Calibrating LAI Parameter with Remote Sensing Data for SIMRIW-RS in Thailand

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Outlines

- Rice production statistics
- Current tools for rice yield estimation
- SIMRIW-RS: a viable tool based on remote sensing
- Data Collection
- Methodology
- Results and Discussion
- Conclusion and future work

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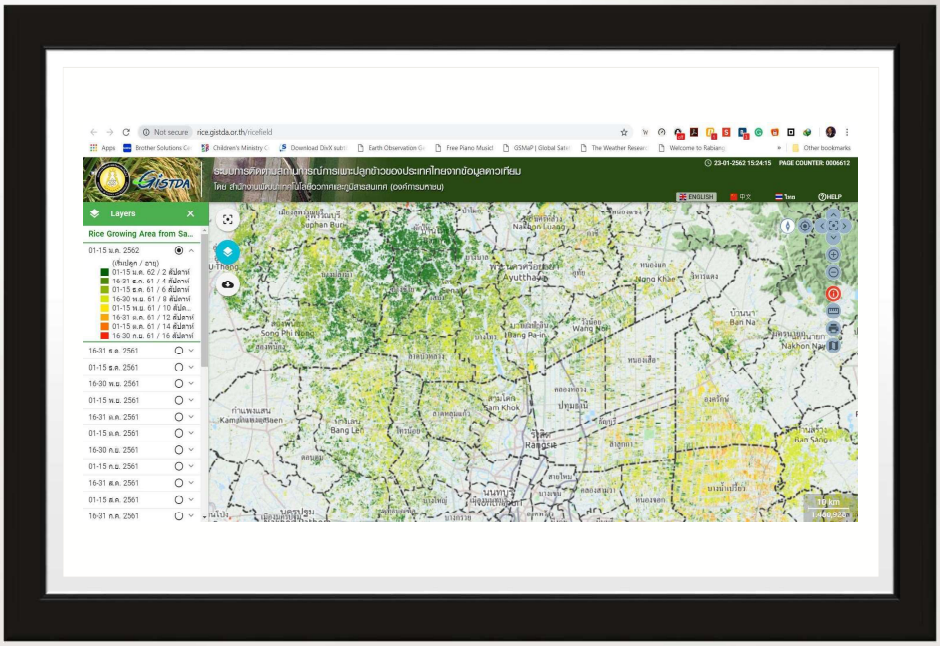
Vital Statistics about Rice Production

- World demand for rice is increasing (1.46% annually for the last decade).
- Climate change (precipitation deficit/temperature rise) reduces rice production at an alarming rate.
- More than 9.2 million hectares and 16 million farmers are involved in rice production in Thailand.
- An ability to accurately estimate rice yield is imperative for adaptation plan to climate change.
- Office of Agricultural Economics (OAE) is responsible for this information but the results are debatable.

What can we do about it?

Current Tools for Rice Yield Estimation (1)



Rice acreage monitoring using remote sensing data provided by GISTDA

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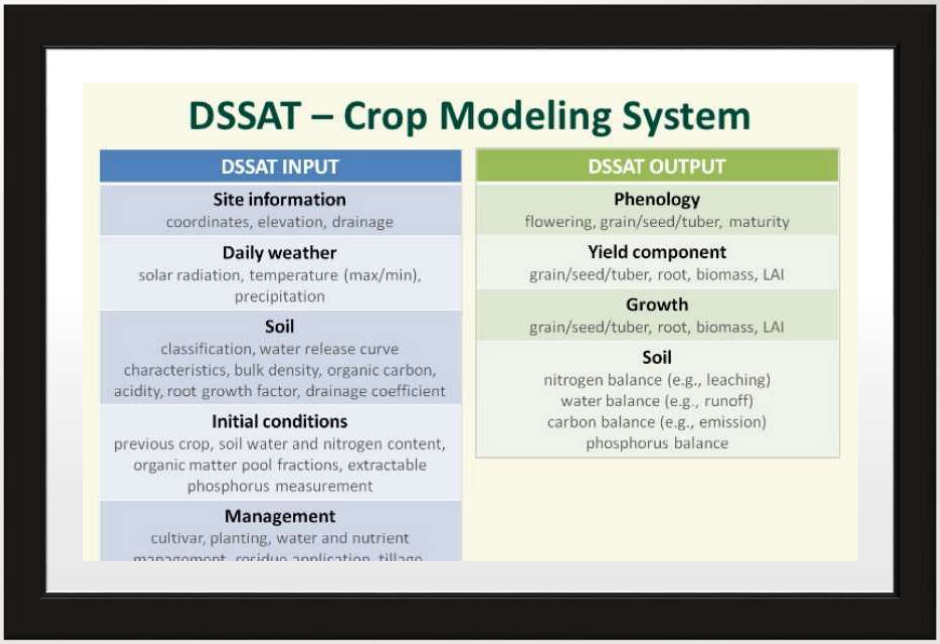
Current Tools for Rice Yield Estimation (2)—DSSAT

Very user-unfriendly



SIMRIW-RS: a viable tool based on remote sensing

- A rice crop simulation model that incorporates weather data, farm management, field parameters, cultivar parameters.
- At least planting date and daily weather are required for simulation.
- Other relevant parameters (e.g., cultivar, water stress) are embedded in LAI value generated by the simulator. Then yield can be estimated at the end.
- However, to achieve good results, this LAI value must be calibrated twice with field measurement in early stage.
- This field measurements are supposedly obtained from remote sensing so that regional-scale yield estimation can be realized!

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Previous Achievement based on SIMRIW-RS

Vientiane, Laos PDR (2013)

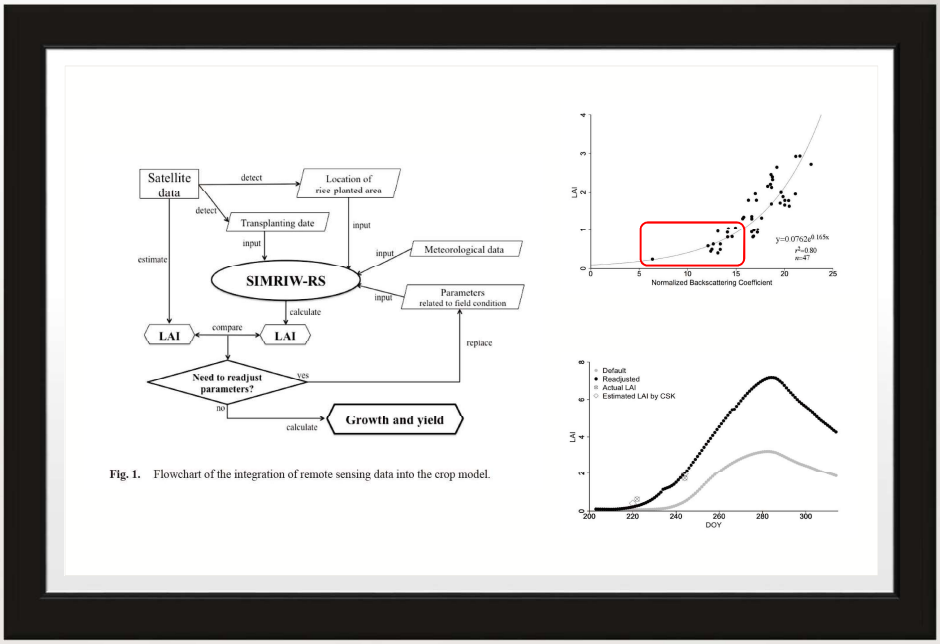

Fig. 1. Flowchart of the integration of remote sensing data into the crop model.

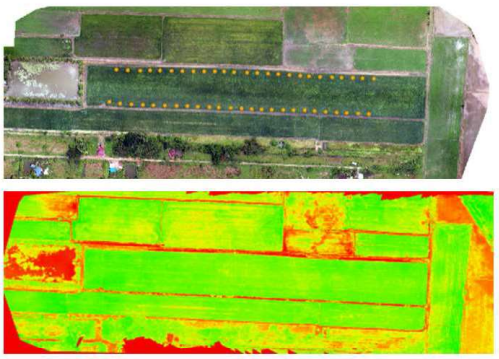

Fig. 1. The experimental field (upper) Orthorectified image and sample plot locations shown in orange dots, (lower) NDVI product (values increase from red to green colors)

TABLE 1. FIELD SURVEY DATES AND AVERAGE LAI VALUES

No.	2017			2018		
	Date	*DAP*[a]	*Average LAI*	*Date*	*DAP*	*Average LAI*
1	01/06	37	2.78	16/05	21	0.83
2	09/06	45	4.06	30/05	35	2.79
3	16/06	52	4.47	07/06	43	3.94
4	23/06	59	4.58	20/06	56	4.54
5	30/06	66	6.00	29/06	65	4.67
6	07/07	73	6.42	09/07	75	4.70
7	27/07	93	3.41	01/08	98	4.36
8	01/08	98	–			–

[a] DAP stands for Day After Planting

Data Collection (1)

THE EXPERIMENTAL FIELD IS A 6.88-HECTARE PADDY FIELD LOCATED AT NONGCHOK DISTRICT IN BANGKOK.

50 PLOTS WERE SETUP.

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Fig. 2. Field survey activities.

Data Collection (2)

LAI (LAI-2200), NDVI/EVI2 (PARROT SEQUOIA/DJI PHANTOM), YIELD, WEATHER DATA (AWS)

Methodology

- Estimating LAI from Remote Sensing Data
  - Data from the 1st – 3rd surveys were used to find relationship between actual LAI and EVI2/NDVI from drone images.
  - Coefficient of determination, R^2, and RMSE are evaluated.
- Evaluating Rice Growing Period for SIMRIW-RS Calibration
  - Estimate LAI values to calibrate SIMRIW-RS, based on Method I: values from the 1st and 2nd surveys, Method II: values from the 2nd and 3rd surveys, and Method III: value from the 1st and 3rd surveys.
  - RMSE of the simulated LAI with the 4th – 6th survey and MPE of the simulated yield are evaluated.
- Resizing pixel size of drone image
  - Resizing pixel size from 10x10cm^2 to 1x1m^2 and repeat the experiment steps.

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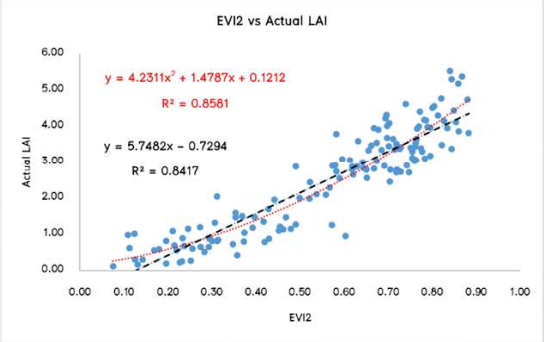
Results

ESTIMATING LAI FROM REMOTE SENSING DATA



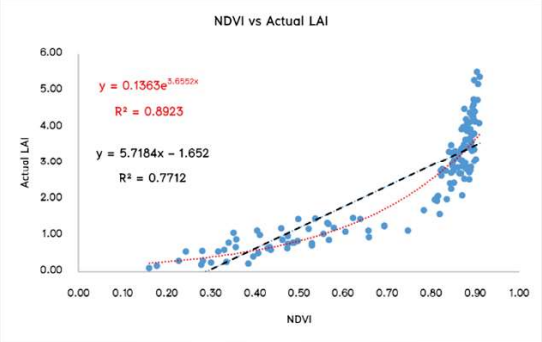
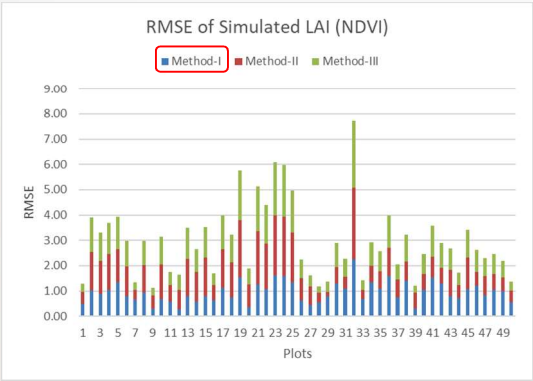


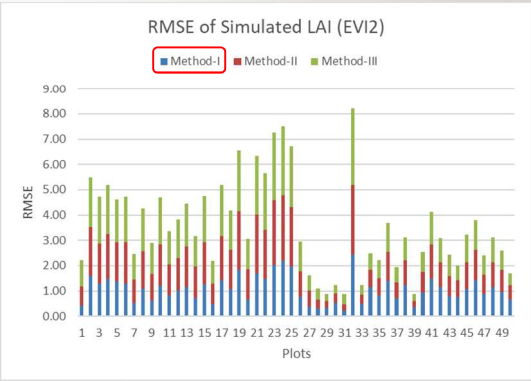
TABLE 2 PERFORMANCE COMPARISON BETWEEN LINEAR AND NONLINEAR REGRESSIONS BASED ON EVI2/NDVI PRODUCTS

	Linear Regression	Nonlinear Regression
EVI2	$LAI = 5.7482 * EVI2 - 0.7294$ $R^2 = 0.8417, RMSE = 1.205$	$LAI = 4.2311 * EVI2^2 + 1.4787 * EVI2 + 0.8581$ $R^2 = 0.8581, RMSE = 1.276$
NDVI	$LAI = 5.7184 * NDVI - 1.652$ $R^2 = 0.7712, RMSE = 1.376$	$LAI = 0.1363 * e^{3.6552 * NDVI}$ $R^2 = 0.8923, RMSE = 1.587$

Results

EVALUATING RICE GROWING PERIOD FOR SIMRIW-RS CALIBRATION





Method-I where DAP equals 37/45 days yield the best RMSE

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Results

RESIZING PIXEL SIZE OF DRONE IMAGE

TABLE 3 PERFORMANCE OF EVI2 AND NDVI CALIBRATIONS ON SIMULATED LAI AND SIMULATED YIELD.

Product	Mode	Method	Pixel Sizes		Diff.
			10x10cm²	*1x1m²*	
EVI2	RMSE (LAI)	I	1.06	1.05	0.02
		II	1.22	1.26	−0.03
		III	1.29	1.30	−0.01
	MPE (Yield)	I	−6.17	−7.31	1.14
		II	−10.27	−11.55	1.27
		III	−11.52	−12.26	0.74
NDVI	RMSE (LAI)	I	***0.95***	***0.93***	0.02
		II	1.04	1.05	0.00
		III	0.97	0.96	0.01
	MPE (Yield)	I	*−2.07*	*−2.25*	0.18
		II	−9.68	−9.92	0.23
		III	6.32	6.32	0.00

NDVI product provides the best results for both simulated LAI and estimated yield.

Discussion

- Although NDVI yields higher RMSE when estimating LAI for model calibration, overall it achieves the best results.
- SIMRIW-RS tends to be conservative (under-estimate) by default, thus normalizes the effect of NDVI.
- Early calibration (Method-I) confirms the result of previous study, because of lower dispersion of estimated LAI values.
- Upsizing the drone image has no significant impact on the results, hence, our methodology is scalable to coarser image such as medium resolution satellite data.

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Conclusions and future work

- SIMRIW-RS is a potential tool used for rice yield estimation in Thailand, with proper calibration, more than 90% accuracy on yield estimation can be achieved.
- Major rice cultivars need to be examined, such as white rice and jasmine rice.
- Sentinel images need to be explored in place of drone images.
- Few more experimental sites need to be setup and collect data. Ayutthaya and Roi-et are planned.