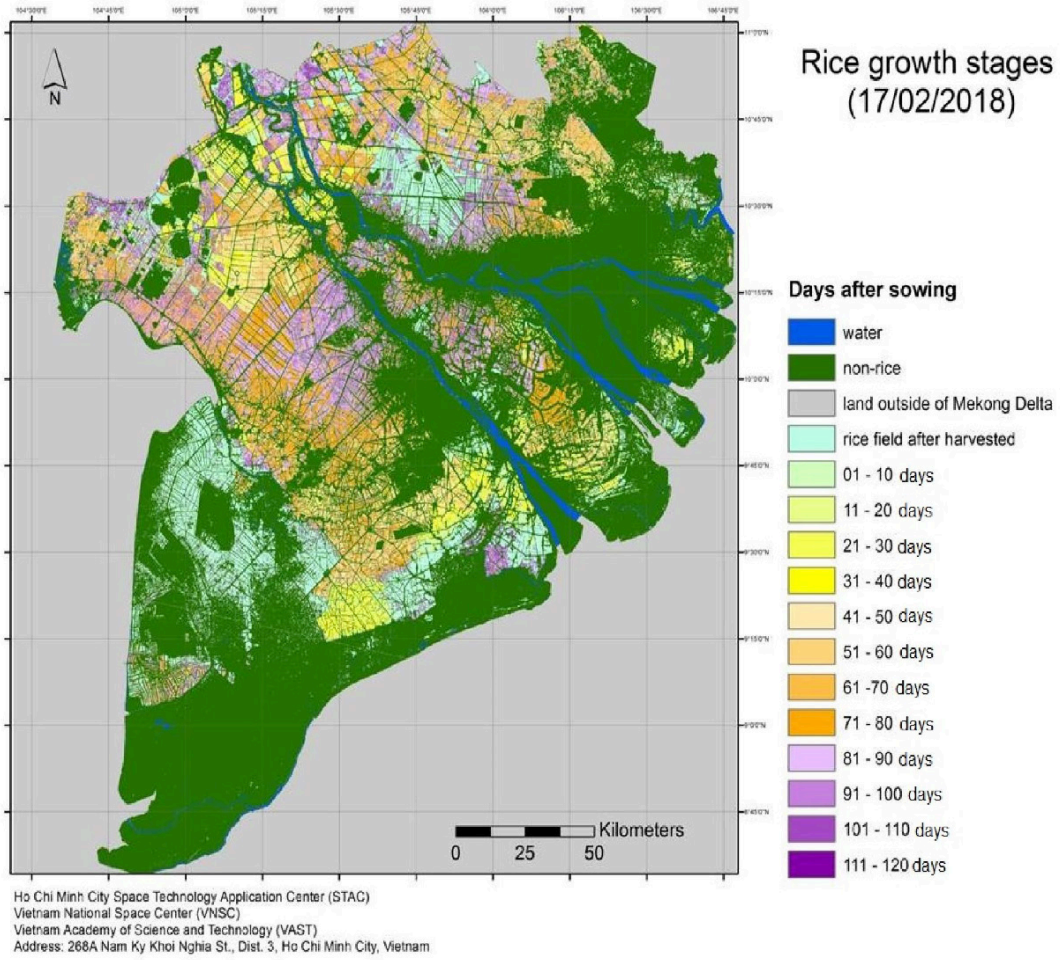
Over the last few years, CEOS Agencies have prioritised efforts to make EO data more accessible, through initiatives such as Analysis Ready Data, Open Data Cube, and the Copernicus Data Information Access Services (DIAS).

As the CEOS Chair for 2019, Vietnam seeks to integrate many of these ongoing CEOS activities in support of regions most affected by climate change, with a focus on the tropical monsoon climate countries in South East Asia (Cambodia, Lao PDR, Thailand, and Vietnam).

By putting the focus on this specific region, the VAST-VNSC CEOS Chair hopes to enhance the contribution and cooperation of CEOS Agencies in the region, identify new Earth observation users, and to respond effectively to their needs through integration across the full range of Earth observations by promoting the sharing of CEOS Agency data and algorithms, and by improving access to and the use of such data via modern data architectures. Integrating existing CEOS thematic acquisition strategies and making data and algorithms available to the international community will enable studies and applications in relation to forests, agriculture, disasters, climate, carbon, and water.

The 2019 Chair Initiative concept is one of a regional observatory, which is intended to continue beyond 2019 and also be extended to other hotspot regions.





The project will leverage and expand the Open Data Cube implemented at VAST-VNSC in Hanoi, Vietnam (officially launched 6 March 2018), to users in the Mekong Delta region (Cambodia, Lao PDR, Thailand, and Vietnam).

The target products include the following for rice:

- Rice Maps
- Rice Phenology / Growth Stage
- Rice Crop Production / Yield Estimation

Asia-RiCE members are playing a key role in the development:

- **JAXA/RESTEC are porting the INAHOR algorithm and providing ALOS analysis-ready data (ARD).**
- **CNES/CESBIO/GEORice have supplied and ingested Sentinel-1 ARD into the VNDC.**
- **CESBIO and VNSC have implemented rice crop mapping algorithms and demonstrated preliminary results using the VNDC.**

Results from VNRice, GEORice, and INAHOR will all be compared and analysed.

For more information on the 2019 CEOS Chair Initiative, please see the website:

http://ceos.org/2019chairinitiative/

Cambodia

One of the newest members of the Asia-RiCE team, Cambodia, through the Department of Planning and Statistics, MAFF, is working to promote rice planted area and production estimation using space-based technologies.

Until now, paddy area and yield related information has been collected through typical data collection methods involving local level surveys, however, DPS/MAFF don't have any means to check the quality of statistics reported by these local offices.

The aim was to develop a new information collecting method that would be cost-effective and complementary to present rice crop area and production estimations, to support statistical information generation and to verify statistics reported by local offices.

Prototype Objectives

1. Develop a standardized, accurate, cost efficient and timely method to monitor rice crop area.

2. Build capacity of SAR data processing (INAHOR with ALOS-2 data).

3. Create maps on land use/land cover as baseline information.

4. Develop a prototype validation framework for statistics reported from local offices with satellite SAR-based information.

INAHOR Validation Workshop and Meeting (October 2018)

Participants from DPS, district offices (four districts) and RESTEC/JAXA validated statistical values using rice-planted areas and maps estimated using INAHOR (for Battambang province) and identified the causes of differences between the official statistics and the INAHOR results.

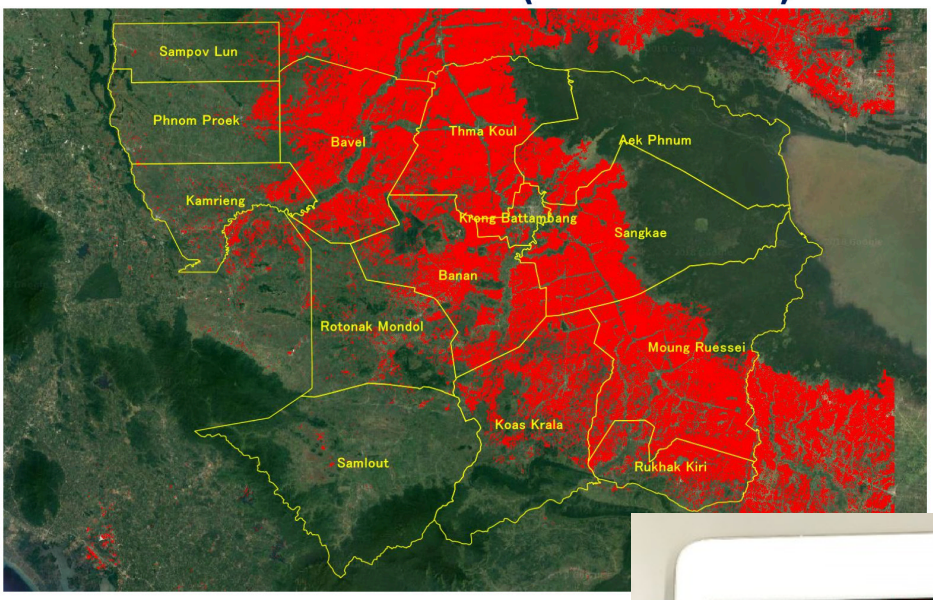
Summary

- The judgement level of rice planted area by INAHOR is acceptable.
- INAHOR can be used as a tool to make and verify the report values.
- Especially, it can be expected that the accuracy of the report value will be improved by the utilization of INAHOR maps by the district offices.
- Further demonstrations for major rice producing provinces are needed.

Next Steps

- Expand the validation framework to the dry season or other provinces, and establish validation work.
- Secure budget for the operational implementation of the validation work.
- DPS and MAFF expect JAXA to continue with the provision of ALOS-2/INAHOR or seasonal rice-planted area maps derived from ALOS-2, and to refine INAHOR to identify rice planted area which is cultivated two times per rainy season.

2017 Wet Season Rice (Normal Year)



^ Rice planted areas from statistics were highly consistent with the INAHOR results.

> Local officers used the map function on smartphones to validate reported values during field visits.

Japan

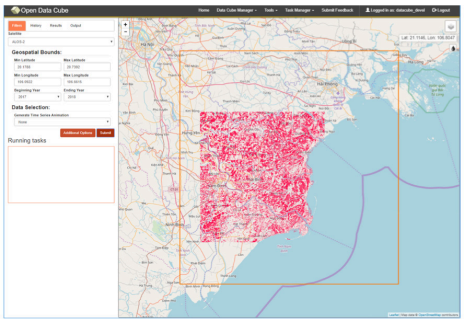
INAHOR

JAXA/RESTEC provide the INAHOR (INternational Asian Harvest mOnitoring system for Rice, crop planted area estimation software) and JASMIN (agro-met information provision system for outlook) tools to assist the ASEAN Food Security Information System (AFSIS) and target country agricultural statistics experts in preparing AMIS outlooks for Asia-RiCE.

Through an Asian Development Bank Technical Assistance project and SAFE projects under APRSAF, INAHOR (using ALOS-2) has been demonstrated to achieve mapping accuracies of 80-90% for target provinces (in Laos, Thailand, Vietnam (North), Philippines, Myanmar, Cambodia, and Indonesia).

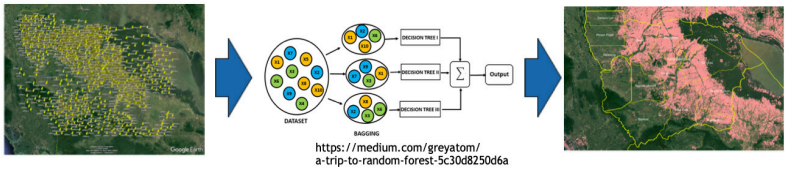
INAHOR-NEO, a machine learning version of the software was developed in 2018. Originally, users would input two threshold values based on field survey results, however with INAHOR-NEO much larger training datasets are used to automatically produce classification models using a machine learning algorithm. Higher accuracies can be achieved with this new version.

A Python version of the INAHOR tool has also been developed for use specifically with the Open Data Cube.



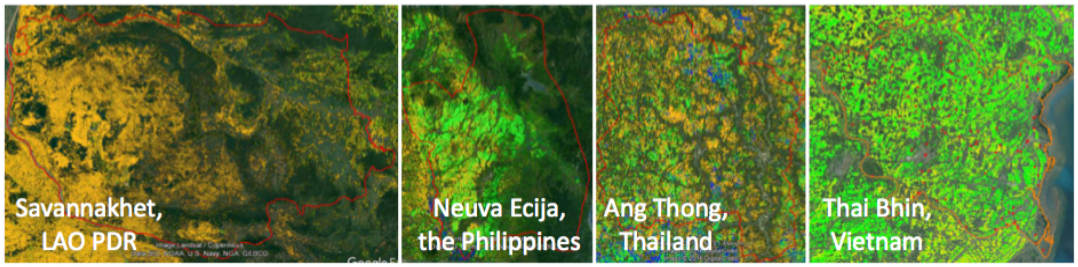
ALOS-2 Analysis Ready Data (ARD) for Agriculture

CEOS, through its Land Surface Imaging Virtual Constellation (LSI-VC) has developed the concept of CEOS Analysis-Ready Data for Land (CARD4L) – satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user



Training Data (Rice/Non-Rice) | Machine Learning (e.g. Random Forest, Deep Learning etc.) | Rice-planted Area

INAHOR has been updated in 2018 to incorporate machine learning capabilities



INAHOR Outputs

effort and interoperability both through time and with other datasets.

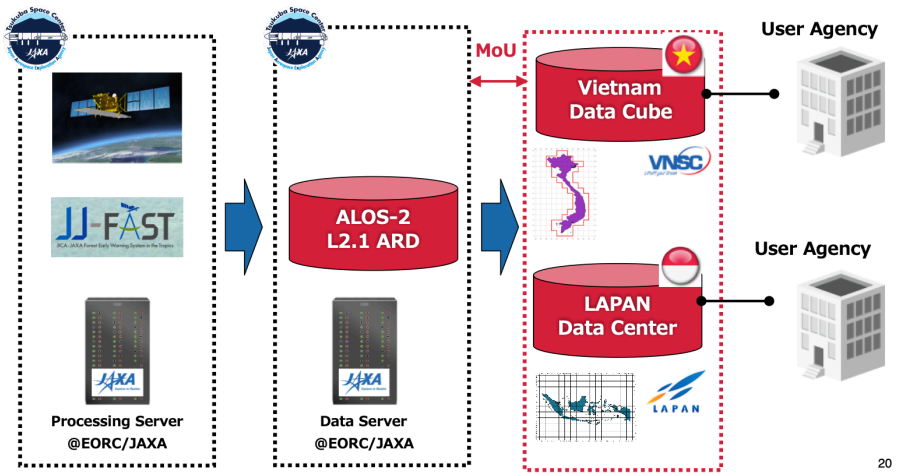
http://ceos.org/ard/

JAXA is a co-lead of the SAR CARD4L specification and also supplies ALOS-2 ARD for agricultural monitoring purposes. This ARD is processed using SIGMA-SAR and was originally processed for the JICA-JAXA deforestation monitoring project, JJ-FAST (JICA-JAXA Forest Early Warning System in the Tropics). It is ortho-rectified/slope-corrected gamma nought data.

ALOS-2 PALSAR-2 ARD is currently being supplied by JAXA to Vietnam and Indonesia for their Data Cube projects, including the 2019 CEOS Chair Initiative.

2018 Summary

- The INAHOR (rice-planted area mapping) software has been demonstrated in collaboration with Southeast Asian countries.
- A new classifier (random forest) with training data showed higher accuracy compared to conventional INAHOR.
- The algorithm in INAHOR is currently being modified to improve the accuracy (e.g., fusing multi-freq/pol and optical data, applying machine learning approaches).
- ALOS-2 ARD for agricultural monitoring is being processed, stored on JAXA servers, and transferred to Vietnam and Indonesia.
- With the launch of GCOM-C, agro-met related GCOM-C products with higher spatial resolution (solar radiation, land surface temperature, vegetation index) will be available on JASMIN after cross-calibration with current MODIS products.



Data Transfer Network for ALOS-2 ARD

Conclusion

A Critical and Unique Space Agency Service

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 GEOGLAM and CEOS.

As a result of Asia-RiCE, improved rice production estimates are being generated at national, regional, and global scales – valuable inputs to the GEOGLAM Crop Monitor and AMIS Market Monitor that would not otherwise be present.

Asia-RiCE thanks all CEOS agencies for their unique and critical contributions.