Project for Profitable Irrigated Agriculture in Western Bago Region (Satellite data analysis)

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JAPAN INTERNATIONAL COOPERATION AGENCY

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Summary

1. Objectives

Irrigation facilities rehabilitated by the “West Bago Irrigation Development Project", and the “Profitable Irrigated Agriculture Project in the West Bago Region (PROFIA)” are concurrently being implemented in order to enhance the incorporation of the profitable agricultural model into the private sector's activities through irrigation agriculture (Figure 1). This study aims to investigate the potential for utilizing satellite data for the evaluation of PROFIA, as well as the experimentation of satellite data analysis applied for information-gathering tools in an area where a statistical survey system for collecting complete data has not been established.

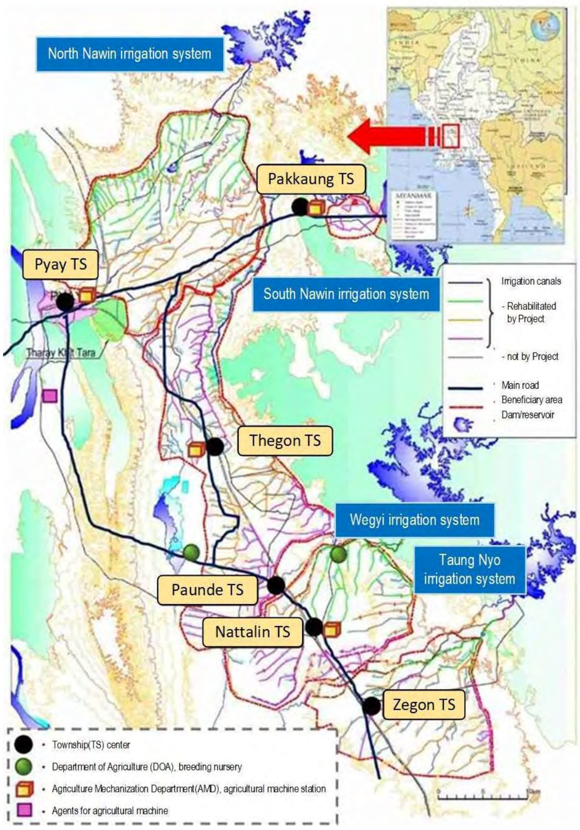


Figure 1 Project Area
(Bago west Irrigation System)

2. Evaluation Contents

The production trends relating to paddy rice, which is closely related to the Project output, were analyzed for Items (1) to (3). In particular, determining the agricultural productivity (unit yield, etc.) in Item (3), which is directly linked to farmer income, was a priority issue.

(1) Tracing of planting area, period, and cycles
(2) Confirmation of planting area by crop in comparison with cropping calendar
(3) Estimation of crop production and yield

3.Implementation of Satellite Data Analysis and Field Survey

The analysis was conducted on both satellite data and field surveys (Farmer Interviews and Yield Survey). First, the cropping area and the number of crop periods were traced in satellite data; in addition, the cropping area for each crop was estimated from the results of the satellite data analysis together with the cropping calendar confirmed by Farmer Interviews. Based on the results of the Yield survey, a re-analysis was conducted to determine (3) production yield.

4. Farmer Interviews and Field Survey

Based on the findings of Farmer Interviews, the cropping period of planting and harvesting time were confirmed, and the rice production was measured by the Yield survey for selected plots in terms of both quantity and quality of rice. Selection keys were as follows: (1) use of certified seeds; (2) differences in cropping methods; and, (3) differences in varieties. According to the survey, the yield of 35 to 105 baskets/acre (1.8 to 5.4 ton/ha) was measured in 18 plots, while results varied depending on the variety, cropping method, and the use of guaranteed seeds.

5. Satellite Image Analysis

The cropping area was estimated using both the optical sensor and SAR sensor data, while the rice sensor yield was determined using solely optical sensor data. The procedure for calculating the acreage and the yield was as follows:

6. Estimation of Paddy Rice Cropping Area

The cropping area was calculated by tracking the crop growth cycle from the SAR backscatter and the time-series variation of the Spectral reflectance characteristics (Vegetation Index - See Figure 2), in comparison with the cropping calendar obtained from Farmer Interviews.

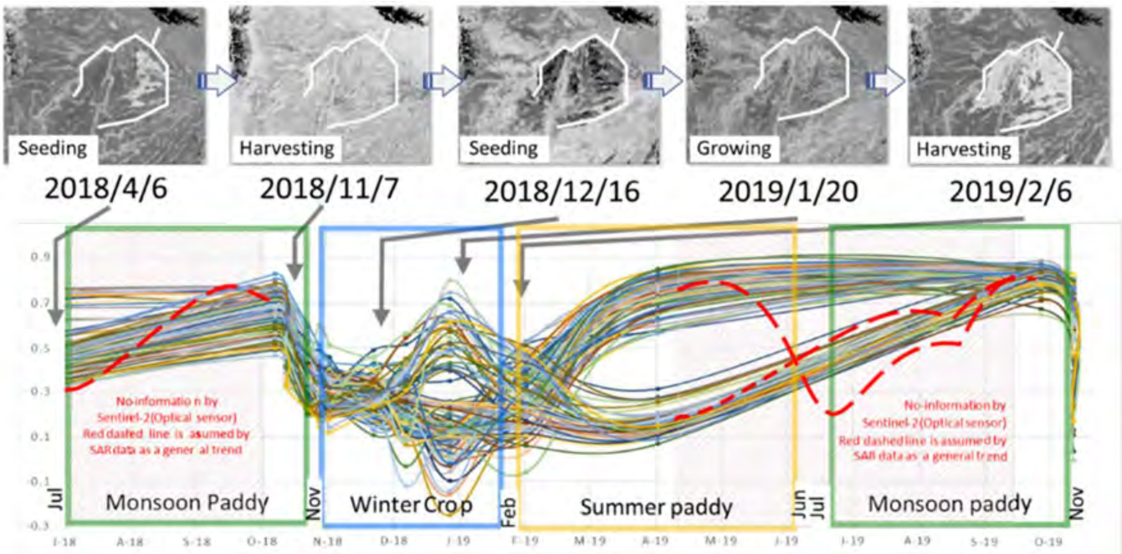


Figure 2 Crop phenology（Changes of NDV）

7. Estimation of Rice Yield

The leaf area index (LAI) was calculated according to optical sensor data in the rice booting period (in October). A relational expression (Regression Model) was also created from the regression analysis while the measurement value of rice production was obtained from the Yield survey. Furthermore, the regression model was applied to convert LAI to rice yield for the Project area. LAI was then used for the delineation of rice yield distribution map (See Figure 3).

8. Expansion of Application Method

The aim of the Project was to obtain necessary information on the actual production of "cropping area" and "crop yield" of major crops by using satellite data to be utilized in the evaluation of agricultural projects. Such information purports to provide basic data for planning agricultural policies. In other large-scale irrigation areas in Myanmar and similar ones in other countries, on-surface surveys are often unable to provide complete statistical information. In such areas, satellite data analysis is considered a scientific measure to offer useful information in order to determine the actual condition of agricultural production. In the Analysis for "Estimation of Cropping Area", the current situation of agricultural land use was visualized by spatial information (referring to quantity), while "Estimation of Crop Yield" targeted quantifying productivity (referring to quality) in the cropping area. Based on these advancements, evaluations on improving farm incomes have become feasible. The Analysis represents an example of satellite data application for Project evaluation. For projects covering the areal extent, the use of satellite data in particular is expected to serve as a powerful tool due to its ability to collect information of similar volume across wide areas, in a simultaneous, systematic, and repeated manner. This method is used not only for project evaluation, but also for improving basic practices in future project implementation, project formation, and cooperation.

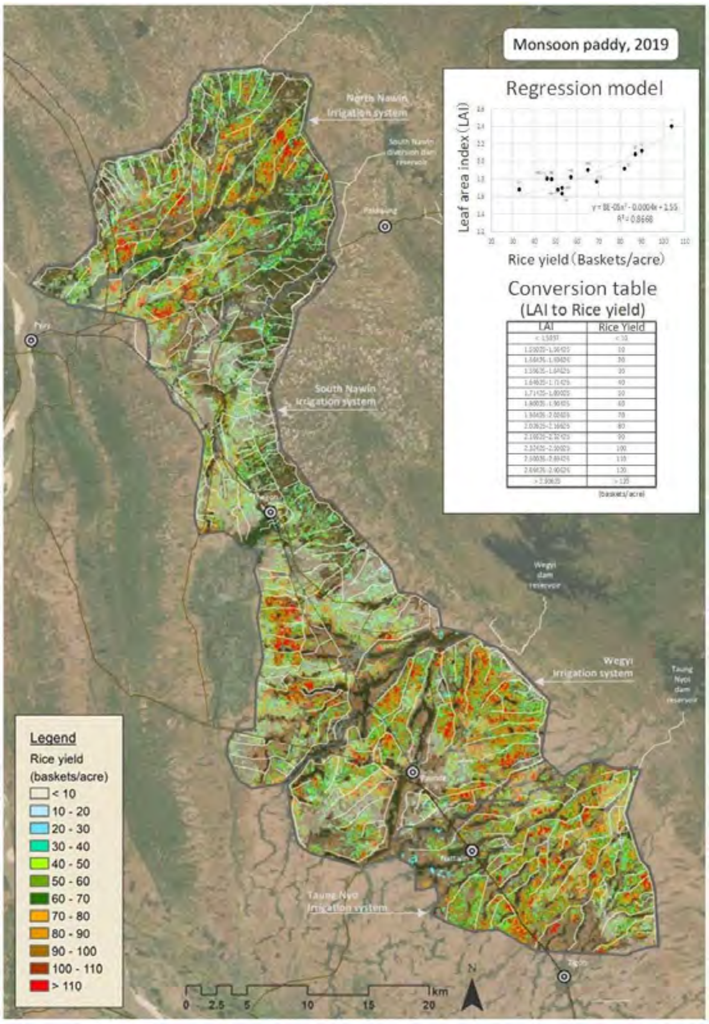
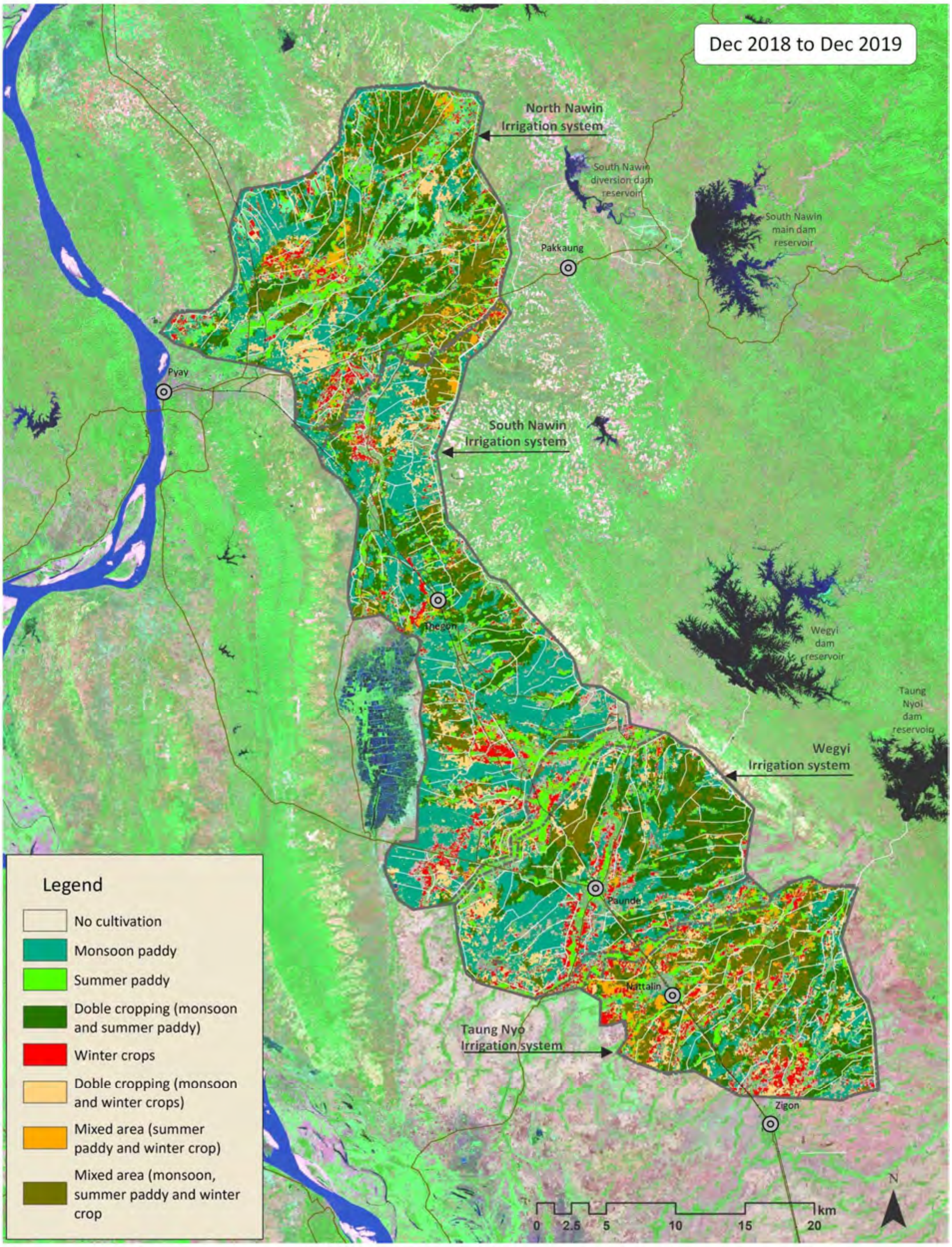


Figure 3 Spatial distribution of rice yield

Example of Satellite Data Analysis (Agricultural Land Use)

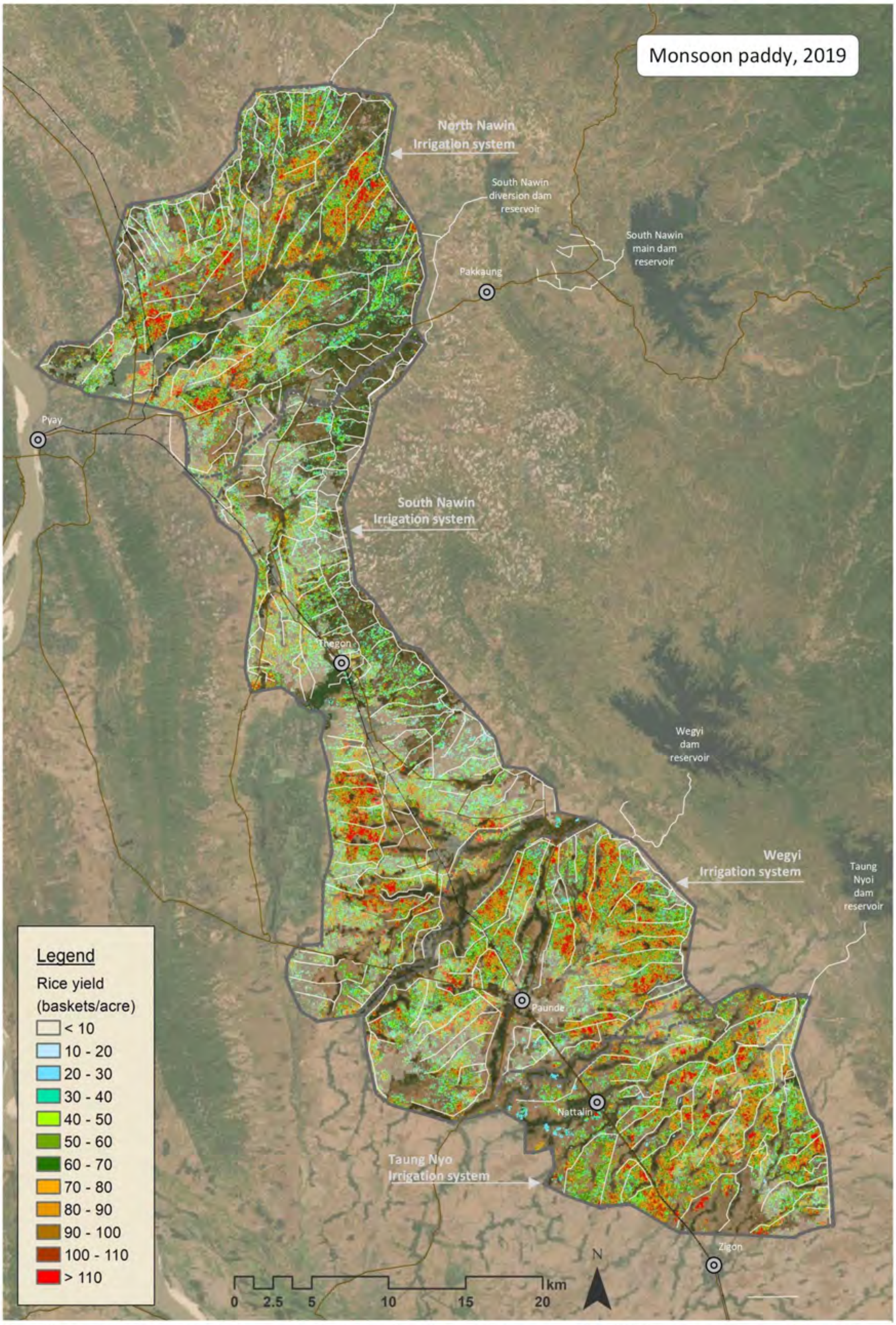
Type of Cultivation in PROFIA Project Area



Note: Cultivation type is determined by the changes of NDVI from Dec. 2018 to Dec. 2019 in comparison with cropping calendar.

Example of satellite data analysis (Agricultural Productivity)

Spatial Distribution of Rice Yield of PROFIA Project Area



Note: Rice yield is estimated by the regression model based on the rice yield survey made in Wedgyi irrigation area on Nov. 2019

Photos of Field Survey (Rice Yield Survey & Farmer Interviews)

Rice yield survey - crop cutting method by spots -
(selection of survey spot using PVC frame)

Rice yield survey - crop cutting method by spots -
(reaping rice at the survey spot)

Rice yield survey - crop cutting method by spots -
(threshing sampled rice)

Rice yield survey - crop cutting method by spots -
(Counting number of grains for sampled rice stocks)

Rice yield survey - crop cutting by combine harvester -
(harvesting operations and transportation)

Rice yield survey - crop cutting by combine harvester -
(measuring weight of rice grain after drying)

Interview survey (at plot)

Interview survey (at villagers' office)

Contents

Appendix

1 Background of Analysis

In Myanmar, the loan aid project known as the “West Bago Irrigation Development Project (the project had been conducted since 2016, hereinafter referred to as“ Project”) was signed in 2014 and completed in September 2019, and the irrigation facilities were repaired. Regarding soft components, the “Profitable Irrigated Agriculture Project in the West Bago Region (PROFIA)” was promoted to develop a profitable agricultural model incorporating private enterprise activities through irrigated agriculture.

In terms of project evaluation, the planted area for each crop was estimated by means of spatial information technology (such as ALOS-2 data) to ensure quantitative and efficient evaluation of the project’s effect in raising agricultural profitability in the Project area[1].

These achievements have been used as baseline data before the Project was implemented; however, the year 2020 marks the sixth year since project implementation with only one year remaining till it is finalized. Upon the Project completion in 2020, evaluation tools that are capable of effectively and quantitatively evaluating the results of the Project activities are urgently required for this analysis.

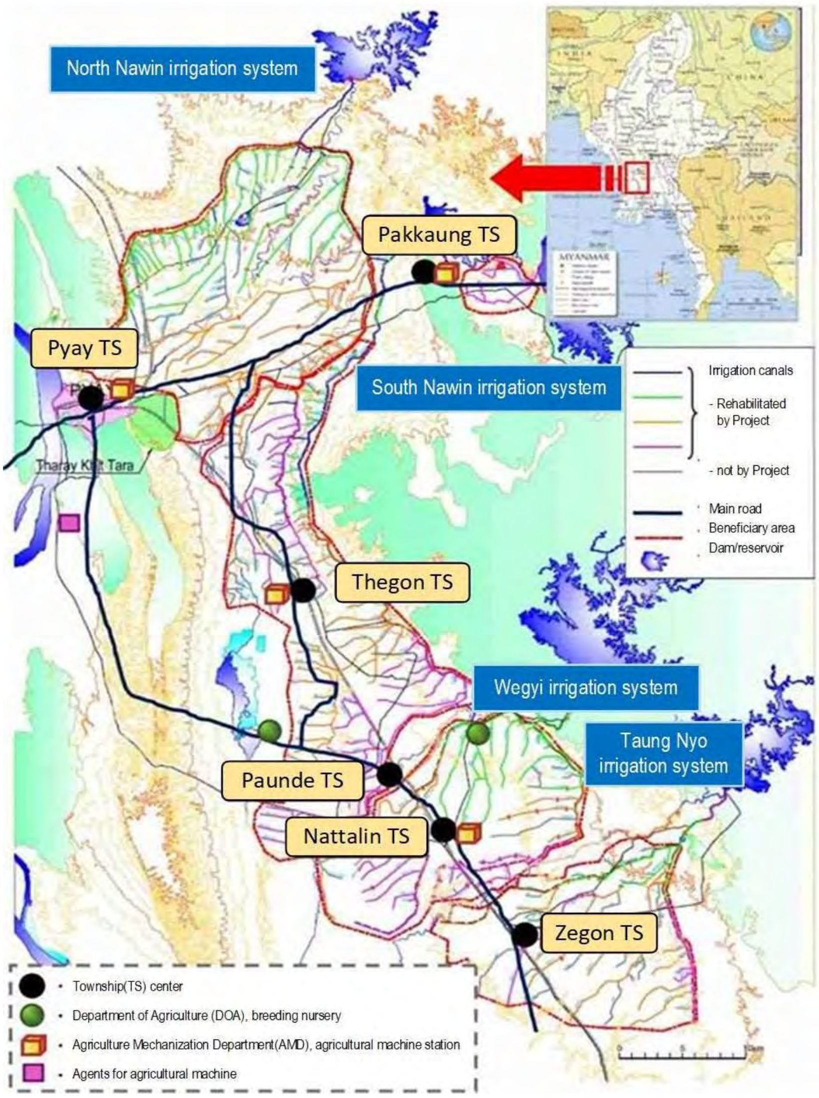


Figure-1 Location map of Project area

Accordingly, the effects of the Project were quantitatively evaluated by using available satellite data together with ground information. At the same time, the possibility of applying this method to collect information in areas with similar issues was examined.

Specifically, the Analysis aimed to collect information on agricultural production in the "cropping area" of major crops and its "production yield" to

[1] In the West Bago area, the cropping area is estimated using ALOS-2 data (SAR sensor data) in cooperation with JAXA. The available data of ALOS-2 in Myanmar so far has been about 10 times a year, and the observation is made based on the StripMap mode (28MHz) with a resolution of 10m.

promote future agricultural projects. Although this type of information is substantial for agricultural policies, it is often challenging to collect complete data in an area where statistical survey systems have not been established (such as other large-scale irrigation areas in Myanmar and/or similar areas in other countries). In such areas, satellite data analysis has proven to be a powerful scientific measure for determining agricultural production in lieu of an on-surface survey.

In the Analysis, the current status of farmland use was estimated by spatial information (quantity) and calculating the unit yield of farmland (quality). Based on both data, the farmers' income was evaluated. In particular, for projects covering a broad area, satellite data analysis has demonstrated its efficacy as a scientific tool due to advances allowing vital information to be collected widely, simultaneously, systematically, and repeatedly. It is considered an effective tool even for improving the basic policies relating to future projects, project formation, and enhanced cooperation.

2 Objective of the Analysis

As described above, evaluation tools using satellite data were developed throughout the various phases of the Project or by other evaluation schemes to assess the actual situation of crop production in the target area. Since these trials were designed to obtain objective and quantitative information on the production trends relating to major crops, they yielded essential information for effective planning of development projects. For large areas widely spread over a number of fields, such as the area of the Project, covering 87,000 ha (See Figure-1), it is imperative to ascertain the actual condition of the soil and crop cultivation in the project planning phase and its management.

This satellite data analysis (hereinafter referred to as "the Analysis") also analyzed the following items (1) to (3) to determine the production trends of major crops in the project target area. In the Analysis, evaluation index on the Analysis is set as "Rice planting area and Yield".

To fulfill the evaluation index, the following three (3) steps are planned in the Analysis.

(1) Tracing of planting area, period, and cycles

(2) Confirmation of planting area by crop in comparison with the cropping calendar

(3) Estimation of crop production and yield

"(1) Tracing the planting area, period, and cycles" is carried out before the Fieldwork as this information is used for field selection in the field survey. "(2) Confirmation of planting area by the crop" is conducted in the Fieldwork. The crop phenology (periodic plant cycle as a result of satellite analysis) is collated to specific areas by comparing between the cropping calendar and cultivation history (crop phenology shape). "(3) Estimation of crop production and yield" is premised on conducting a Yield survey and Inventory survey for farmers, while subsequent work is conducted after the Fieldwork.

Step (3), measuring crop production and yield, is particularly difficult to estimate solely by satellite data analysis; therefore, conducting an In-situ Yield survey and Inventory survey are required during the harvesting period.

Furthermore, due to the heavy burden of conducting In-situ Surveys, analysis is often carried out on paddy rice (or wheat), which is the main crop, with fewer studies for secondary crops such as pulse and sesame.

Due to seasonal limitations relating to the field, the analysis focuses on the main rice crop (the rainy season of 2019).

2-1 Analysis Targets

The PROFIA evaluated in the Analysis aims to promote a profitable agricultural model that incorporates private enterprise activities through irrigated agriculture by activity of rice-certified seeds, careful cultivation with transplantation, and provision of local varieties with stable markets.
Accordingly, the evaluation index on the Satellite Data Analysis is set as “Rice planting area and Yield”. Despite measuring the results of each activity in the Project, it is difficult to identify the plot type solely by satellite information, such as the rice variety and seed quality (such as C/S or non-C/S) being planted. Assuming "the paddy fields tackled in the Project becomes to be a high-yield", the indices of Project achievement was replaced by the expansion of high-yield fields and the increase in overall yield, and proceeded with analysis using satellite images.
The analysis area was the Wegyi irrigation system, which is the test field of the PROFIA and the center of its activities (See Figure-1).

2-2 Existing Studies

With regards to the Analysis objectives (1 to 3) as shown in the previous sub-section, Items 1 to 2 (1: Tracing of planting area, period and cycles, 2: Confirmation of planting area by crop in comparison with the cropping calendar) are practically served by use of SAR sensor images (PARSER-2) in a previous study conducted in Myanmar[2], as shown in Figure-2.

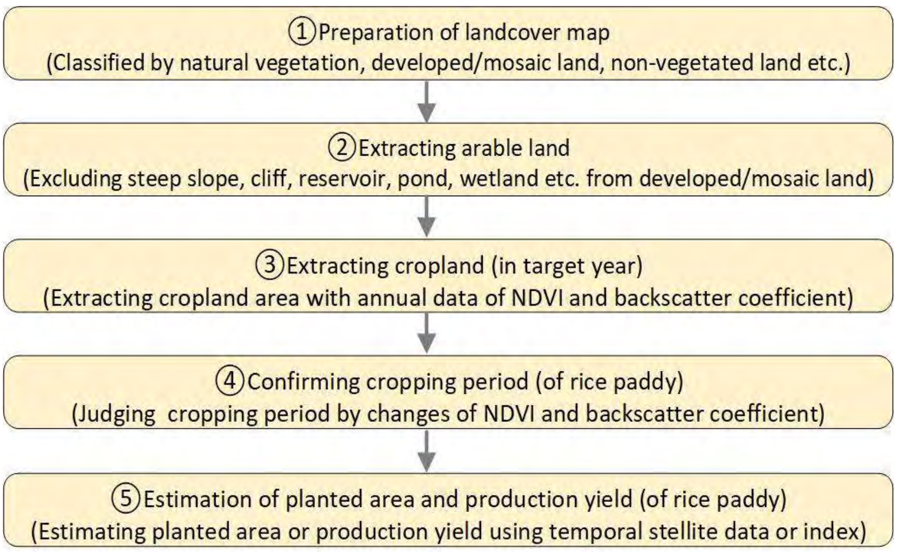


Figure-2 General process of satellite data analysis

This represents a successful case of utilizing SAR sensor images as the period of sowing (July) to growing (September) occurs at the peak of the monsoon, and high-quality optical sensor images were hard to achieve (overcast sky covering the area).
As with the existing study, the analysis of Items 1 to 2 was conducted with images generated by the SAR sensor. Regarding the analysis of Item 3 (Estimation of crop production and yield), since the growing stage takes place after the rainy season (mid-September), an optical sensor image was used, and the wavelength range from visible to short-wavelength was specifically applied for estimating the production yield.

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2 - Monitoring Rice Agriculture across Using Time Series Sentinel-1 and Landsat-8 and PALSAR-2, remote Sens. 2017,9,119 (www.mdpi.com/journal/remotesensing)
- Agriculture Monitoring (GLAM) Project Global

2-3 General Procedures for Satellite Data analysis and Field Survey

As shown in Figure-3, the Analysis was implemented in three stages: the first homework, the field survey, and the second homework. In the first homework, "(1) Tracing of planting area, period and cycles" was carried out by carrying out a preliminary analysis of the cultivation status of the target area; in the field survey, "(2) Confirmation of planting area by crop in comparison with the cropping calendar" was conducted based on the results of the pre-analysis and comparative study for then cultivation calendar; in the second homework, "(3) Estimation of crop production and yield" was performed by comparing the rice yield data obtained in the field survey with the satellite data (processed data).

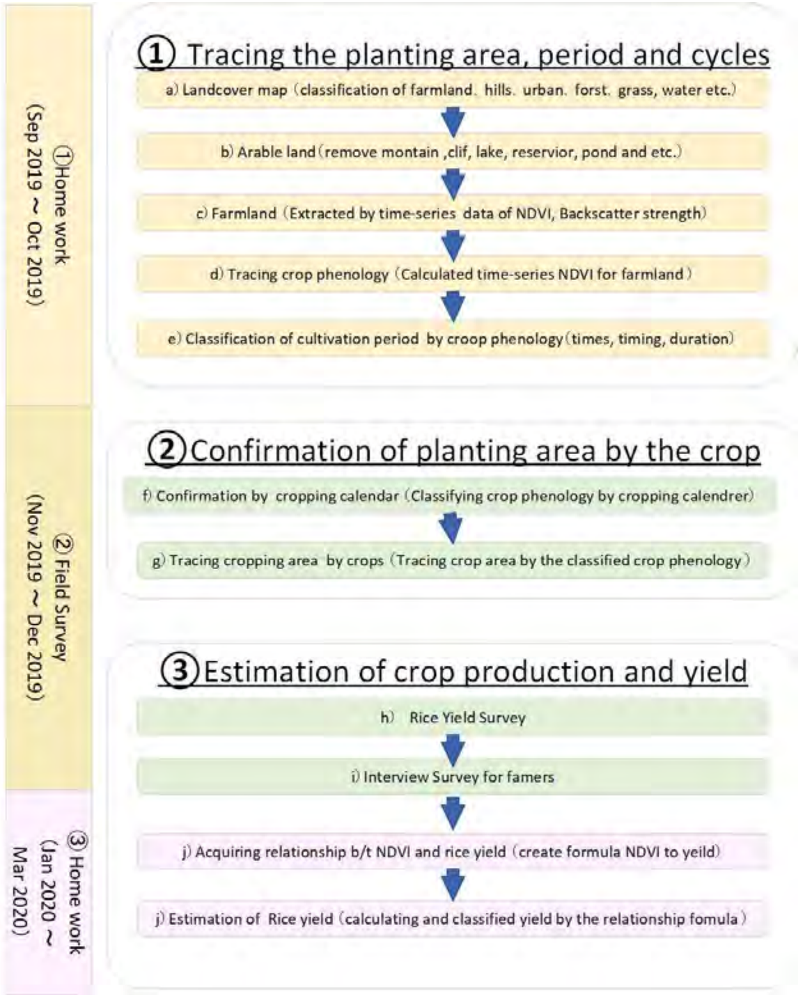


Figure-3 General process of satellite data analysis

3 Field Survey

Yield surveys were conducted from early to late November according to the rice growth stage in 2019. Within this period, the Sentinel-2 satellite had passed the project area four times, but good optical images were only obtained in late November due to an oceanic cyclone moving northward in early to mid-November. The result of the yield survey conducted during harvesting time and farmer interviews after harvesting are described in the next sub-section.

3-1 Rice Yield Survey

In the yield survey, the (1) use of certified seeds, (2) differences in cropping methods, and (3) differences in varieties are evaluated in terms of both quantity and quality. In the fields, the geometry of the target farm is measured by GPS, and the yield is surveyed by a combination of unit acreage sampling and whole field measurement as accurately as possible in the yield per unit area.

The survey was conducted at 18 sites as shown in Figure-4 and Table-1, and the surveyed yield varied in width from 35 to 105 baskets[3] depending on their varieties, cultivation methods, and use or non-use of certified seeds. Among the 18 sites, three (3) sites may include unreliable values, resulting in the following: 1. a noticeable difference between spot survey (i.e. crop cutting by spot with manual) and area survey (crop cutting all the plot area by combine harvester) even on the same site; 2. uneven growing conditions in the survey site; and, 3. surveying before ripening stage.

Table - 1 Summarized table of rice yield survey

Test No.	Village name	Variety	CS/NCS	Planting	Yield/ac (basket)	Remarks
1	Daung Yat Chaung	Inle	NCS	Broadcasting	69	
2	Daung Yike Chaung	Inle	NCS	Broadcasting	90	
3	Htan Kone Village	Hmaw Bi	CS	Transplanting	46	
4	Htan Kone Village	Hmaw Bi	NCS	Broadcasting	48	
5	Htan Kone Village	Hmaw Bi	NCS	Transplanting	51	
6	Htan Kone Village	Hmaw Bi	NCS	Transplanting	53	
7	Htan Kone Village	Hmaw Bi	NCS	Broadcasting	57	
8	Htan Kone Village	Hmaw Bi	CS	Transplanting	65	
9	Inn Gyi Village	Hmaw Bi	CS	Broadcasting	35	Early Harvesting
10	Inn Gyi village	Taung Pyan	NCS	Broadcasting	33	
11	Inn Gyi village	Taung Pyan		Broadcasting	53	
12	Inn Gyi Village	Yadanartoe	NCS	Broadcasting	82	
13	Inn Gyi Village	Yadanartoe	NCS	Broadcasting	87	Test made at same point as Sr12
14	Inn Gyi Village	Yadanartoe	NCS	Drum Seeder	87	Very high change of yield in testing paddy (STD= 37%)
15	Inn Gyi Village	Yadanartoe	NCS	Transplanting	94	
16	Inn Gyi Village	Yadanatoe	NCS	Transplanting	68	
17	Taung Kone Village	Inle	NCS	Broadcasting	104	
18	Taung Kone Village	Taung Pyan	NCS	Broadcasting	54	Early Harvesting
				Average	65	

Note: Location of test paddy refers to Figure-4

[3] In Myanmar, the production yield is measured in units of a volume called "baskets," and the sampling surveys confirmed the actual weight per basket (generally converted to 20.9 kg). At the survey, since the weight varied depending on the moisture condition of the un hulled rice, so the moisture content of each sample was measured with a “grain moisture meter” and the weight of all samples was evaluated as a converted weight in 14% of moisture.

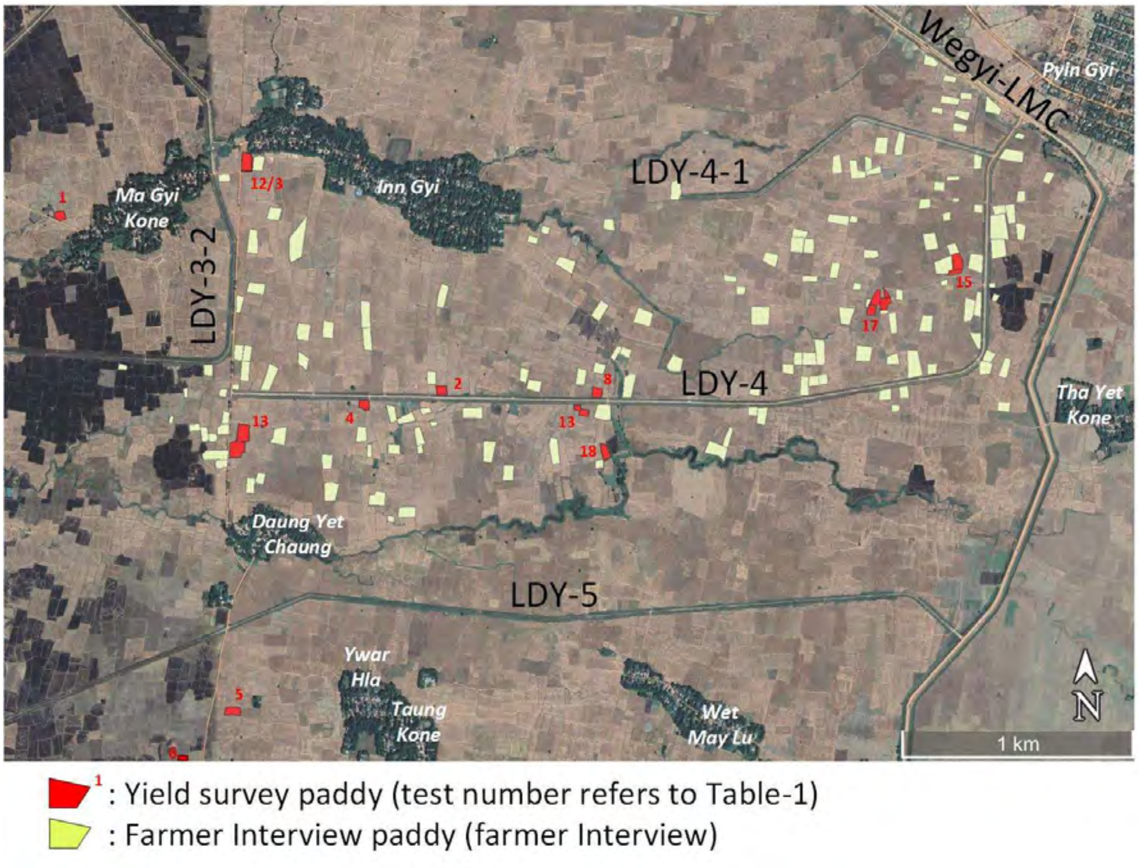


Figure-4 Paddy field for yield survey and farmer interview survey
(in / around LDY-4 branch canal of Wegyi irrigation system)

3-2 Interview Survey

Out of 472 farmers from the WUA that belongs to the LDY-4 branch canal of the Wegyi Irrigation System, 160 were selected as target farms. GPS surveys and farmer interviews were subsequently conducted with these participants.

In the selection of the target farms, consideration was given to avoiding a large difference in the number of samples for each survey item (use of certified seeds, planting method, and variety).

To obtain the maximum amount of information from farmers during the survey period, the interview items were narrowed down to extract the necessary information for satellite data analysis. Consequently, interview items were selected on the basis of field geometry (a measurement of field range by GPS positioning), use of certified seeds, planting methods, rice varieties, production yields, cultivation periods (seeding and harvesting periods), and fertilization conditions.

The next section summarizes the results of interviews with farmers regarding the cultivation period, varieties, planting methods, and the use of certified seeds.

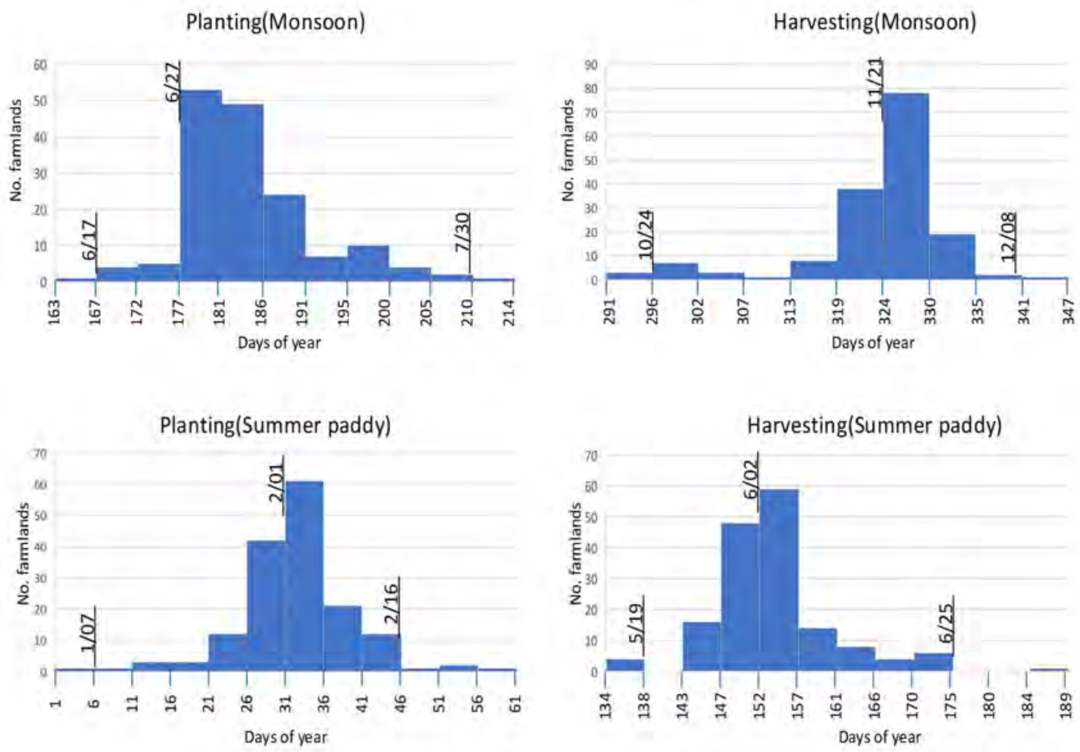


Figure-5 Histogram planting and harvesting period in LDY-4 branch canal area

(1) Timing of Seeding and Harvesting

In the monsoon paddy of 2019, broadcasting (or transplanting) was carried out from mid-June to the end of July. The harvesting was completed by the end of October for an early-ripening variety and by the end of November for late-ripening variety.

Regarding the highest duration of both planting and harvesting in the histogram as shown in Figure-5, the planting (or transplanting) reached a peak from June 27 to June 30, and the harvest was made from November 21 to 27. Given the difference between peaks (both planting and harvesting), 147 days represents the growth period. On the other hand, in the summer crop of 2019, the sowing season is from early January to mid-February, the harvest season from mid-May to late June, and the peaks on February 1 and June 2, indicating that the growing period was calculated at 121 days.

Based on this information, the target period for the Analysis was selected monsoon paddy in 2019 as the adequate period of determining agricultural productivity, while satellite data were collected at five-day intervals in the period from the end of June to early December 2019.

(2) Type of Variety, Certified Seed and Planting Method

In the monsoon paddy of 2019, six(6) rice varieties (Hmaw Bi, Inle, Ngwetow, Taung Pyan, Tintayargyi, Yadanartoe) were cultivated in the fields belonging to the LDY-4 branch canal at an average of 50 baskets/acre, as shown in Figure-6.

Furthermore, of those six (6) varieties, Yadanartoe indicated the highest yield of 60 baskets/acre, corresponding to an increase of roughly 20% over other varieties.

On the other hand, the native species such as Taung Pyan show a low yield of fewer than 50 baskets/acre.

While in summer paddy, three (3) varieties (Pyitawyin, Sinhwelatt, Yadanartoe) were cultivated, the yields were all higher than those of the monsoon paddy, exceeding 60 baskets/acre.
High-yield varieties of Sinhwelatt and Yadanartoe, in particular, were reported at an average yield of 80 baskets/acre.
With respect to differences in the presence or absence of certified seeds, high production yields were observed in fields where certified seeds were cultivated in both monsoon and summer paddy. On average, the yield increased by 14% in monsoon paddy and by 49% in the summer paddy (most of the certified seeds were Yadanartoe, a high-yielding variety while non-guaranteed seeds were native varieties).
Regarding the effect on yield by planting method, transplanting showed priority with a higher yield that increased by 26% compared to those of broadcasting in monsoon paddy. However, a comparison with summer paddy could not be made since none of the farmers applied the transplanting method in the summer season.

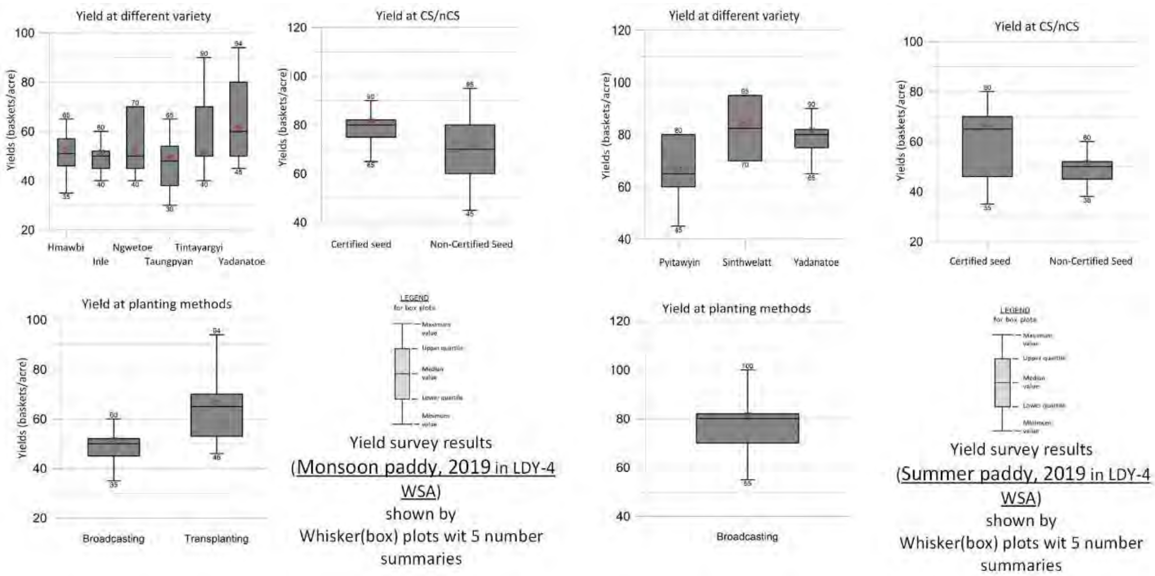


Figure-6 Production yield classified by type of variety, certified seed and planting method

According to statistical analysis, PROFIA activities in rice cultivation in the LDY-4 irrigated area, demonstrating use of certified seeds, precise cultivation management through transplantation, and recommendation of stable local varieties in the market, were proven to be effective components in rice production.
Moreover, the results of interviews provided sufficient evidence of the validity of re-setting the degree of achievement indicators of PROFIA activities to “expansion of high-yield fields” and “increase of overall yield”.

4 Satellite Data Analysis

The planted area of the paddy field was calculated by use of optical and SAR sensor images, while the production yield was estimated solely by optical sensor images. The procedure for calculating the planted area and production yield is described in the following subsection:

a. The changes in land use during the monsoon season over a six (6)-month period in 2019 (June 2019 to December 2019) is confirmed by optical sensor images and SAR sensor images to extract the range of farmlands.

b. The time-series data of vegetation indices are compared with the cropping calendar obtained from the field survey (interview survey) to confirm the period of monsoon paddy for the target area.

c. As shown in Figure-7, paddy fields (corresponding to flooded areas) are extracted by the optical sensor image (Sentinel-2) and SAR sensor image (Sentinel-1) during the sowing period (June to July) according to the cropping calendar for rice cultivation.

d. Calculating the leaf area index (LAI) and the normalized difference vegetation index (NDVI) from the optical sensor images taken for the booting stage (October) of rice and creating the spatial distribution maps.

e. Performing regression analysis between rice yield (obtained from the yield survey) and LAI and NDVI for the booting stage of rice to take relational expression (regression model).

f. By applying a regression model to the spatial distribution map (LAI and NDVI map – See Section d.), unit production map of rice (i.e. distribution map of planted area and production yield) is created.

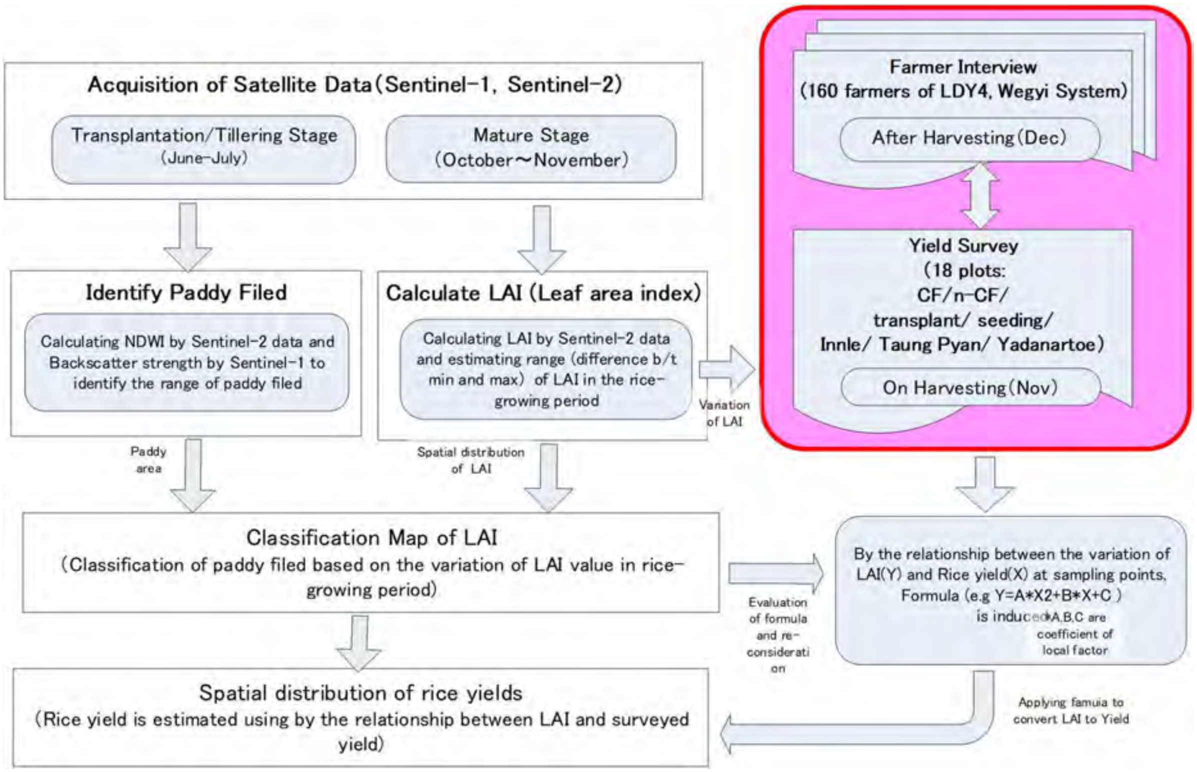


Figure -7 Flow of satellite data analysis

4-1 Acquisition of Satellite Data

Satellite data acquisition was made every five (5) days during the monsoon season between June and December 2019 and taken on a monthly basis from April 2018 to June 2019. Despite attempts to obtain optical sensor images (Sentinel-2) across all target periods, it was difficult to achieve the acceptable quality for reliable analysis, particularly at the peak of the monsoon season from June to September with cloudiness levels exceeding 20%. Thus, as alternative information, Sentinel-1 images (SAR images of C-band[4]) were obtained in the monsoon season to trace plant growth in the reproductive phase. In particular, the frequent acquisition was made in early July to assess the area of paddy fields[5]. The resolution of both Sentinel-1 and Sentinel-2 is 10 m (about one (1) are) that is possible to extract small plots of even several are. Table-2 shows the acquired images of each satellite data and the acquisition time required by the cropping calendar and for analysis purposes.

[4] The applied SAR data is product type of GRD (Ground Range Detected, data projection on the ground surface) of acquisition modes of IW (Interferometric Wide swath mode, main acquisition mode, resolution 20.4 × 22.5 m, swath width 250 km) was used. In GRD data, two types of VV and VH polarizations are available, but the VH polarization (backscatter coefficient) indicated as a more sensitive response to the growth (prosperity) of rice communities was used to estimate the rice cropping area, and the growth status was tracked. In the analysis, low-level processing such as radiometric calibration, atmospheric correction, speckle filter correction, terrain correction, and backscatter coefficient (σ0) conversion were performed.

[5] The cropping calendar was confirmed using SAR image during the rainy season in 2019. After acquiring Level 1 data of Sentinel-1, pre-processing (low-level processing) was performed to track the change in the backscatter coefficient (σ0). In the σ0 distribution map, the minimum period was detected in early July and the value gradually increased as the rice grow. After reaching the maximum activity, it was abruptly reduced by harvesting. While in time-series change graph (σ0 - time), the cropping calendar (sowing and harvesting period) was consistent with the cycle of σ0 value. Inundation (lodging of paddy), caused by heavy rain at the end of August, was also traced as a sharp decrease in the backscatter coefficient.

Table-2 Acquired satellite data

No	Year	Month	Sentinel-2			Sentinel-1	No	Year	Month	Sentinel-2			Sentinel-1
			46QFG (tile no)	46QGG (tile no)	Cloud condition					46QFG (tile no)	46QGG (tile no)	Cloud condition	
1		4	2018/4/6	2018/4/6	○		23	2019	7				2019/7/9
2		4	2018/4/26	2018/4/26	×		24		8				2019/8/2
3		5	2018/5/21	2018/5/21	△		25		8				2019/8/26
4		9	2018/9/28	2018/9/28	△		26		9	2019/9/18	2019/9/18	×	2019/9/1
5		10	2018/10/18	2018/10/18	△		27		9	2019/9/23	2019/9/23	×	2019/9/4
6	2018	11	2018/11/2	2018/11/2	○		28		9	2019/9/28	2019/9/28	△	2019/9/25
7		11	2018/11/7	2018/11/7	○		29		10	2019/10/3	2019/10/3	△	2019/10/7
8		11	2018/11/17	2018/11/17	○		30		10	2019/10/8	2019/10/8	×	2019/10/13
9		11	2018/11/22	2018/11/22	○		31		10	2019/10/13	2019/10/13	△	2019/10/19
10		11	2018/11/27	2018/11/27	○		32		10	2019/10/18	2019/10/18	△	2019/10/25
11		12	2018/12/17	2018/12/17	○		33		10	2019/10/28	2019/10/28	△	2019/10/31
12		12	2018/12/27	2018/12/27	○	2018/12/17	34		11	2019/11/2	2019/11/2	△	2019/11/6
13	2019	1	2019/1/1	2019/1/1	○	2019/1/10	35		11	2019/11/7	2019/11/7	×	2019/11/11
14		1	2019/1/21	2019/1/21	○		36		11	2019/11/12	2019/11/12	×	2019/11/18
15		2	2019/2/5	2019/2/5	○		37		11	2019/11/17	2019/11/17	△	2019/11/24
16		2	2019/2/25	2019/2/25	○	2019/2/15	38		11	2019/11/22	2019/11/22	△	2019/11/24
17		3	2019/3/22	2019/3/22	○	2019/3/11	39		11	2019/11/27	2019/11/27	○	2019/11/30
18		4	2019/4/21	2019/4/21	○	2019/4/4	40		12	2019/12/2	2019/12/2	○	2019/12/6
19		4	2019/4/26	2019/4/26	○		41		12	2019/12/7	2019/12/7	○	
20		5				2019/5/10	42		12	2019/12/12	2019/12/12	○	
21		6				2019/6/3	43		12	2019/12/17	2019/12/17	○	
22		7				2019/7/6	44		12	2019/12/22	2019/12/22	○	

Period of data acquisition and cropping pattern

Year	2018		2019											
Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice (main; monsoon season)														
Rice (second; summer season)														
Analysis Period														
Timig data aquisation														
Sentinel-2 (optical data)	○	○	○	○	○	○	△	×	×	×	△	△	○	○
Sentinel-1 (Microwave data, SAR)		○	○	○	○	○	○	○	○	○	○	○	○	○
Filed survey														

FAO rice crop calander: Sowing Growing Harvesting

○ : Aquisation data (Archeve image) × : No-aquisatin data by poor quallity by cloud cover △ : Aquisation data with limitted use by cloud

4-2 Calculation of NDVI

The vegetation index, designed to determine the state of vegetation using the wavelength band of optical satellite data, is an index that indicates the presence or absence of vegetation, denseness, and vitality of crops[6].

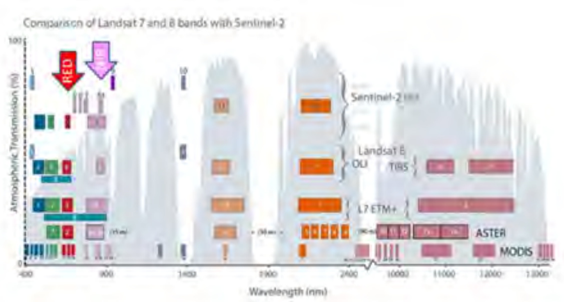
In principle, the vegetation index is a spectral index that is expressed as a difference (DVI index or a ratio (RVI index) between red (R: wavelength 0.68μm) and near-infrared (NIR: 0.75 to 1.3μm). It indicates photosynthesis activity using high and low absorption band for solar energy.

[6] When plants perform photosynthesis, chlorophyll absorbs visible light of blue (B: 0.45 μm) and red (R: 0.68-0.75 μm) well and resulted in low reflectance. Conversely, infrared ray is highly reflected to protect chlorophyll that is weak to heat. In particular, the near-infrared wavelength range (NIR: 0.75 μm to 1.3 μm) behaves as the highest reflectance. The difference or ratio between the absorbed red (R band) and the near-infrared (NIR band) that is not absorbed and reflected is called the vegetation index and is very important for the analysis of crops.

Name	Purpose/Classification	Short Description	Type
NDVI	Normalized Difference Vegetation Index	The well-known classical vegetation index. The NDVI composes a measurement for the photosynthetic activity and is strongly in correlation with density and vitality of the vegetation	Vegetation Index
DVI	Difference Vegetation Index	This index is sensitive to the amount of vegetation	Vegetation Index
RVI	Ratio Vegetation Index	The simplest ratio-based index, it is also called the Simple Ratio (SR). It indicates the amount of vegetation. It also reduces the effects of atmosphere and topography	Vegetation Index
E.g. index for vegetation are PVI, RVI, UPVI, WDVI, TNDVI, GNDVI, GEMI, ARVI, NDI45, MTCI, .REIP, .S2REP, .IRECI, RSSRa.etc.			

$$NDVI=(NIR-RED)/(NIR+RED)$$

Source: ESA Sentinel-2 Toolbox help documentation



Source: http://landsat.gsfc.nasa.gov/?p=10643http://landsat.gsfc.nasa.gov/?p=10643

Figure-8 Calculation of Normalized Difference Vegetation Index (NDVI)

Although various types have been proposed, a normalized vegetation index (NDVI, Figure-8) was applied in the Analysis as the most common index to investigate the relationship between cultivated land area and planted area to production yield of rice.

In the calculation, NDVI was calculated using band 4 (664.6 nm) and band 8A (864.7 nm) of Sentiel-2 MSI.

4-3 Cropping Calendar

Cropping calendar validation was made by comparison with the time-series changes of NDVI, which was approximate to the crop phenology in the LDY-4 branch canal area of the Wegyi irrigation system. NDVI was calculated from April 2018 to November 2019, and the variability of the cropping calendar (See Figure-9) was confirmed with NDVI linked by each pixel.

Through the comparative study between the cropping calendar and NDVI, four (4) cropping seasons - 2018 monsoon paddy, 2019 winter crop, 2019 summer paddy, and 2019 monsoon paddy - were identified. However, the period between the end of the summer crop and the start of monsoon paddy could not be traced by optical sensor image due to the peak of the monsoon; thus, comparison with the cropping calendar was performed using the SAR sensor images. Besides, as indicated by interviews with farmers, crop conversion from pulses to rice was performed in November 2018 to February 2019, causing a one-month delay in the growing period of summer paddy compared with that of pulses. Consequently, the sowing timing of monsoon paddy experienced a similar push back of about one month to early July.

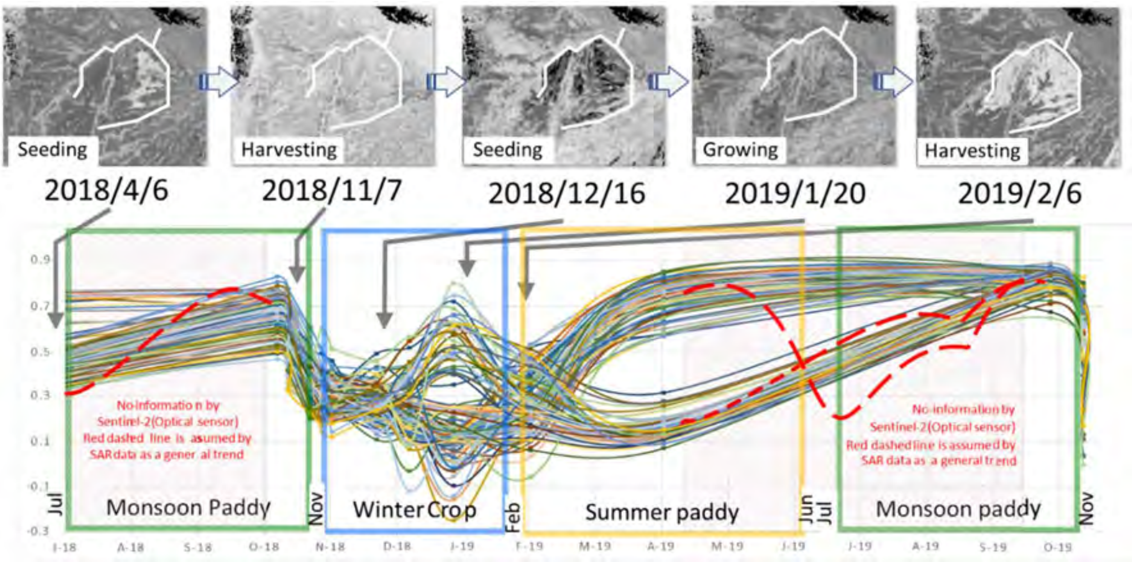


Figure-9 Changes of normalized difference vegetation index (NDVI)
(Comparison between crop phenology and cropping pattern)

4-4 Estimation of Agricultural Land and Planted area

In the monsoon season of 2019, the target period, rice cultivation was spread extensively to the farmland and was almost exclusively occupied by rice paddy.

The area of the paddy field was determined by the NDVI range (difference of minimum and maximum value) for the rice-growing period, delimited by planting and harvesting timing based on the cropping calendar, and confirmed by the distribution of the backscattering coefficient soon after rice planting.

In the Wegyi irrigated area, NDVI and backscattering coefficient differ greatly between cultivated and non-cultivated land, so classification between cultivated and non-cultivated land (setting of threshold value) was applied by the natural classification method (Jenks Natural Breaks). Figure-10 shows the NDVI of the Wegyi irrigation area used for calculating the acreage[7].

Figure-10 (left) shows the differences in NDVI between April 2019 and November 2019. The area characterized by large value is recognized as a cultivated land with high plant activity due to cultivation, while the low-value area is regarded as non-cultivated land with stable vegetation throughout the period, similar to natural vegetation.

Figure-10 (right) shows the distribution of the SAR backscattering coefficient soon after broadcasting (or transplanting) on July 6, 2019. Differences between the cropping area (paddy field) and non-cropping area (natural vegetation) were traced by its reflectance intensity.

Based on the clear distribution, a threshold was able to be naturally set to calculate the planted area in the 2019 monsoon season.

The analyzed cropping area can tabulate for each crop. Furthermore, it is possible to quantitatively trace these changes over time through time-series analysis, including variations in high yield acreage,

[7] In the analysis, the acreage was determined based on the change in NDVI taken from the optical satellite data, and the SAR data was used as supplementary data for the collation to the calculated acreage. After calculating the harvested area of rice (as an assumption as nearly the same as the sowing area) from the NDVI change between the growing season and the post-harvest as shown in Figure 10 (left), it was correlated to the SAR data as indicated in Figure 10 (right). The SAR analysis diagram was the backscatter coefficient (σ0) on July 7 which was the peak of the sowing period (June 17 to July 30) in the rainy season 2019.

such as increase or decrease of area.

Maximum changes of NDVI in Apr. 2018 to Nov. 2019 with threshold

Temporal data after seeding on 07 July with threshold

Figure-10 Estimation of agricultural land

4-5 Calculation of Leaf Area Index (LAI)

The Leaf Area Index (LAI) entails the conversion of value obtained by integrating the total leaf area of all the plants on the ground surface to unit value per land area[8]. Since photosynthesis occurs in the leaves of plants, their relationship with crop production is utilized for tracing plant growth. As the number of leaves increases with crop growth and the area of individual leaves increases, the leaf area index similarly increases and reaches a maximum value. After the maximum period, withering takes place at the lower leaves, while the leaf area index gradually decreases.

Biophysical indices such as LAI correlate with the dry matter content of crops. If the relation is observed at the growth stage related to the crop yield, LAI can be used for the prediction of crop yield. Based on this assumption, in the Analysis, the appropriate time for prediction was selected from the cropping calendar and LAI was calculated at the same growth stage.

In the Sentinel-2 appreciation, the LAI calculation uses 11 bands of B3, B4, B5, B6, B7, B8a, 11, B12, cos (viewing_zenith), cos (sun_zenith), and cos (relative_azimuth_angle) with European Space Agency (ESA) algorithm[9]. The calculation result was arranged on the LAI distribution map for converting the crop yield according to the LAI-yield regression model.

Figure -11 shows an example of LAI distribution in the Wegyi irrigation area.

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[8] Sum of leaf area (one side) existing per unit land area (m2 / m2). It is an indicator of plant growth. The acronym of Leaf Area Index is also called as LAI. The dry matter production of a plant is represented by the product of the Leaf Area Index and the net assimilation rate (dry matter production per unit leaf area), and is an important factor in considering the substance production of the plant growth. The maximum value is reached with the growth of the crop, but the time varies depending on the crop type and environmental conditions. In rice, the leaf area increases immediately before the heading stage, but in soybean, the leaf area increases even after the flowering stage and reaches a maximum at the start of the grain enlargement. (NAROPEDIA, National Agriculture and Food Research Organization).

[9] Sentinel-2 equips 3 bands (B5, B6, and B7) on the red edge, and they can trace photosynthesis activity to calculate LAI. The algorithm of LAI calculation has been used by the same as LANDSAT, SOPT, etc., and adding the empirical values (comparison data) accumulated in the ESA database (ANN: Artificial Neural Network) as input parameters. the data includes empirical values obtained from demonstration tests conducted by ESA for major crops.

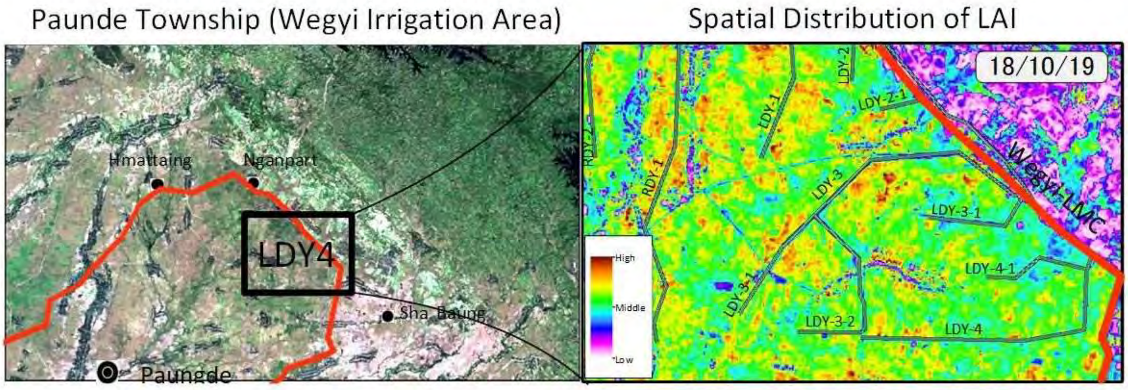


Figure-11 Example of LAI distribution in Wegyi irrigation area

4-6 Time-series Changes of Leaf Area Index (LAI) and NDVI

Regarding the relationship between LAI and rice yield, it has been reported that the correlation between the two become increases just before the heading stage (Yoshihiro Hiraoka et al, Journal of Agricultural Meteorology 73 (1): 16-21 2017, https: //www.jstage .jst.go.jp / article / agrmet / 73/1 / 73_D-14-00021 / _pdf). Besides, one study found that the reflection intensity in the red edge frequency range at each growth stage of rice is higher before the booting stage than that of both panicle initiation and the ripening stage, while the value at the booting stage is most effective for estimating the subsequent yield (Kawamura K et al. (2018), Remote Sens. 2018, 10 (8), 1249; https://doi.org/10.3390/rs10081249).

From these case studies, LAI at the booting stage should prove to be highly relevant to rice yield. The LAI and NDVI fluctuations were then tracked from the end of September when optical sensor images were available to determine the booting period in the target area. Figure-12 shows the changes in LAI and NDVI, and the rice growth stages.

The change in LAI varies depending on the type of crop; however, in the case of rice, it increases with the growth of the crop, reaches a maximum value at the heading stage, and then gradually decreases during the ripening period (Takeshi HORIE and Tetsuo SAKURATANI, Journal of Agricultural Meteorology 40 (4): 331-342 1985).

In the target area, as shown in Figure-12, both LAI and NDVI peaked at the beginning of October,

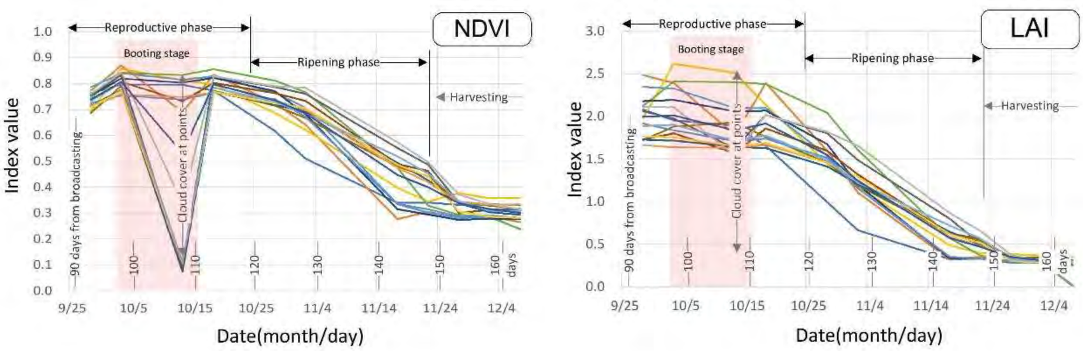


Figure-12 Changes in LAI and NDVI and the rice growth stages

then gradually decreased, continuing to decrease until December after the harvesting at the end of November.
From the change in LAI, the peaking period from early October to mid-October was determined to be the booting period. Besides, according to the farmer interviews, planting occurred from the end of June to the beginning of July 2019 and harvesting took place at the end of November. Therefore, the booting stage was determined to be October 1 to 15, that is, between 97 to 110 days after the planting period.
Due to the relationship between the LAI and rice yield, before and after the booting stage from the end of September to the end of October was set as the period for examining the relationship between LAI and measurement yield in the target area.
The difference between NDVI and LAI is that NDVI largely depends on atmospheric conditions such as cloudiness levels, whereas LAI shows little variation due to external conditions.
Although the booting stage (peak time) is substantial timing for the calculation of yield, the value of NDVI may behave in a saturation effect with little difference between measurement sites, while LAI's showed a clear difference between them.

4-7 Relation between LAI and Rice Yield

Since the booting stage was estimated from early- to mid-October, the Analysis focused on the same period, and vital data, inclusive of LAI, NDVI, and the measurement yield, were obtained from both satellite data and yield survey for subsequent regression analysis.
Prior to the analysis, yield data was verified by cropping conditions, and the following cases of (1) to (3) were identified as uncommon cases, yielding unreliable results.

(1) The data taken by 'unit acreage sampling' was significantly different from that of 'whole field measurement', even in the same test field.

(2) The data taken indicated significantly lower yields due to early harvesting before the full ripening owing to unavailability of combine harvester.

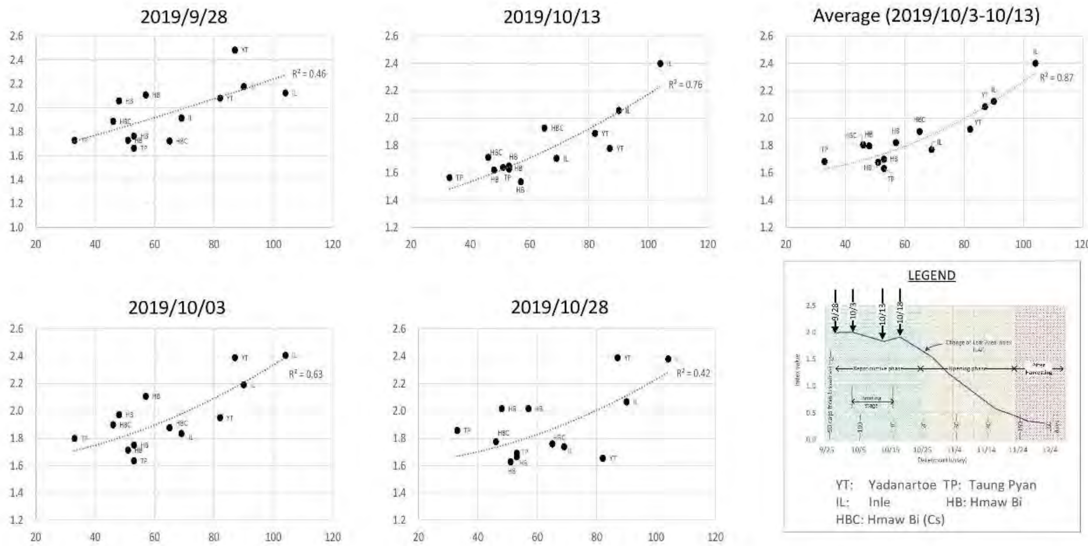
(3) The data taken by 'unit acreage sampling' was affected by a very high variation in the growing conditions in the test plot.

After examining the conditions of the above yield survey, those unreliable values were excluded from the regression analysis. In consequence, 13 out of the 18 yield survey tests were determined to be reliable measurements. As for acquired timing, the Sentinel-2 data obtained before and after the booting stage were September 28, October 3, October 13, and October 28.
The regression analysis was performed at four (4) timings using the explanatory variable (X axis: Yield) and the dependent variable (Y axis: LAI or NDVI). A quadratic regression equation (LAI or NDVI = a × Yield^2 × b × Yield + c) was adopted. Table-3 shows the LAI, yield, and coefficient of determination of the regression analysis for the four (4) timings.

Table-3 Results of regression analysis (coefficient of determination LAI / NDVI to yield)

Index	Date taken satellite data (2019)				
Coefficient of determination(R2)	9/28	10/03	10/13	10/28	10/3-10/13
LAI to yield	0.46	0.63	0.76	0.42	0.87
NDVI to yield	0.16	0.14	0.34	0.23	-

LAI to observed rice yield



NDVI to observed rice yield

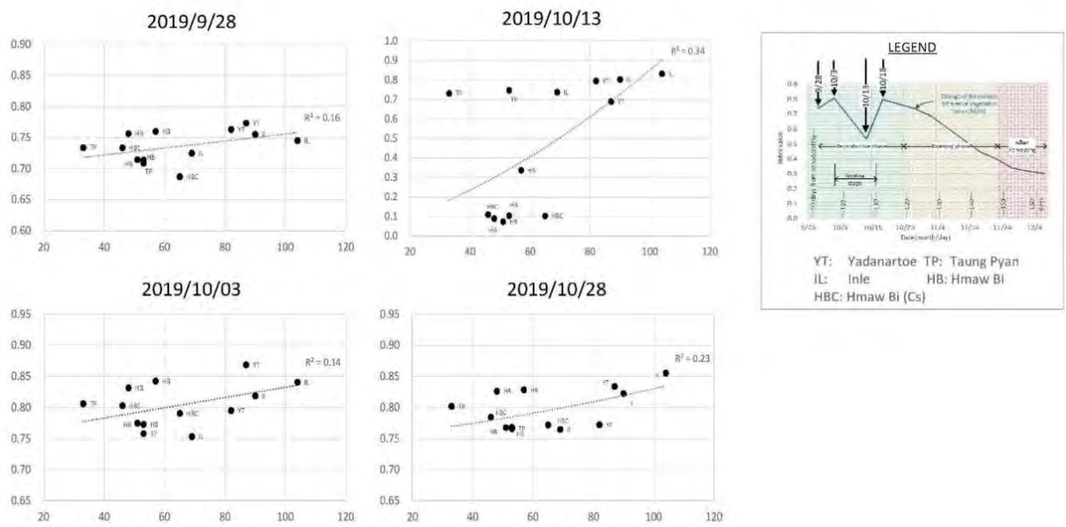


Figure-13 Results of regression analysis (LAI to yield / NDVI to yield)

As shown in Table-3 and Figure-13, the coefficient of determination (R2) for the four periods was R2 = 0.42 to 0.72 for LAI and R = 0.16 to 0.34 for NDVI.

There was a slight correlation between NDVI and yield, which did not exceed 0.34 even at the highest value of the target period (October 13); thus, it was deemed inapplicable as a predictive model.

On the other hand, a regression (prediction) model for LAI resulted in a high correlation with R2 = 0.76 on October 13 at the end of the booting stage (the transition from the booting stage to the heading stage), so the model could be judged as a capable tool for rice prediction.

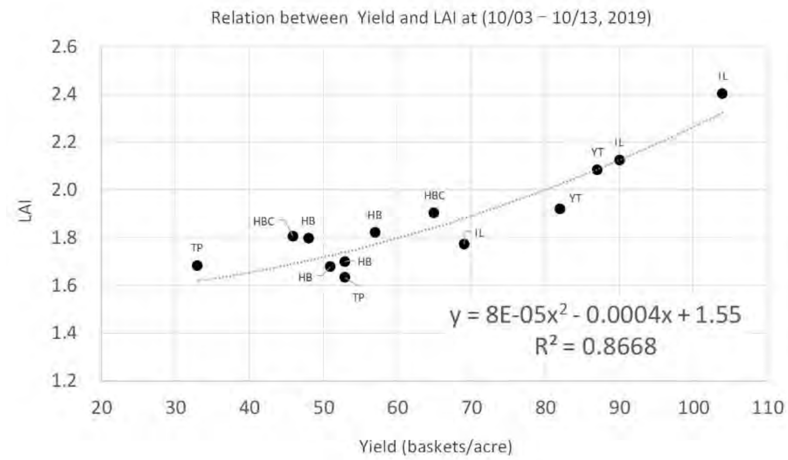
However, there was 15% cloud density on October 13, which was the highest timing of LAI. To reduce this influence, cloud removal was achieved by applying all the periods of booting stage, including a clear day (October 3) of the second-largest coefficient of determination.

Regression analysis was, therefore, performed once again using the average value for the entire period (October 3 to October 13). As a result, the influence of clouds was reduced and the coefficient of determination (R2) improved to 0.87.

4-8 Regression Model (converting LAI to rice yield)

Rice yield was predicted by the regression model created for the booting season of the 2019 monsoon paddy. Although the predicted value implied a certain level of reliability as the coefficient of determination (R2) was over 0.8, there was a slight variation among the varieties[10]. The correlation was significant in high-yielding varieties such as Yadanartoe and Inle, while it was low in low-yielding native varieties such as Taung Pyan and Hmaw Bi (SeeFigure-14).

To create a rice yield distribution map, the conversion table of LAI to yield (13 steps) was at first prepared by the regression equation in quadratic polynomial, as shown in Figure-14. Subsequently, the LIA distribution map was changed to the rice yield distribution map by applying the conversion table.



LAI	YIELD (baskets/acre)
< 1.5897	< 10
1.55025-1.56425	10
1.56425-1.59625	20
1.59625-1.64625	30
1.64625-1.71425	40
1.71425-1.80025	50
1.80025-1.90425	60
1.90425-2.02625	70
2.02625-2.16625	80
2.16625-2.32425	90
2.32425-2.50025	100
2.50025-2.69425	110
2.69425-2.90625	120
> 2.90625	> 120

Figure-14 Conversion LAI to rice production yield

4-9 Estimation of Rice Yield

The spatial distribution of rice yield (hereinafter, referred to as 'Rice yield map') was prepared for the 2019 monsoon paddy. Based on the results of the Farmer Interview survey, the rice yield was divided

[10] Although the reason for the variation of measurement yield could not be confirmed at the time of the field survey, it depends on 1) the survey method/operational error, and 2) difference in the appropriate survey timing among varieties.

1) Survey method/operational error: Yield survey is carried out by different methods of 'Unit acreage sampling' and 'Whole field measurement', and they respectively involve an inherent measurement error. In the survey of 'Unit acreage sampling', an error may cause in the selection of sampling points, while in 'Whole field measurement', it poeses the harvest loss using a combine harvester, and operational loss due to different surveyors (groups).

2) Difference in the appropriate survey timing among varieties: In the monsoon season of 2019, high-yield varieties (Inle and Yadanartoe) matured early to middle November, while native varieties (Hmaw Bi and Taung Pyan) matured mid to late November. The ripening time differs for each variety and the booting stage therefore supposed to be deferent. However, LAI was calculated based on the same timing of early October for all the varieties due to satellite data (i.e.crop phenology). Besides, some survey points of the native varieties, cases that the combine harvester could not be hired at the appropriate ripening was indicated as the reason for the error.

into 11 stages in the range of 0-110 baskets/acre, with the addition of one (1) stage of a high yield exceeding 120 baskets/acre.

In the Wedgyi irrigation area, as shown in Figure-15, there was a broad distribution of the average yield of 50-70 baskets/acre. Besides, the high yield paddy exceeding 100 baskets/acre was found slightly downstream along the branch canals.[11]

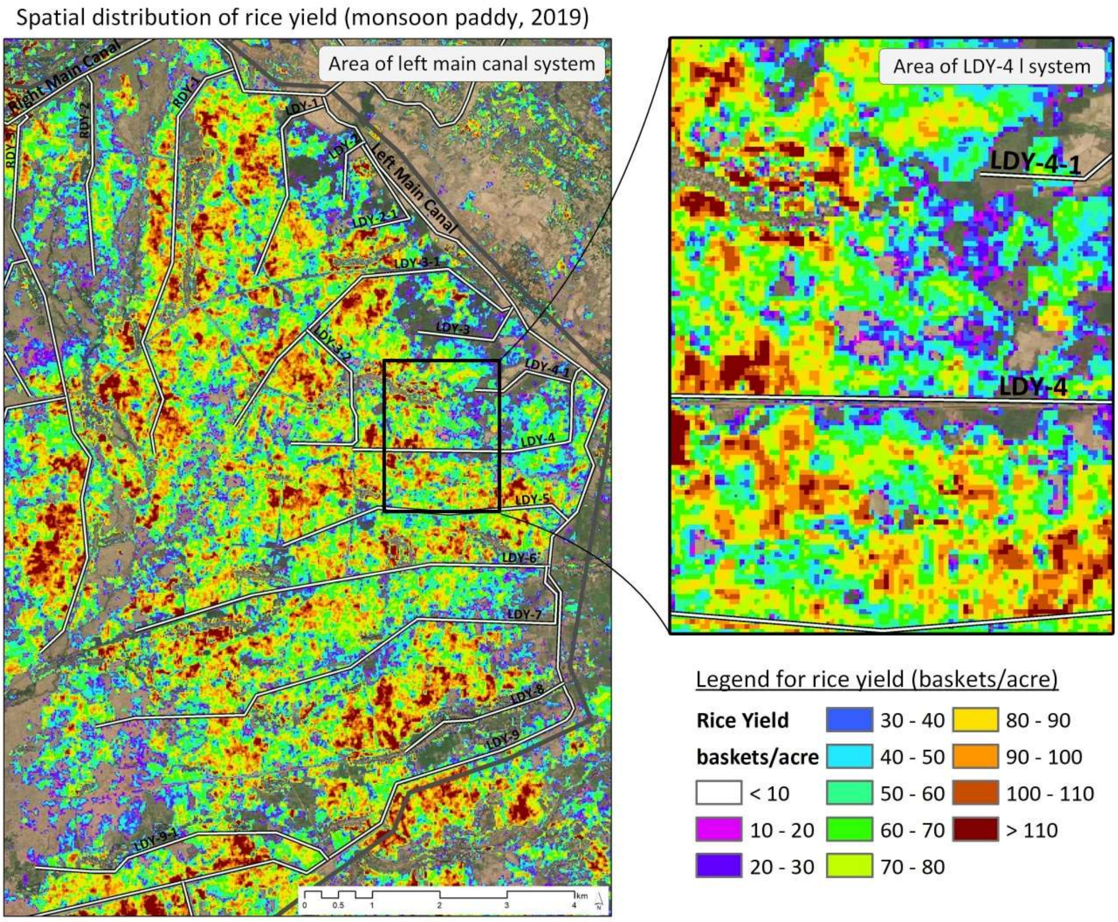


Figure-15 Spatial distribution of rice yield in Wedgyi irrigation area (2019, monsoon paddy)

Although the reason for these high-yield distributions has not been investigated in detail, it is expected to include the outcomes of the Project activities such as introducing high-yield varieties, improving planting methods, and enhancing cultivation techniques.

[11] Although the detail field survey has not been made yet, the reason for the area of high yield has been discussed with some assumptions. As possible reasoning, it depends on 1) Rice variety 2) Irrigation system(plot-to-plot) such that dissolved fertilizer in irrigation water moves the next plot before adsorption into the soil, and fertilizer accumulates in the downstream paddy fields year by year, and 3) Water temperature (relatively low temperature) at the in-lets to plots reduces nutrient absorption.

5 Applying Constructed Model to Other Areas

In the previous study on Myanmar, the cropping area and rice yield were estimated by satellite data and compared to the field data. The matching coefficient between the estimation and field data was reported as follows:

(1) 0.70 (of a substantial level of coincidence) was taken only by SAR sensor data (ALOS-2 or Sentinel-1),

(2) 0.94 (of a high level of coincidence) was taken only by an optical sensor (Landsat-8),

(3) 0.95 (of a high level of coincidence) was taken by the integration method using optical sensors (Landsat-8) and the SAR sensor (Alos-2 and Sentinel-1).

In the above combinations, 3) the integration method with Sentinel-2 and Sentinel-1 was applied for the Analysis. Despite their ability to estimate the acreage and yield by SAR or optical sensor alone, they have respectively unique features (advantages/disadvantages) as the types of electromagnetic waves to be observed differ depending on the sensor. When an optical sensor is used, it is easy to achieve a high spatial resolution due to short wavelength, but it is easily affected by cloud density. Conversely, SAR sensor uses microwaves with long wavelengths, rendering them less susceptible to clouds. However, SAR sensors must transmit signals and combine received signals in order to ensure resolution.
The next sub-section describes the application of optical sensor used for other areas and the characteristics of other satellite data.

5.1 Application of Optical Sensor (extracting method of sector information)

(1) Characteristics of Application Method

As for information to be extracted from satellite data, the biophysical properties of crops that can be used for yield prediction are the spectral intensities in the red edge range, and indices such as SR (simple ratio), DVI, NDVI, and LAI derived from these are used. Of these, NDVI has been often used for yield prediction as it relates to long-term plant activity. However, its value tends to become saturated (NDVI saturation) for the dense vegetation (high photosynthetic activity), or high level of NDVI. In the Analysis, the NDVI peak was found at the booting stage, and its sensitivity was slowed due to saturation. In contrast, LAI has remained sensitive even in the high photosynthetic condition that caused NDVI saturation. Originally, LAI was used to estimate the amount of biomass in crops in the plot size survey, since it implies a certain relation to the dry matter weight of the crop. However, it was only used for plot size surveys and could not be applied to a wide range such as in the Analysis. Recently, however, , with advances in the use of remote sensing data (satellite data, UAV data, etc.), the LAI estimation has been enhanced from both the optical satellite data and SAR data in various ways, so they are being used to calculate crop yield over a wider area.
In the Analysis, the LAI was calculated using the Sentinel-2 tool, which provides an index proportional to crop yield, such as LAI and PAR (Photosynthetically Active Radiation). The basic algorithm of the calculation was the method used in LANDSAT, SPOT, etc., and the applied data was taken by Sentinel-2 MSI (Multi-Spectral Instrument), which includes three bands of the range (B5, B6, B7). As for the

regression model for LAI calculation, it was constructed by selecting the best timing based on the results of the interview survey and comparing them with the yield. In consequence, the reliable level of the model had been achieved as the coefficient of determination> 0.8.

(2) Extension of Application Method

Although the method is expected to provide a certain level of accuracy in the Wedgyi irrigation area, its application has limitations in terms of the quality of data obtained, the number of surveys conducted, and the actual situation. In the Analysis, images were able to be acquired at the end of September immediately after the end of the monsoon season, when it was correlative with the target time for analysis (the booting stage). However, uncertain climate conditions, there can cause the cropping season to be advanced, and the rainy season prolonged. In addition, the booting stage takes place in the cyclone or marine tropical storm seasons.

Regarding applications in other regions, it is necessary to consider risks due to weather conditions. The same applies to dry-season crops. It is necessary to put into consideration that the heading season is in May and that the rainy season starts early in some years, in addition to severe cloud density and inferior quality data. Considering these facts, climate conditions and growth periods of the target area must be considered for the expansion to other areas. Particularly, the method is restricted in the southern part, indicating that application to coastal areas with a long rainy season is strongly affected by the climate. Also, since the response to LAI varies depending on the cultivation time, it may be necessary to perform a yield survey, calibrate the regression model, and collect the cultivation calendar before applying to areas other than the Wedgyi irrigated area or areas with different cultivars and cultivation times.

5-2 Characteristics of Other Satellite Data

Since the scale of the project covers an area of several 100 to 10,000 ha, and the purpose of the Analysis is to investigate each paddy in the scale of one(1) to several ha, the desired resolution of satellite data is less than 10 m. Based on these conditions, typical optical sensors are Sentinel-2 and ALOS-3 (to be launched), and SAR sensors are ALOS-2 and Sentinel-1. The next sub-section describes optical sensors and SAR sensors that can be used for the same purposes as the Analysis. Table-5 shows a comparison of the specifications of Sentinel-1, Sentinel-2, and ALOS-2.

(1) Optical Sensor (Sentinel-2, ALOS-3: to be launched in 2020)

The MODIS series, Landsat series, and Sentinel-2 are typical satellites equipped with optical sensors that can be obtained free of charge. The MODIS and Landsat series have been in operation for a long time and have ample archives. Even in the rainy season, images with clear to few clouds can be found in some timings. However, the spatial resolution is only 250 m/pixel in MODIS and 30 m/pixel in the latest Landsat-8, and the accuracy is somewhat insufficient for a project-based analysis that includes small paddies or farmlands. On the other hand, the resolution of Sentinel-2 is 10m in minimum scale with three (3) times higher accuracy than that of Landsat-8 can be expected. ALOS-3 is the Japanese satellite scheduled to be launched by JAXA as the optical satellite in 2020, and observations will be made at a resolution equal to or higher than that of Sentinel-2. The features of Sentinel-2 and ALOS-3 are described below.

a) Sentinel-2

The Sentinel-2 series was designed to perform surface observations to support projects such as forest monitoring, land cover change detection, and natural disaster countermeasures by the European Space Agency (ESA). Sentinel-2a was launched in June 2015, and Sentinel-2b was subsequently launched in March 2017. The two satellites have been operating as the constellation system since 2017. If cloudless conditions are in place, a clear image can be obtained in a 5-day global revisit. The primary processed product is available to the public free of charge from the European Space Agency (ESA).

and the image is available throughout the year in the required area. In the Analysis, despite the unclear image mainly due to cloudy conditions of the monsoon season from July to September, it was possible to acquire the images at the timings of seeding and harvesting, enabling the cropping acreage to be estimated in 2019. Using sentinel-2 data, short revisit days is an advantage to be obtained at a necessary timing.

b) ALOS-3

The launch of ALOS-3 (Advanced Optical Satellite) is scheduled for 2020, which will be the successor to ALOS (Advanced Land Observing Satellite; 2006-2011). The mission aims to achieve efficient operation for long-term observation in both high resolution (0.8 m/pixel ground resolution) and wide-area observation (3.2 m/pixel ground resolution in strip map observation mode). Among the above operations, the observation mode that can be used in the agricultural sectors is wide-area observation. This sensor uses 6 bands (multi-spectral sensor: 4 bands of visible light, 1 band of red edge, and 1 band of near infrared. From this spectral information, it is possible to track the crop cultivation process with high accuracy, but there is no information on operation details. It is expected to operate frequently and distribute products in Myanmar (commercial purposes will not be free).

(2) SAR Sensor (ALOS-2, Ssentinel-1)

ALOS-2 and Sentinel-1 are typical examples of SAR sensors that can be used based on existing studies and appropriate accuracy for the same type of projects. ALOS-2 is not free, but Sentinel-1 observational data can be searched in the archives from ESA Copernicus project portal sites, regardless of purposes, including researches like the Analysis. Table-4 shows a comparison of the main specifications of ALOS-2 and Sentinel-1.

Table-4 Comparison between ALOS-2 and Ssentinel-1

Items	ALOS-2	Sentinel-1
Operator	JAXA	ESA
Launch date	2014 年	2014 年
Wavelength	L-band	C-band
Swath width*1	50km	250km
Ground resolution	3m×3m	5m×20m
Orbital altitude	628 ㎞	693 ㎞
Incidence angle range	8°-70°	29.1°-46°
Orbit	Sun-synchronous near-polar orbit	Sun-synchronous near-polar orbit
Repeat orbit cycle	14 days	12days (6days by 2 satellites)
Number of path	207path/cycle	175path/cycle

*1：Swath width in IW (Interferometric Wide Swath mode) Both satellites are launched at about the same time and orbit in the same altitude and orbit, but there are differences in (a) wavelength band, (b) observation width/resolution and, (c) data acquisition opportunities, etc. depending on the operational purpose and sensor configuration.

(a) Wavelength band: C-band (wavelength $\lambda \fallingdotseq 6$cm) of radio waves (microwave) used by Sentinel-1 is a shorter wavelength than the L-band (wavelength $\lambda \fallingdotseq 24$ cm) of ALOS-2. C-band is expected to be a higher resolution than L-band, but it is difficult to accurately detect the surface displacement due to irregular reflections on plants such as forests on the surface. On the other hand, the resolution of the L-band used by ALOS-2 is inferior to that of the C-band, being more suitable for judging high-crop crops such as corn than low-crop crops such as rice. It is considered to be superior to C-band in determining water surface and ground surface.

(b) Swath width and resolution: The swath width of Sentinel-1(about 250 km: IW mode) is larger than that of ALOS-2 (about 50 km: high-resolution mode). Conversely, the resolution is 5m x 20m in Sentinel-1 IW mode, while 6m or 10m in ALOS-2 in high-resolution mode.

(c) Opportunities for data acquisition: Sentinel-1 data can be acquired only in IW mode and the scene is taken at six-day intervals in Myanmar. On the other hand, ALOS-2 data is operated in various observation modes by a single system at 14 days revisit, so there is less opportunity for data acquisition than Sentinel-1 data. In Myanmar, high resolution (10 m resolution) data is required for future analysis, but according to the basic observation scenario (global), the available scenes in the past two years (rainy season 2017 to rainy season 2019) averaged 10 scenes a year.

Table-4 Specification of Sentinel-1, Sentinel-2 and ALOS-2

Satellite	SAR sensor									Optical sensor	
	Sentinel-1				ALOS-2					Sentinel-2	
	Copernicus: Sentinel-1 - The SAR Imaging Constellation for Land and Ocean Services				Daichi 2: Advanced Land Observing Satellite 2					Copernicus: Sentinel-2 - The Optical Imaging Mission for Land Services	
Launch (status)	1A:2014-04-03, 1B:2016-04-25 (in operation)				2014-05-24(in operation)					2A:2015-06-23, 2B:2017/03/07 (in operation)	
Operator	ESA/EC				JAXA					ESA/EC	
Observation purpose	Acquiring information on landform, land-surface image, sea-surface image, sea wind (direction and speed in the horizontal direction), sea-surface (flow velocity and wave height) and sea-ice distribution and type).				Improving technologies and utilization results proven by the land observing satellite DAICHI, the system is to construct a system able to rapidly process, and distribute high-resolution, wide-area observation data for large-scale natural disasters in Japan and overseas, and verify the use in disaster prevention activities and disaster response of related organizations. In addition to assessing the status of disasters, expand the use of satellite data in a variety of fields that meet the needs of normal times that occupy a majority of satellite operations, such as national land management and resource management.					Observing land data for utilizing land monitoring, emergency management, security, and climate change.	
Orbit	Sun-synchronous near-polar orbit				Sun synchronous sub-recurrent orbit					Sun synchronous orbit	
Altitude	693 km				628 km					786 km	
Cycle	98.74 min				97 min					100.7 min	
Incidence angle	98.19 °				97.9 °					98.5 °	
Local Time at Descending Node	18:00(passing south to north at the equator)				12:00:00(noon)					10:30	
Cycle	12 day(6 day by constellation)				14 day					10 day(5 day by constellation)	
instrument	C-band SAR instrument(C-SAR)				Phased Array Type L-band Synthetic Aperture Radar					Multispectral Imager (MSI)	
Observation mode	Stripmap	IWS (Interferometric Wide Swath)	EWS (Extra Wide Swath)	Wave	Spotlight	StripMap HR(3m)	HR(6m)	HR(10m)	ScanSAR	Observation mode	13 band(443-2190 nm) 10 m (R/G/B/NIR band) 20 m(6 Red edge,andSWIR band) 60 m (3 Atmospheric correction band)
Frequency	8180MHz				1257.5MHz	1257.5 or 123.5MHz			1278.5 MHz		
Incidence angle	29.1 - 46°					8-70°					
Wavelength	280MHz				84 MHz	84 MHz	42 MHz	28 MHz	14 MHz		
Ground resolution	5 m×5 m	5 m×20 m	25 m×100 m	5 m×20 m	3x1m	3m	6m	10m	100m		
Swath width	80km	250km	400km	20km×20km	25x25km	50km	50km	70km	350km	Observation width	290km
Available polarization	HH-HV, VV-VH			HH or VV	SP	SP/DP/FP/CP			SP/DP	Resolution	10m(B2,B3,B4,B8)
					SP: single polarimetric HH or VV or HV), DP: dual polarimetric (HH+HV or VV+VH switchable) FP: full polarimetric (HH+HV+VH+VV),CP: compact polarimetric mode (test mode)						20m(B5,B6,B7,B8a,B11,B12)
Specification imagery	IWS (Interferometric Wide Swath)				StripMap(Fine) Resolution 10m、Swath width 70km						60m(B1,B9,B10)
Level	L1 (resolution 20m)				L15 (resolution 10m) Range and multi-look azimuth compressed data is represented by amplitude data. Range coordinate is converted from slant range to ground range, and map projection is performed.					Level	L1C (resolution 10m)
					L21 (resolution 10m) The data is orthorectified from level 1.1 data by using digital elevation model.						L2A(resolution 10m)

6 Preparation of Evaluation Model

In the satellite data analysis of the Project, as described in Section 2-1, the Project activity, involving the promotion of guaranteed seeds, transplanting methods, and varieties, etc. is not available to be evaluated. Instead, the project achievement was measured by the indexes of (1) expansion of the planted area, (2) expanding high-yield paddy, and (3) increment of production yield.

Based on the results of the analysis, an evaluation model (standard analysis process) as shown in Figure-16 is proposed for the quantitative measurement of the above three (3) indexes.

As for the index (1), as per the method in many examples, the planted area, indicating high changes of vegetation by the artificial act (by human intervention), is clarified by the comparison with low changes of natural vegetation and by the backscatter contrast between them.

On the other hand, in Indices (2) and (3), the methods developed in the Analysis using biophysical indices can be applied to the evaluation of rice yield. For the estimation, as in the referenced parameter, on-growth information and actual yield are required. However, in similar conditions, the regression model applied in the Analysis can be diverted for the Wedgyi irrigation area.

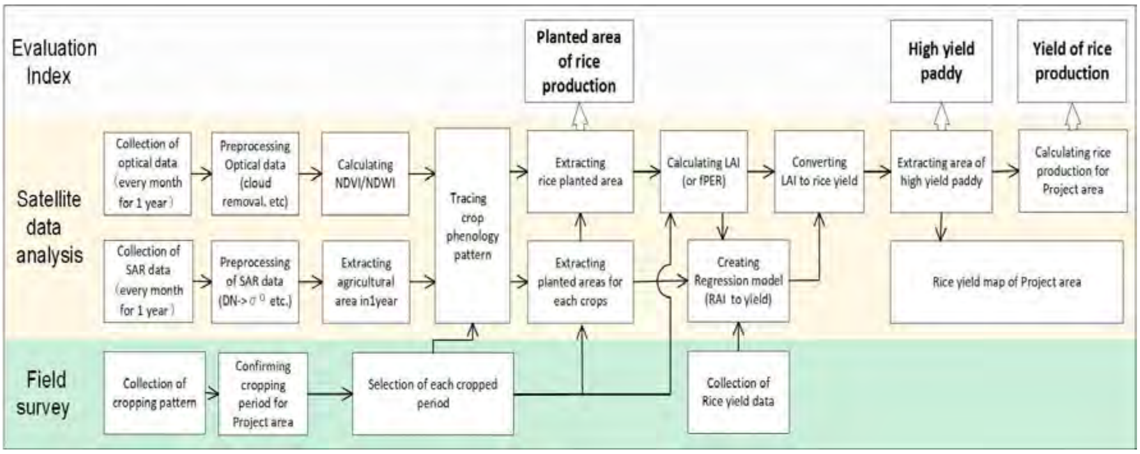


Figure-16 Typical analysis process of planted area of paddy and unit rice yield

7 Application of Satellite Data to Monitoring and Ex-post Evaluation

Satellite data is used for various purposes. In the agriculture field such as this project, the following uses are listed, as shown in Table-4.

Table-4 Purpose of satellite data analysis and items of usage

Purpose of use	Items of usage
Efficient use of farmland	Planted area, number of planted, planted area by each crop (comparison of cropping calendar), abandoned farmland, renewal of farmland
Increase in crop production	Yield, Unit yield, Variation of yield in field
Improvement of growth conditions	Water stress, monthly growth, soil moisture (in irrigation), flooding range and period, fertilization, growth level, growth stage, soil fertility, crop quality
Others	Flood damage, drought damage, low(high) temperature damage

Source: Remote sensing GIS / GPS utilization guide for agricultural and environmental research (Yoshio Inoue, etc.)

Since the aim is to improve the efficiency of agricultural land use, increase crop production, and improve growing conditions, different information such as plant activity, ground surface temperature, and soil moisture is required to be extracted from satellite data (electromagnetic waves). Specifically, as in the Project, the satellite information on acreage and unit yield forecasts is used for ex-post evaluation and effective planning for the project, including crop growth management.

There are two major advantages of satellite data:, wide-area characteristics and Long-term observations, which provide many opportunities to apply these characteristics to post-project monitoring and ex-post evaluation. In the agricultural sector, the main items that can utilize satellite data for large business districts are:

(1) Changes in land-use: change in arable land area, water area, land area, wetland, expansion, and contraction of wasteland and urban area

(2) Changes in agricultural land: changes in farmland, cultivated land, paddy area, planted area per crop, and distribution of soil salinity and flooded area

(3) Changes in production yield: changes in the distribution of high-yielding fields, unit yield, and yields of major crops

(4) Changes in growing conditions: changes in rice yields, soil moisture, rice protein content, crop moisture, leaf area index, photosynthetically active radiation, and differences in transplantation methods

Most of the above items can be monitored by optical sensors. However, in the monsoon season when the ground surface is covered by clouds for long durations, SAR sensor is only available for observing the surface condition. For continuous and stable monitoring, both optical sensors and SAR sensors, (or only SAR sensors for part of the items) are expected to be utilized for ex-post evaluation.

Appendix

A-1Summary of yield survey (unit acreage sampling method) (1/2)

Sample Yield Harvest																				
Sr.	Village name	Variety	TO	Plot	Sowing Method	Before Drying						After Drying						Coordination Point		Remarks
						Sampling Date	Initial MC (%)	Yield/m2 (Kg/m2)	Yield/ac (Kg)	Yield/ac (lb)	Yield/ac (basket)	Sample Measuring Date	Actual MC%	Yield/m2 (Kg/m2)	Yield/ac (kg)	Yield/ac (lb)	Yield/ac (basket)	X-Axis	Y-Axis	
1	Inn Gyi Village	Yadanartoe	-	I	Broadcasting	3.11.2019	24.9	0.50	2023	4451.5	96.77	6.11.2019	12.0	0.43	1740	3828.3	83.2	95.572	18.542	3) Varity (Yadanartoe, Inle, Taung Pyan)
1	Inn Gyi Village	Yadanartoe	-	II	Broadcasting	3.11.2019	25.4	0.48	1942	4273.5	92.90	6.11.2019	12.9	0.38	1538	3383.2	73.5	95.572	18.542	
1	Inn Gyi Village	Yadanartoe	-	III	Broadcasting	3.11.2019	25.5	0.53	2145	4718.6	102.58	6.11.2019	12.8	0.43	1740	3828.3	83.2	95.572	18.542	
1	Inn Gyi Village	Yadanartoe	-	IV	Broadcasting	3.11.2019	22.7	0.51	2064	4540.6	98.71	6.11.2019	12.7	0.45	1821	4006.4	87.1	95.572	18.542	
1	Inn Gyi Village	Yadanartoe	-	V	Broadcasting	3.11.2019	24.5	0.52	2104	4629.6	100.64	6.11.2019	12.7	0.44	1781	3917.4	85.2	95.572	18.542	
1							24.6				98.32		12.6				82.5			
2	Inn Gyi Village	Yadanartoe	TO-13	I	Broadcasting	5.11.2019	18.9	0.54	2185	4807.7	104.51	8.11.2019	14.2	0.48	1942	4273.5	92.9	95.587	18.535	3) Varity (Yadanartoe, Inle, Taung Pyan)
2	Inn Gyi Village	Yadanartoe	TO-13	II	Broadcasting	5.11.2019	19.6	0.53	2145	4718.6	102.58	8.11.2019	13.8	0.46	1862	4095.4	89.0	95.588	18.535	
2	Inn Gyi Village	Yadanartoe	TO-13	III	Broadcasting	5.11.2019	19.1	0.52	2104	4629.6	100.64	8.11.2019	13.5	0.46	1862	4095.4	89.0	95.588	18.535	
2	Inn Gyi Village	Yadanartoe	TO-13	IV	Broadcasting	5.11.2019	16.2	0.47	1902	4184.4	90.97	8.11.2019	12.7	0.43	1740	3828.3	83.2	95.587	18.535	
2	Inn Gyi Village	Yadanartoe	TO-13	V	Broadcasting	5.11.2019	18.4	0.48	1942	4273.5	92.90	8.11.2019	13.6	0.42	1700	3739.3	81.3			
2							18.5				98.32		13.56				87.1			
3	Inn Gyi Village	Yadanartoe	TO-16	I	Transplanting	6.11.2019	22.9	0.55	2226	4896.7	106.45	9.11.2019	12.6	0.47	1902	4184.4	91.0	95.579	18.544	3) Varity (Yadanartoe, Inle, Taung Pyan)
3	Inn Gyi Village	Yadanartoe	TO-16	II	Transplanting	6.11.2019	22.8	0.56	2266	4985.7	108.39	9.11.2019	13.0	0.49	1983	4362.5	94.8	95.580	18.544	
3	Inn Gyi Village	Yadanartoe	TO-16	III	Transplanting	6.11.2019	23.5	0.58	2347	5163.8	112.26	9.11.2019	12.7	0.50	2023	4451.5	96.8	95.580	18.544	
3	Inn Gyi Village	Yadanartoe	TO-16	IV	Transplanting	6.11.2019	21.4	0.54	2185	4807.7	104.51	9.11.2019	11.7	0.48	1942	4273.5	92.9	95.580	18.544	
3	Inn Gyi Village	Yadanartoe	TO-16	V	Transplanting	6.11.2019	21.1	0.56	2266	4985.7	108.39	9.11.2019	12.4	0.50	2023	4451.5	96.8	95.579	18.544	
3							22.3				108.00		12.5				94.5			
4	Inn Gyi Village	Yadanartoe	TO-13	I	Drum Seeder	7.11.2019	21.6	0.51	2064	4540.6	98.71	10.11.2019	13.2	0.45	1821	4006.4	87.1	95.584	18.535	3) Varity (Yadanartoe, Inle, Taung Pyan)
4	Inn Gyi Village	Yadanartoe	TO-13	II	Drum Seeder	7.11.2019	19.8	0.49	1983	4362.5	94.84	10.11.2019	13.4	0.44	1781	3917.4	85.2	95.585	18.535	
4	Inn Gyi Village	Yadanartoe	TO-13	III	Drum Seeder	7.11.2019	21.3	0.48	1942	4273.5	92.90	10.11.2019	13.4	0.42	1700	3739.3	81.3	95.585	18.534	
4	Inn Gyi Village	Yadanartoe	TO-13	IV	Drum Seeder	7.11.2019	20.5	0.51	2064	4540.6	98.71	10.11.2019	13.5	0.46	1862	4095.4	89.0	95.584	18.534	
4	Inn Gyi Village	Yadanartoe	TO-13	V	Drum Seeder	7.11.2019	19.9	0.52	2104	4629.6	100.64	10.11.2019	13.4	0.47	1902	4184.4	91.0	95.584	18.534	
4							20.6				97.16		13.4				86.7			
5	Taung Kone Village	Taung Pyan	-	I	Broadcasting	12.11.2019	29.3	0.48	1942	4273.5	92.90	17.11.2019	12.3	0.38	1538	3383.2	73.5	95.579	18.523	3) Varity (Yadanartoe, Inle, Taung Pyan)
5	Taung Kone Village	Taung Pyan	-	II	Broadcasting	12.11.2019	27.4	0.35	1416	3116.1	67.74	17.11.2019	11.6	0.27	1093	2403.8	52.3	95.579	18.523	
5	Taung Kone Village	Taung Pyan	-	III	Broadcasting	12.11.2019	26.3	0.34	1376	3027.0	65.81	17.11.2019	12.3	0.28	1133	2492.9	54.2	95.579	18.522	
5	Taung Kone Village	Taung Pyan	-	IV	Broadcasting	12.11.2019	26.4	0.31	1255	2760.0	60.00	17.11.2019	11.4	0.25	1012	2225.8	48.4	95.579	18.522	
5	Taung Kone Village	Taung Pyan	-	V	Broadcasting	12.11.2019	28.7	0.27	1093	2403.8	52.26	17.11.2019	10.2	0.22	890	1958.7	42.6	0.000	0.000	
5							27.6				67.74		11.6				54.2			
6	Taung Kone Village	Inle	-	I	Broadcasting	12.11.2019	26.9	0.56	2266	4985.7	108.39	17.11.2019	11.2	0.46	1862	4095.4	89.0	95.576	18.518	3) Varity (Yadanartoe, Inle, Taung Pyan)
6	Taung Kone Village	Inle	-	II	Broadcasting	12.11.2019	26.9	0.67	2711	5965.1	129.68	17.11.2019	10.1	0.54	2185	4807.7	104.5	95.576	18.519	
6	Taung Kone Village	Inle	-	III	Broadcasting	12.11.2019	27.8	0.67	2711	5965.1	129.68	17.11.2019	11.0	0.55	2226	4896.7	106.4	95.577	18.519	
6	Taung Kone Village	Inle	-	IV	Broadcasting	12.11.2019	27.5	0.67	2711	5965.1	129.68	17.11.2019	10.3	0.55	2226	4896.7	106.4	95.577	18.519	
6	Taung Kone Village	Inle	-	V	Broadcasting	12.11.2019	27.3	0.69	2792	6143.1	133.55	17.11.2019	12.5	0.58	2347	5163.8	112.3	95.577	18.518	

A-1 Summary of yield survey (unit acreage sampling method) (2/2)

Sample Yield Harvest																				
						Before Drying						After Drying						Coordination Point		
Sr.	Village name	Variety	TO	Plot	Sowing Method	Sampling Date	Initial MC (%)	Yield/m2 (Kg/m2)	Yield/ac (Kg)	Yield/ac (lb)	Yield/ac (basket)	Sample Measuring Date	Actual MC%	Yield/m2 (Kg/m2)	Yield/ac (kg)	Yield/ac (lb)	Yield/ac (basket)	X-Axis	Y-Axis	Remarks
6							27.3				126.19		11.0				103.7			
7	Daung Yike Chaung Village	Inle	TO-15	I	Broadcasting	12.11.2019	25.2	0.76	3076	6766.3	147.09	17.11.2019	11.8	0.64	2590	5698.0	123.9	95.579	18.534	3) Varity (Yadanartoe, Inle, Taung Pyan)
7	Daung Yike Chaung Village	Inle	TO-15	II	Broadcasting	12.11.2019	25.2	0.61	2469	5430.9	118.06	17.11.2019	12.2	0.51	2064	4540.6	98.7	95.580	18.534	
7	Daung Yike Chaung Village	Inle	TO-15	III	Broadcasting	12.11.2019	24.5	0.41	1659	3650.3	79.35	17.11.2019	11.0	0.35	1416	3116.1	67.7	95.580	18.533	
7	Daung Yike Chaung Village	Inle	TO-15	IV	Broadcasting	12.11.2019	24.2	0.54	2185	4807.7	104.51	17.11.2019	12.1	0.46	1862	4095.4	89.0	95.579	18.533	
7	Daung Yike Chaung Village	Inle	TO-15	V	Broadcasting	12.11.2019	25.1	0.43	1740	3828.3	83.22	17.11.2019	12.1	0.37	1497	3294.1	71.6	0.000	0.000	
7							24.8				106.45		11.8				90.2			
8	Inn Gyi village	Taung Pyan	TO-12	I	Broadcasting	12.11.2019	27.9	0.19	769	1691.6	36.77	17.11.2019	10.6	0.15	607	1335.5	29.0	95.594	18.535	3) Varity (Yadanartoe, Inle, Taung Pyan)
8	Inn Gyi village	Taung Pyan	TO-12	II	Broadcasting	12.11.2019	28.5	0.17	688	1513.5	32.90	17.11.2019	11.4	0.14	567	1246.4	27.1	95.594	18.535	
8	Inn Gyi village	Taung Pyan	TO-12	III	Broadcasting	12.11.2019	26.5	0.20	809	1780.6	38.71	17.11.2019	11.7	0.16	647	1424.5	31.0	95.594	18.535	
8	Inn Gyi village	Taung Pyan	TO-12	IV	Broadcasting	12.11.2019	25.6	0.23	931	2047.7	44.52	17.11.2019	11.7	0.19	769	1691.6	36.8	95.594	18.535	
8	Inn Gyi village	Taung Pyan	TO-12	V	Broadcasting	12.11.2019	27.3	0.27	1093	2403.8	52.26	17.11.2019	10.1	0.22	890	1958.7	42.6	95.594	18.535	
8							27.2				41.03		11.1				33.3			
9	Htan Kone Village	Hmaw Bi - (Non CS)	TO-3	I	Broadcasting	12.11.2019	27.6	0.32	1295	2849.0	61.93	17.11.2019	12.0	0.27	1093	2403.8	52.3	95.609	18.540	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
9	Htan Kone Village	Hmaw Bi - (Non CS)	TO-3	II	Broadcasting	12.11.2019	26.5	0.27	1093	2403.8	52.26	17.11.2019	12.1	0.22	890	1958.7	42.6	95.608	18.539	
9	Htan Kone Village	Hmaw Bi - (Non CS)	TO-3	III	Broadcasting	12.11.2019	26.3	0.30	1214	2670.9	58.06	17.11.2019	11.0	0.24	971	2136.7	46.5	95.608	18.540	
9	Htan Kone Village	Hmaw Bi - (Non CS)	TO-3	IV	Broadcasting	12.11.2019	26.0	0.34	1376	3027.0	65.81	17.11.2019	11.7	0.28	1133	2492.9	54.2	95.609	18.540	
9	Htan Kone Village	Hmaw Bi - (Non CS)	TO-3	V	Broadcasting	12.11.2019	28.4	0.28	1133	2492.9	54.19	17.11.2019	12.5	0.23	931	2047.7	44.5	0.000	0.000	
9							27.0				58.45		11.9				48.0			
10	Htan Kone Village	Hmaw Bi - (CS)	TO-5	I	Transplanting	12.11.2019	21.5	0.46	1862	4095.4	89.03	17.11.2019	11.4	0.40	1619	3561.2	77.4	95.605	18.538	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
10	Htan Kone Village	Hmaw Bi - (CS)	TO-5	II	Transplanting	12.11.2019	23.5	0.44	1781	3917.4	85.16	17.11.2019	11.8	0.34	1376	3027.0	65.8	95.605	18.538	
10	Htan Kone Village	Hmaw Bi - (CS)	TO-5	III	Transplanting	12.11.2019	21.5	0.33	1335	2938.0	63.87	17.11.2019	11.9	0.27	1093	2403.8	52.3	95.605	18.538	
10	Htan Kone Village	Hmaw Bi - (CS)	TO-5	IV	Transplanting	12.11.2019	24.1	0.47	1902	4184.4	90.97	17.11.2019	12.9	0.4	1619	3561.2	77.4	95.605	18.538	
10	Htan Kone Village	Hmaw Bi - (CS)	TO-5	V	Transplanting	12.11.2019	25.8	0.31	1255	2760.0	60.00	17.11.2019	12.3	0.26	1052	2314.8	50.3	95.605	18.538	
10							23.3				77.81		12.1				64.6			
11	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	I	Transplanting	12.11.2019	25.9	0.37	1497	3294.1	71.61	17.11.2019	12.3	0.31	1255	2760.0	60.0	95.606	18.539	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
11	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	II	Transplanting	12.11.2019	25.2	0.29	1174	2581.9	56.13	17.11.2019	11.7	0.24	971	2136.7	46.5	95.606	18.539	
11	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	III	Transplanting	12.11.2019	28.0	0.32	1295	2849.0	61.93	17.11.2019	12.7	0.24	971	2136.7	46.5	95.606	18.539	
11	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	IV	Transplanting	12.11.2019	25.6	0.27	1093	2403.8	52.26	17.11.2019	11.6	0.22	890	1958.7	42.6	95.606	18.539	
11	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	V	Transplanting	12.11.2019	26.5	0.37	1497	3294.1	71.61	17.11.2019	13.0	0.3	1214	2670.9	58.1	95.606	18.539	
							26.2				62.71		12.3				50.7			

A-2 Summary of yield survey (whole fields measurement method)

Combine Harvesting Inside LDY-4 Result by Combine Harvester

Sr.	Village Name	Variety Name	TO No	Area	Sowing Method	Combine Harvesting Date	MC %			Yield/Unit Area (lb)	Yield/Acre (lb)	Yield/Acre (basket)			Assuming MC at 14%	Yield/Acre (basket)	X-Axis	Y-Axis	
12	Inn Gyi Village	Yadanatoe	TO-16	0.9	Transplanting	14.11.2019	18.5			2985.0	3316.7	72.1	0.31	1255	14.0	68.3	95.579	18.544	3) Varity (Yadanartoe, Inle, Taung Pyan)
																	95.580	18.544	
																	95.580	18.544	
																	95.580	18.544	
																	95.579	18.544	
13	Daung Yat Chaung	Inle	TO-15	1	Broadcasting	16.11.2019	22.0			3937.0	3937.0	75.9	0.31	1255	14.0	68.8	95.579	18.533	3) Varity (Yadanartoe, Inle, Taung Pyan)
																	95.579	18.533	
																	95.580	18.530	
																	95.580	18.533	
																	95.579	18.533	
																	95.579	18.532	
																	95.579	18.532	
14	Inn Gyi village	Taung Pyan	TO-11	0.5	Broadcasting	22.11.2019	16.8			1253.0	2506.0	54.5	0.31	1255	14.0	52.7	95.593	18.534	3) Varity (Yadanartoe, Inle, Taung Pyan)
																	95.593	18.534	
																	95.593	18.534	
																	95.594	18.534	
																	95.594	18.534	
																	95.593	18.534	
																	95.593	18.534	
																	95.593	18.534	
																	95.593	18.534	
																	95.593	18.534	
15	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	0.7	Broadcasting	25.11.2019	19.4			1967.0	2810.0	61.1	0.31	1255	14.0	57.3	95.609	18.540	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
																	95.609	18.540	
16	Htan Kone Village	Hmaw Bi - (Non CS)	TO-5	0.5	Transplanting	25.11.2019	15.6			1243.0	2486.0	54.0	0.31	1255	14.0	53.0	95.606	18.539	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
																	95.606	18.539	
																	95.606	18.538	
																	95.606	18.538	
																	95.606	18.538	
																	95.606	18.538	
																	95.606	18.539	
17	Htan Kone Village	Hmaw Bi - (CS)	TO-5	0.7	Transplanting	25.11.2019	14.3			1491.0	2130.0	46.3	0.24	971	14.0	46.1	95.606	18.538	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
																	95.605	18.538	
																	95.605	18.539	
																	95.605	18.539	
																	95.606	18.539	
																	95.606	18.538	
18	Inn Gyi Village	Hmaw Bi - (CS)	TO-11	0.5	Broadcasting	1.12.2019	27.7			1047	2094.0	41.88			14.0	35.2	95.594	18.533	1) Cs and nonCS (the survey made by PROFIA) & 2) Broadcasting(Drum) and transplanting (the survey made by PROFIA)
																	95.594	18.533	
																	95.595	18.532	
																	95.594	18.532	
																	95.594	18.533	
																	95.594	18.533	

A-3 Summary of farmer Interview (1/3)

Sr	Survey Date	Village tract	Village	TO No.	Monsoon Paddy (2019)									Summer Paddy (2019)								
					Variety Name	Used of Seed (CS or NCS)	Sowing ime	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk/ acre)	Variety Name	Used of Seed CS or NCS)	Sowing Time	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk)
1	23.11.2019	Ma Gyi Gone	Inn Gyi	13	Ngwetoe	NCS	19.7.2019	Broadcasting	20.11.2019	Combine	1	2	70	Yadanar toe	CS	5.2.2019	Broadcasting	5.6.2019	Combine	1	2	70
2	23.11.2019	Ma Gyi Gone	Inn Gyi	13	Ngwetoe	NCS	20.7.2019	Broadcasting	21.11.2019	Combine	0.2	0.5	70	Yadanar toe	CS	30.1.2019	Broadcasting	30.5.2019	Combine	0.2	0.5	115
3	23.11.2019	Ma Gyi Gone	Inn Gyi	13	Inle	NCS	20.7.2019	Broadcasting	22.11.2019	Combine	0.97	2.425	60	Yadanar toe	CS	10.2.2019	Broadcasting	10.6.2019	Combine	0.97	2.91	55
4	23.11.2019	Ma Gyi Gone	Inn Gyi	13	Ngwetoe	NCS	17.7.2019	Transplanting	26.11.2019	Combine	0.37	0.74	60	Yadanar toe	CS	11.2.2019	Broadcasting	11.6.2019	Combine	0.37	1.11	75
5	23.11.2019	Kyar Ni Kan	Htan Kone	7	Ngwetoe	NCS	15.7.2019	Broadcasting	23.11.2019	Combine	0.73	1.46	40	Yadanar toe	CS	15.2.2019	Broadcasting	20.6.2019	Combine	0.73	1.46	55
6	23.11.2019	Kyar Ni Kan	Chay Pin	7	Inle	NCS	16.7.2019	Broadcasting	23.11.2019	Combine	0.42	1.26	55	Yadanar toe	CS	16.2.2019	Broadcasting	20.6.2020	Combine	0.42	0.84	70
7	24.11.2019	Kyar Ni Kan	Pan Dat Myaung	7	Inle	NCS	15.7.2019	Broadcasting	24.11.2019	Combine	0.23	0.805	52	Yadanar toe	CS	15.2.2019	Broadcasting	20.6.2019	Combine	0.23	0.575	70
8	24.11.2019	Kyar Ni Kan	Htan Kone	7	Inle	NCS	17.7.2019	Broadcasting	27.11.2019	Combine	0.67	1.675	50	Yadanar toe	CS	15.2.2019	Broadcasting	20.6.2019	Combine	0.67	1.34	80
9	24.11.2019	Kyar Ni Kan	Kyot Pin	6	Inle	CS	15.7.2019	Broadcasting	28.11.2019	Combine	1.07	2.14	60	Yadanar toe	CS	10.2.2019	Broadcasting	13.6.2019	Combine	1.07	2.675	70
10	24.11.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	CS	15.7.2019	Broadcasting	24.11.2019	Combine	0.6	0.9	60	Yadanar toe	CS	2.3.2019	Broadcasting	5.7.2019	Combine	0.6	0.9	100
11	24.11.2019	Kyar Ni Kan	Htan Kone	6	Yadanatoe	CS	24.7.2019	Transplanting	26.11.2019	Combine	1.56	2.34	80	Yadanar toe	CS	30.1.2019	Broadcasting	2.6.2019	Combine	1.56	3.12	80
12	24.11.2019	Kyar Ni Kan	Htan Kone	5	Yadanatoe	CS	22.7.2019	Transplanting	20.11.2019	Combine	0.38	0.57	70	Yadanar toe	CS	15.1.2019	Broadcasting	15.5.2019	Combine	0.38	1.14	90
13	25.11.2019	Kyar Ni Kan	Htan Kone	3	Inle	NCS	25.7.2019	Broadcasting	26.11.2019	Combine	0.11	0.22	60	Yadanar toe	NCS	10.1.2019	Broadcasting	14.5.2019	Combine	0.11	0.22	60
14	25.11.2019	Ma Gyi Gone	Inn Gyi	17	Taung Pyan	NCS	12.6.2019	Broadcasting	25.11.2019	Combine	0.27	0.54	65	Yadanar toe	CS	13.1.2019	Broadcasting	15.5.2019	Combine	0.27	0.54	80
15	25.11.2019	Kyar Ni Kan	Htan Kone	2	Tin Ta Yar Gyi	NCS	3.7.2019	Broadcasting	29.11.2019	Combine	0.13	0.26	90	Yadanar toe	CS	3.2.2019	Broadcasting	4.6.2019	Combine	0.13	0.26	80
16	25.11.2019	Kyar Ni Kan	Htan Kone	1	Inle	NCS	10.7.2019	Transplanting	30.11.2019	Combine	1.92	3.84	60	Yadanar toe	NCS	15.2.2019	Broadcasting	17.6.2019	Combine	1.92	3.84	70
17	25.11.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	CS	13.7.2019	Transplanting	15.11.2019	Combine	0.2	0.3	70	Yadanar toe	CS	12.2.2019	Broadcasting	16.6.2019	Combine	0.2	0.4	80
18	25.11.2019	Ma Gyi Gone	Inn Gyi	11	Taung Pyan	NCS	8.7.2019	Broadcasting	10.12.2019	Combine	1	2.5	80	Yadanar toe	CS	13.1.2019	Broadcasting	16.5.2019	Combine	1	2.5	80
19	26.11.2019	Ma Gyi Gone	Inn Gyi	12	Yadanatoe	CS	30.7.2019	Broadcasting	7.12.2019	Combine	0.52	1.3	65	Yadanar toe	CS	2.2.2019	Broadcasting	3.6.2019	Combine	0.52	1.56	80
20	26.11.2019	Kyar Ni Kan	Htan Kone	3	Inle	NCS	15.7.2019	Broadcasting	30.11.2019	Combine	0.42	0.84	50	Yadanar toe	CS	3.2.2019	Broadcasting	5.6.2019	Combine	0.42	0.84	70
21	26.11.2019	Kyar Ni Kan	Chae Pin	1	Inle	NCS	28.7.2019	Broadcasting	25.11.2019	Combine	0.62	1.24	40	Pyi Taw Yin	NCS	25.2.2019	Broadcasting	30..5.2019	Combine	0.62	1.24	45
22	26.11.2019	Kyar Ni Kan	Chae Pin	1	Inle	NCS	15.7.2019	Broadcasting	30.11.2019	Combine	0.93	1.86	60	Pyi Taw Yin	NCS	25.2.2019	Broadcasting	29.5.2019	Combine	0.93	1.86	60
23	26.11.2019	Kyar Ni Kan	Chae Pin	M1	Inle	NCS	7.7.2019	Broadcasting	30.11.2019	Combine	1.2	2.4	55	Yadanar toe	CS	15.2.2019	Broadcasting	13.6.2019	Combine	1.2	2.4	50
24	26.11.2019	Kyar Ni Kan	Chae Pin	5	Tin Ta Yar Gyi	NCS	8.7.2019	Broadcasting	26.11.2019	Combine	0.6	1.2	70	Yadanar toe	CS	14.2.2019	Broadcasting	17.6.2019	Combine	0.6	1.2	70
25	27.11.2019	Kyar Ni Kan	Pyin Gyi	7	Inle	NCS	20.6.2019	Broadcasting	27.11.2019	Combine	0.72	1.44	40	Yadanar toe	CS	30.1.2019	Broadcasting	1.6.2019	Combine	0.72	1.44	70
26	27.11.2019	Kyar Ni Kan	Chae Pin	3	Tin Ta Yar Gyi	NCS	13.7.2019	Broadcasting	23.11.2019	Combine	0.49	0.98	50	Yadanar toe	CS	2.2.2019	Broadcasting	2.6.2019	Combine	0.49	0.98	70
27	27.11.2019	Kyar Ni Kan	Chae Pin	5	Tin Ta Yar Gyi	NCS	8.7.2019	Broadcasting	26.11.2019	Combine	0.88	1.76	60	Yadanar toe	CS	13.2.2019	Broadcasting	15.6.2019	Combine	0.88	1.76	90
28	27.11.2019	Kyar Ni Kan	Se Sone Gone	5	Tin Ta Yar Gyi	NCS	30.6.2019	Broadcasting	26.11.2019	Combine	0.31	0.62	40	Yadanar toe	CS	10.2.2019	Broadcasting	11.6.2019	Combine	0.31	0.62	65
29	27.11.2019	Kyar Ni Kan	Chae Pin	1	Tin Ta Yar Gyi	NCS	10.7.2019	Broadcasting	28.11.2019	Combine	1.2	3.6	50	Sin Thwe Latt	NCS	10.2.2019	Broadcasting	20.6.2019	Combine	1.2	3	95
30	27.11.2019	Kyar Ni Kan	Chae Pin	8	Inle	NCS	20.6.2019	Broadcasting	26.11.2019	Combine	0.58	1.16	50	Yadanar toe	CS	2.2.2019	Broadcasting	3.6.2019	Combine	0.58	1.16	80
31	28.11.2019	Ma Gyi Gone	Inn Gyi	11	Inle	NCS	20.6.2019	Broadcasting	22.11.2019	Combine	0.32	0.64	70	Yadanar toe	CS	30.1.2019	Broadcasting	28.5.2019	Combine	0.32	0.8	90
32	28.11.2019	Ma Gyi Gone	Inn Gyi	16	Yadanatoe	CS	20.6.2919	Broadcasting	18.10.2019	Combine	1.15	1.725	80	Yadanar toe	CS	5.2.2019	Broadcasting	2.6.2019	Combine	1.15	1.725	78
33	28.11.2019	Ma Gyi Gone	Inn Gyi	11	Taung Pyan	NCS	26.6.2019	Broadcasting	22.11.2019	Combine	0.66	1.32	52	Yadanar toe	CS	2.2.2019	Broadcasting	4.6.2019	Combine	0.66	1.32	82
34	28.11.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Inle	NCS	27.6.2019	Broadcasting	24.11.2019	Combine	0.81	2.43	40	Yadanar toe	CS	28.1.2019	Broadcasting	29.5.2019	Combine	0.81	1.215	60
35	28.11.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Inle	NCS	29.6.2019	Broadcasting	19.11.2019	Combine	0.41	1.025	48	Yadanar toe	CS	27.1.2019	Broadcasting	25.5.2019	Combine	0.41	0.82	80
36	28.11.2019	Ma Gyi Gone	Inn Gyi	11	Inle	NCS	28.6.2019	Broadcasting	20.11.2019	Combine	0.33	0.66	45	Yadanar toe	CS	3.2.2019	Broadcasting	4.6.2019	Combine	0.33	0.66	82
37	29.11.2019	Ma Gyi Gone	Inn Gyi	11	Inle	NCS	1.7.2019	Broadcasting	21.11.2019	Combine	0.49	0.98	40	Yadanar toe	CS	4.2.2019	Broadcasting	1.6.2019	Combine	0.49	0.98	82
38	29.11.2019	Sinn Luu	Daung Yat Chaung	15	Inle	NCS	29.6.2019	Broadcasting	15.11.2019	Combine	0.31	0.62	60	Yadanar toe	CS	1.2.2019	Broadcasting	2.6.2019	Combine	0.31	0.93	75
39	29.11.2019	Sinn Luu	Daung Yat Chaung	15	Inle	NCS	28.6.2019	Broadcasting	21.11.2019	Combine	1	2	55	Yadanar toe	CS	6.2.2019	Broadcasting	3.6.2019	Combine	1	2	80
40	29.11.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	2.7.2019	Broadcasting	24.11.2019	Combine	0.42	0.84	52	Yadanar toe	CS	27.1.2019	Broadcasting	2.6.2019	Combine	0.42	1.26	80
41	29.11.2019	Ma Gyi Gone	Inn Gyi	MTO-3L	Inle	NCS	27.6.2019	Broadcasting	19.11.2019	Combine	0.84	1.68	45	Yadanar toe	CS	1.2.2019	Broadcasting	28.5.2019	Combine	0.84	2.52	83
42	29.11.2019	Ma Gyi Gone	Inn Gyi	15	Inle	NCS	28.6.2019	Broadcasting	26.11.2019	Combine	0.85	2.125	50	Yadanar toe	CS	4.2.2019	Broadcasting	30.5.2019	Combine	0.85	2.55	80
43	30.11.2019	Ma Gyi Gone	Inn Gyi	14	Inle	NCS	29.6.2019	Broadcasting	22.11.2019	Combine	0.81	1.62	60	Yadanar toe	CS	23.1.2019	Broadcasting	24.5.2019	Combine	0.81	2.43	79
44	30.11.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Taung Pyan	NCS	30.6.2019	Broadcasting	23.11.2019	Combine	0.91	1.82	55	Yadanar toe	CS	27.1.2019	Broadcasting	30.5.2919	Combine	0.91	2.73	81
45	30.11.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Inle	NCS	28.6.2019	Broadcasting	19.11.2019	Combine	0.42	0.84	45	Yadanar toe	CS	30.1.2019	Broadcasting	1.6.2019	Combine	0.42	1.26	80
46	30.11.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Inle	NCS	1.7.2019	Broadcasting	24.11.2019	Combine	0.39	0.78	52	Yadanar toe	CS	28.1.2019	Broadcasting	26.5.2019	Combine	0.39	1.17	78
47	30.11.2019	Ma Gyi Gone	Inn Gyi	12	Inle	NCS	3.7.2019	Broadcasting	26.11.2019	Combine	0.51	1.275	75	Yadanar toe	CS	2.2.2019	Broadcasting	8.6.2019	Combine	0.51	1.275	100
48	30.11.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	2.7.2019	Broadcasting	21.11.2019	Combine	0.68	1.7	50	Yadanar toe	CS	6.2.2019	Broadcasting	10.6.2019	Combine	0.68	2.04	100
49	2.12.2019	Ma Gyi Gone	Inn Gyi	MTO-3L	Inle	NCS	2.7.2019	Broadcasting	20.11.2019	Combine	0.53	1.325	52	Yadanar toe	CS	29.1.2019	Broadcasting	29.5.2019	Combine	0.53	1.06	81
50	2.12.2019	Me Khaung	Tha Yet Gone	2	Inle	NCS	29.6.2019	Broadcasting	19.11.2019	Combine	0.94	2.82	40	Yadanar toe	CS	29.1.2019	Broadcasting	2.6.2019	Combine	0.94	2.82	70
51	2.12.2019	Me Khaung	Tha Yet Gone	4	Inle	NCS	12.7.2019	Broadcasting	30.11.2019	Combine	0.57	1.71	50	Yadanar toe	CS	2.2.2019	Broadcasting	29.5.2019	Combine	0.57	1.71	90
52	2.12.2019	Ma Gyi Gone	Inn Gyi	MTO-4	Inle	NCS	10.7.2019	Broadcasting	29.11.2019	Combine	0.75	1.875	55	Sin Thwe Latt	NCS	3.2.2019	Broadcasting	28.5.2019	Combine	0.75	1.875	70
53	2.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	5.7.2019	Broadcasting	22.11.2019	Combine	1.14	2.85	52	Yadanar toe	CS	26.1.2019	Broadcasting	2.6.2019	Combine	1.14	2.28	100
54	2.12.2019	Ma Gyi Gone	Inn Gyi	15	Inle	NCS	29.6.2019	Broadcasting	25.11.2019	Combine	0.55	1.375	60	Yadanar toe	CS	3.2.2019	Broadcasting	28.5.2019	Combine	0.55	1.65	80
55	3.12.2019	Ma Gyi Gone	Inn Gyi	MTO-5	Yadanatoe	CS	25.6.2019	Seeder	20.10.2019	Manual	0.54	0.54	45	Yadanar toe	CS	5.2.2019	Seeder	25.5.2019	Manual	0.54	1.35	40
56	3.12.2019	Me Khaung	Tha Yet Gone	5	Inle	NCS	13.7.2109	Broadcasting	21.11.2019	Combine	0.98	2.45	51	Yadanar toe	CS	27.1.2019	Broadcasting	27.5.2019	Combine	0.98	2.94	100

A-3 Summary of farmer Interview (2/3)

Sr.	Survey Date	Village tract	Village	TO No.	Monsoon Paddy (2019)										Summer Paddy (2019)								
					Variety Name	Used of Seed (CS or NCS)	Sowing ime	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk/ acre)	Variety Name	Used of Seed CS or NCS)	Sowing Time	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk)
57	3.12.2019	Kyar Ni Kan	Htan Kone	5	Inle	NCS	12.7.2019	Broadcasting	30.11.2019	Combine	0.16	0.4	49	Yadanar toe	CS	7.2.2019	Broadcasting	2.6.2019	Combine	0.16	0.48	100
58	3.12.2019	Ma Gyi Gone	Inn Gyi	MTO-3L	Inle	NCS	28.6.2019	Broadcasting	19.11.2019	Combine	0.14	0.42	50	Yadanar toe	CS	2.2.2019	Broadcasting	2.6.2019	Combine	0.14	0.28	81
59	3.12.2019	Me Khaung	Tha Yet Gone	5	Inle	NCS	9.7.2019	Broadcasting	23.11.2019	Combine	0.26	0.78	44	Yadanar toe	CS	21.1.2019	Broadcasting	27.5.2019	Combine	0.26	0.78	70
60	3.12.2019	Kyar Ni Kan	Se Sone Gone	MTO-1L	Inle	NCS	12.7.2019	Broadcasting	29.11.2019	Combine	0.94	1.88	42	Yadanar toe	CS	4.2.2019	Broadcasting	6.6.2019	Combine	0.94	1.41	40
61	4.12.2019	Ma Gyi Gone	Inn Gyi	11	Taung Pyan	NCS	9.7.2019	Broadcasting	26.11.2019	Combine	0.46	1.38	30	Yadanar toe	CS	5.2.2019	Broadcasting	9.6.2019	Combine	0.46	1.38	95
62	4.12.2019	Daaung Yet Chanung	Sin Luu	15	Inle	NCS	27.6.2019	Broadcasting	25.11.2019	Combine	0.41	1.23	43	Yadanar toe	CS	25.1.2019	Broadcasting	27.5.2019	Combine	0.41	1.23	80
63	4.12.2019	Daaung Yet Chanung	Sin Luu	15	Taung Pyan	NCS	8.7.2019	Broadcasting	21.11.2019	Combine	0.57	1.71	51	Yadanar toe	CS	28.1.2019	Broadcasting	1.6.2019	Combine	0.57	1.71	75
64	4.12.2019	Kyar Ni Kan	Chae Pin	MTO-1L	Inle	NCS	27.6.2019	Broadcasting	29.11.2019	Combine	0.74	1.48	45	Yadanar toe	CS	3.2.2019	Broadcasting	7.6.2019	Combine	0.74	1.11	45
65	4.12.2019	Kyar Ni Kan	Chae Pin	3	Inle	NCS	8.7.2019	Broadcasting	30.11.2019	Combine	0.29	0.58	45	Yadanar toe	CS	7.2.2019	Broadcasting	4.6.2019	Combine	0.29	0.58	65
66	4.12.2019	Kyar Ni Kan	Chae Pin	3	Inle	NCS	6.7.2019	Broadcasting	26.11.2019	Combine	0.32	0.64	50	Pyi Taw Yin	NCS	30.1.2019	Broadcasting	29.5.2019	Combine	0.32	0.64	70
67	5.12.2019	Kyar Ni Kan	Chae Pin	1	Inle	NCS	5.7.2019	Broadcasting	23.11.2019	Combine	1.12	2.24	45	Pyi Taw Yin	NCS	25.1.2019	Broadcasting	1.6.2019	Combine	1.12	2.24	80
68	5.12.2019	Kyar Ni Kan	Pyin Gyi	7	Inle	NCS	28.6.2019	Broadcasting	24.11.2019	Combine	0.19	0.475	48	Yadanar toe	CS	25.1.2019	Broadcasting	26.5.2019	Combine	0.19	0.19	75
69	5.12.2019	Kyar Ni Kan	Pyin Gyi	7	Inle	NCS	30.6.2019	Broadcasting	25.11.2019	Combine	0.49	1.47	52	Yadanar toe	CS	3.2.2019	Broadcasting	29.5.2019	Combine	0.49	0.49	75
70	5.12.2019	Kyar Ni Kan	Htan Kone	7	Inle	NCS	27.6.2019	Broadcasting	21.11.2019	Combine	0.4	0.8	50	Yadanar toe	CS	6.2.2019	Broadcasting	1.6.2019	Combine	0.4	0.4	80
71	5.12.2019	Me Khaung	Tha Yet Gone	4	Inle	NCS	8.7.2019	Broadcasting	30.11.2019	Combine	0.51	1.02	45	Yadanar toe	CS	30.1.2019	Broadcasting	3.6.2019	Combine	0.51	1.02	75
72	5.12.2019	Me Khaung	Tha Yet Gone	4	Inle	NCS	6.7.2019	Broadcasting	19.11.2019	Combine	0.57	1.425	50	Yadanar toe	CS	2.2.2019	Broadcasting	5.6.2019	Combine	0.57	1.71	70
73	6.12.2019	Me Khaung	Tha Yet Gone	4	Inle	NCS	28.6.2019	Broadcasting	24.11.2019	Combine	0.18	0.36	52	Yadanar toe	CS	23.1.2019	Broadcasting	27.5.2019	Combine	0.18	0.45	70
74	6.12.2019	Kyar Ni Kan	Pyin Gyi	4	Inle	NCS	2.7.2019	Broadcasting	26.11.2019	Combine	0.55	1.65	45	Yadanar toe	CS	28.1.2019	Broadcasting	2.6.2019	Combine	0.55	1.1	80
75	6.12.2019	Me Khaung	Tha Yet Gone	5	Inle	NCS	3.7.2019	Broadcasting	23.11.2019	Combine	0.55	1.375	50	Yadanar toe	CS	4.2.2019	Broadcasting	30.5.2019	Combine	0.55	1.925	82
76	6.12.2019	Me Khaung	Tha Yet Gone	4	Inle	NCS	30.6.2019	Broadcasting	21.11.2019	Combine	0.75	1.5	48	Yadanar toe	CS	26.1.2019	Broadcasting	3.6.2019	Combine	0.75	1.125	90
77	6.12.2019	Kyar Ni Kan	Pyin Gyi	6	Inle	NCS	1.7.2019	Broadcasting	22.11.2019	Combine	0.85	2.125	45	Yadanar toe	CS	4.2.2019	Broadcasting	7.6.2019	Combine	0.85	1.7	85
78	6.12.2019	Kyar Ni Kan	Htan Kone	8	Inle	NCS	6.7.2019	Broadcasting	19.11.2019	Combine	0.24	0.6	50	Yadanar toe	CS	5.2.2019	Broadcasting	6.6.2019	Combine	0.24	0.6	75
79	7.12.2019	Kyar Ni Kan	Chae Pin	7	Inle	NCS	29.6.2019	Broadcasting	24.11.2019	Combine	0.46	0.92	48	Yadanar toe	CS	28.1.2019	Broadcasting	2.6.2019	Combine	0.46	0.92	80
80	7.12.2019	Kyar Ni Kan	Htan Kone	8	Inle	NCS	3.7.2019	Broadcasting	19.11.2019	Combine	0.25	0.625	45	Yadanar toe	CS	29.1.2019	Broadcasting	30.5.2019	Combine	0.25	0.75	95
81	7.12.2019	Ma Gyi Gone	Inn Gyi	16	Taung Pyan	NCS	28.6.2019	Broadcasting	15.11.2019	Combine	0.18	0.18	38	Yadanar toe	CS	30.1.2019	Broadcasting	2.6.2019	Combine	0.18	0.45	80
82	7.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	5.7.2019	Broadcasting	21.11.2019	Combine	0.79	1.975	50	Yadanar toe	CS	3.2.2019	Broadcasting	1.6.2019	Combine	0.79	2.37	90
83	7.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	6.7.2019	Broadcasting	23.11.2019	Combine	0.64	1.6	45	Yadanar toe	CS	1.2.2019	Broadcasting	3.6.2019	Combine	0.64	1.28	78
84	7.12.2019	Ma Gyi Gone	Inn Gyi	16	Taung Pyan	NCS	2.7.2019	Broadcasting	13.11.2019	Combine	0.49	0.98	42	Yadanar toe	CS	27.1.2019	Broadcasting	29.5.2019	Combine	0.49	1.47	82
85	8.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	29.6.2019	Broadcasting	17.11.2019	Combine	1.06	3.18	52	Yadanar toe	CS	3.2.2019	Broadcasting	4.6.2019	Combine	1.06	3.18	60
86	8.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	29.6.2019	Broadcasting	16.11.2019	Combine	0.72	1.44	44	Yadanar toe	CS	2.2.2019	Broadcasting	7.6.2019	Combine	0.72	1.8	80
87	8.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	2.7.2019	Broadcasting	22.11.2019	Combine	0.73	2.19	42	Yadanar toe	CS	6.2.2019	Broadcasting	5.6.2019	Combine	0.73	1.46	82
88	8.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	2.7.2019	Broadcasting	23.11.2019	Combine	0.58	1.74	49	Yadanar toe	CS	27.1.2019	Broadcasting	29.5.2019	Combine	0.58	1.74	82
89	8.12.2019	Ma Gyi Gone	Inn Gyi	16	Inle	NCS	3.7.2019	Broadcasting	24.11.2019	Combine	0.84	2.52	43	Yadanar toe	CS	28.1.2019	Broadcasting	1.6.2019	Combine	0.84	2.1	75
90	8.12.2019	Ma Gyi Gone	Inn Gyi	14	Inle	NCS	28.6.2019	Broadcasting	18.11.2019	Combine	3.07	6.14	51	Yadanar toe	CS	4.2.2019	Broadcasting	3.6.2019	Combine	3.07	9.21	80
91	9.12.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	5.7.2019	Broadcasting	15.11.2019	Combine	0.46	0.92	45	Yadanar toe	CS	5.2.2019	Broadcasting	3.6.2019	Combine	0.46	1.38	80
92	9.12.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	8.7.2019	Broadcasting	26.11.2019	Combine	0.34	0.68	45	Yadanar toe	CS	7.2.1019	Broadcasting	2.6.2019	Combine	0.34	0.68	83
93	9.12.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	4.7.2019	Broadcasting	23.11.2019	Combine	0.17	0.34	50	Yadanar toe	CS	27.1.2019	Broadcasting	29.5.2019	Combine	0.17	0.51	80
94	9.12.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	30.6.2019	Broadcasting	19.11.2019	Combine	0.12	0.3	52	Yadanar toe	CS	25.1.2019	Broadcasting	28.5.2019	Combine	0.12	0.3	79
95	9.12.2019	Ma Gyi Gone	Ma Gyi Gone	17	Inle	NCS	1.7.2019	Broadcasting	20.11.2019	Combine	0.22	0.66	45	Yadanar toe	CS	5.2.2019	Broadcasting	5.6.2019	Combine	0.22	0.66	81
96	9.12.2019	Daaung Yet Chanung	Sin Luu	17	Taung Pyan	NCS	4.7.2019	Broadcasting	18.11.2019	Combine	1.1	2.2	38	Yadanar toe	CS	2.2.2019	Broadcasting	8.6.2019	Combine	1.1	3.3	80
97	10.12.2019	Kyar Ni Kan	Pyin Gyi	3	Tin Ta Yar Gyi	NCS	2.7.2019	Broadcasting	15.11.2019	Combine	0.46	0.92	48	Yadanar toe	CS	6.2.2019	Broadcasting	3.6.2019	Combine	0.46	0.92	78
98	10.12.2019	Ma Gyi Gone	Ma Gyi Gone	16	Inle	NCS	29.6.2019	Broadcasting	17.11.2019	Combine	0.4	1	45	Yadanar toe	CS	4.2.2019	Broadcasting	1.6.2019	Combine	0.4	1.2	100
99	10.12.2019	Ma Gyi Gone	Inn Gyi	14	Inle	NCS	8.7.2019	Broadcasting	27.11.2019	Combine	1.13	2.26	50	Yadanar toe	CS	1.2.2019	Broadcasting	6.6.2019	Combine	1.13	1.695	82
100	10.12.2019	Ma Gyi Gone	Inn Gyi	14	Inle	NCS	7.7.2019	Broadcasting	26.11.2019	Combine	0.87	2.61	48	Yadanar toe	CS	4.2.2019	Broadcasting	2.6.2019	Combine	0.87	2.61	82
101	10.12.2019	Kyar Ni Kan	Htan Kone	6	Yadanatoe	NCS	11.7.2019	Broadcasting	8.11.2019	Combine	0.45	1.125	52	Yadanar toe	CS	6.2.2019	Broadcasting	7.6.2019	Combine	0.45	1.35	75
102	10.12.2019	Kyar Ni Kan	kyot Pin Ing	4	Inle	NCS	28.6.2019	Broadcasting	17.11.2019	Combine	0.47	0.94	50	Yadanar toe	CS	7.2.2019	Broadcasting	9.6.2019	Combine	0.47	1.41	80
103	11.12.2019	Kyar Ni Kan	Chae Pin	3	Inle	NCS	28.6.2019	Broadcasting	18.11.2019	Combine	0.44	1.1	45	Yadanar toe	CS	28.1.2019	Broadcasting	2.6.2019	Combine	0.44	0.66	80
104	11.12.2019	Me Khaung	Tha Yet Gone	5	Tin Ta Yar Gyi	NCS	3.7.2019	Broadcasting	21.11.2019	Combine	1.05	2.625	50	Yadanar toe	CS	4.2.2019	Broadcasting	4.6.2019	Combine	1.05	2.1	83
105	11.12.2019	Kyar Ni Kan	Pyin Gyi	3	Inle	NCS	4.7.2019	Broadcasting	20.11.2019	Combine	0.75	1.5	52	Yadanar toe	CS	4.2.2019	Broadcasting	1.6.2019	Combine	0.75	1.875	80
106	11.12.2019	Kyar Ni Kan	Htan Kone	8	Inle	NCS	30.6.2019	Broadcasting	15.11.2019	Combine	1.08	2.7	49	Yadanar toe	CS	7.2.2019	Broadcasting	9.6.2019	Combine	1.08	2.16	79
107	11.12.2019	Ma Gyi Gone	Inn Gyi	MTO-4R	Inle	NCS	4.7.2019	Broadcasting	27.11.2019	Combine	0.68	1.7	50	Yadanar toe	CS	4.2.2019	Broadcasting	6.6.2019	Combine	0.68	1.36	81
108	11.12.2019	Kyar Ni Kan	Pyin Gyi	8	Inle	NCS	28.6.2019	Broadcasting	17.11.2019	Combine	0.5	1.5	48	Yadanar toe	CS	28.1.2019	Broadcasting	29.5.2019	Combine	0.5	1.5	100
109	12.12.2019	Me Khaung	Tha Yet Gone	8	Inle	NCS	29.6.2019	Broadcasting	18.11.2019	Combine	0.13	0.325	52	Yadanar toe	CS	30.1.2019	Broadcasting	1.6.2019	Combine	0.13	0.26	75
110	12.12.2019	Kyar Ni Kan	Htan Kone	8	Inle	NCS	1.7.2019	Broadcasting	22.11.2019	Combine	0.5	1	50	Yadanar toe	CS	29.1.2019	Broadcasting	29.5.2019	Combine	0.5	1.5	70
111	12.12.2019	Kyar Ni Kan	Pyin Gyi	8	Inle	NCS	28.6.2019	Broadcasting	17.11.2019	Combine	0.37	0.74	51	Yadanar toe	CS	27.1.2019	Broadcasting	27.5.2019	Combine	0.37	1.11	80
112	12.12.2019	Me Khaung	Tha Yet Gone	MTO-1L	Taung Pyan	NCS	3.7.2019	Broadcasting	24.11.2019	Combine	0.49	1.225	40	Yadanar toe	CS	7.2.2019	Broadcasting	2.6.2019	Combine	0.49	1.225	83

A-3 Summary of farmer Interview (3/3)

Sr.	Survey Date	Village tract	Village	TO No.	Monsoon Paddy (2019)									Summer Paddy (2019)								
					Variety Name	Used of Seed (CS or NCS)	Sowing ime	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk/ acre)	Variety Name	Used of Seed CS or NCS)	Sowing Time	Sowing Method	Harvesting Time	Harvesting Method	Area (acre)	Seed rate (bsk)	Yield (bsk)
113	12.12.2019	Kyar Ni Kan	Pyin Gyi	1	Inle	NCS	2.7.2019	Broadcasting	21.11.2019	Combine	0.19	0.475	45	Yadanar toe	CS	28.1.2019	Broadcasting	1.6.2019	Combine	0.19	0.38	80
114	12.12.2019	Kyar Ni Kan	Htan Kone	1	Inle	NCS	5.7.2019	Broadcasting	23.11.2019	Combine	0.41	1.23	50	Yadanar toe	CS	21.1.2019	Broadcasting	27.5.2019	Combine	0.41	1.435	79
115	12.12.2019	Kyar Ni Kan	Se Sone Gone	1	Inle	NCS	30.6.2019	Broadcasting	18.11.2019	Combine	0.53	1.06	45	Yadanar toe	CS	4.2.2019	Broadcasting	6.6.2019	Combine	0.53	0.795	81
116	13.12.2019	Me Khaung	Tha Yet Gone	1	Inle	NCS	8.7.2019	Broadcasting	25.11.2019	Combine	0.12	0.3	48	Yadanar toe	CS	5.2.2019	Broadcasting	9.6.2019	Combine	0.12	0.24	80
117	13.12.2019	Me Khaung	Tha Yet Gone	1	Inle	NCS	28.6.2019	Broadcasting	18.11.2019	Combine	0.68	2.04	52	Yadanar toe	CS	25.1.2019	Broadcasting	27.5.2019	Combine	0.68	1.7	78
118	13.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	29.6.2019	Broadcasting	2.11.2019	Combine	0.49	1.47	50	Yadanar toe	CS	28.1.2019	Broadcasting	1.6.2019	Combine	0.49	0.98	100
119	13.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	28.6.2019	Broadcasting	28.10.2019	Combine	0.54	1.62	45	Yadanar toe	CS	2.2.2019	Broadcasting	4.6.2019	Combine	0.54	1.35	60
120	13.12.2019	Sinn Luu	Daung Yat Chaung	13	Ngwetoe	NCS	1.7.2019	Broadcasting	30.10.2019	Combine	0.84	1.68	50	Yadanar toe	CS	28.1.2019	Broadcasting	29.5.2019	Combine	0.84	1.68	80
121	13.12.2019	Ma Gyi Gone	Inn Gyi	13	Ngwetoe	NCS	5.7.2019	Broadcasting	27.10.2019	Combine	0.18	0.36	45	Yadanar toe	CS	27.1.2019	Broadcasting	25.5.2019	Combine	0.18	0.54	82
122	14.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	2.7.2019	Broadcasting	28.10.2019	Combine	0.57	1.425	50	Yadanar toe	CS	3.2.2019	Broadcasting	4.6.2019	Combine	0.57	1.425	82
123	14.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	9.7.2019	Broadcasting	30.10.2019	Combine	1.1	2.75	48	Yadanar toe	CS	4.2.2019	Broadcasting	1.6.2019	Combine	1.1	3.3	115
124	14.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	3.7.2019	Broadcasting	29.10.2019	Combine	0.67	2.01	52	Yadanar toe	CS	1.2.2019	Broadcasting	2.6.2019	Combine	0.67	2.01	81
125	14.12.2019	Ma Gyi Gone	Inn Gyi	13	Ngwetoe	NCS	28.6.2019	Broadcasting	24.10.2019	Combine	0.29	0.725	50	Yadanar toe	CS	6.2.2019	Broadcasting	3.6.2019	Combine	0.29	0.58	80
126	14.12.2019	Ma Gyi Gone	Inn Gyi	13	Yadanatoe	NCS	27.6.2019	Broadcasting	22.10.2019	Combine	0.28	0.7	45	Yadanar toe	CS	27.1.2019	Broadcasting	2.6.2019	Combine	0.28	0.84	78
127	14.12.2019	Ma Gyi Gone	Inn Gyi	10	Inle	NCS	2.7.2019	Broadcasting	18.11.2019	Combine	0.67	1.34	50	Yadanar toe	CS	1.2.2019	Broadcasting	28.5.2019	Combine	0.67	1.675	100
128	15.12.2019	Ma Gyi Gone	Inn Gyi	10	Inle	NCS	26.6.2019	Broadcasting	14.11.2019	Combine	0.34	0.68	52	Yadanar toe	CS	15.2.2019	Broadcasting	13.6.2019	Combine	0.34	1.02	82
129	15.12.2019	Ma Gyi Gone	Inn Gyi	10	Inle	NCS	30.6.2019	Broadcasting	22.11.2019	Combine	0.51	1.53	49	Yadanar toe	CS	14.2.2019	Broadcasting	17.6.2019	Combine	0.51	1.53	82
130	15.12.2019	Ma Gyi Gone	Inn Gyi	12	Yadanatoe	NCS	4.7.2019	Broadcasting	28.10.2019	Combine	0.88	2.2	50	Yadanar toe	CS	30.1.2019	Broadcasting	1.6.2019	Combine	0.88	1.76	75
131	15.12.2019	Kyar Ni Kan	Ngwe Paw	2	Inle	NCS	1.7.2019	Broadcasting	17.11.2019	Combine	0.52	1.3	45	Yadanar toe	CS	2.2.2019	Broadcasting	2.6.2019	Combine	0.52	1.56	70
132	15.12.2019	Kyar Ni Kan	Late Paw	2	Inle	NCS	7.7.2019	Broadcasting	23.11.2019	Combine	0.6	1.8	50	Yadanar toe	CS	13.2.2019	Broadcasting	15.6.2019	Combine	0.6	1.8	90
133	15.12.2019	Kyar Ni Kan	Htan Kone	2	Inle	NCS	5.7.2019	Broadcasting	24.11.2019	Combine	0.35	0.7	48	Yadanar toe	CS	10.2.2019	Broadcasting	11.6.2019	Combine	0.35	0.875	70
134	16.12.2019	Kyar Ni Kan	Chae Pin	2	Inle	NCS	2.7.2019	Broadcasting	24.11.2019	Combine	0.52	1.04	45	Yadanar toe	CS	10.2.2019	Broadcasting	20.6.2019	Combine	0.52	1.04	100
135	16.12.2019	Kyar Ni Kan	Se Sone Gone	2	Inle	NCS	28.6.2019	Broadcasting	19.11.2019	Combine	0.47	1.175	50	Yadanar toe	CS	2.2.2019	Broadcasting	3.6.2019	Combine	0.47	1.41	80
136	16.12.2019	Kyar Ni Kan	Pyin Gyi	2	Inle	NCS	26.6.2019	Broadcasting	20.11.2019	Combine	0.3	0.75	48	Yadanar toe	CS	21.1.2019	Broadcasting	27.5.2019	Combine	0.3	0.75	70
137	16.12.2019	Nwar Chan Kone	Yae Pyar	2	Inle	NCS	30.6.2019	Broadcasting	22.11.2019	Combine	0.32	0.64	45	Yadanar toe	CS	4.2.2019	Broadcasting	6.6.2019	Combine	0.32	0.96	70
138	16.12.2019	Kyar Ni Kan	Late Khwe	2	Inle	NCS	27.6.2019	Broadcasting	16.11.2019	Combine	0.8	2	50	Yadanar toe	CS	5.2.2019	Broadcasting	9.6.2019	Combine	0.8	2.4	90
139	16.12.2019	Kyar Ni Kan	Ngwe Paw	MTO-3L	Inle	NCS	1.7.2019	Broadcasting	20.11.2019	Combine	0.65	1.625	55	Yadanar toe	CS	25.1.2019	Broadcasting	27.5.2019	Combine	0.65	1.3	65
140	17.12.2019	Kyar Ni Kan	Pyin Gyi	3	Inle	NCS	30.6.2019	Broadcasting	24.11.2019	Combine	0.51	1.02	52	Yadanar toe	CS	28.1.2019	Broadcasting	1.6.2019	Combine	0.51	1.53	95
141	17.12.2019	Ma Gyi Gone	Inn Gyi	MTO-3L	Inle	NCS	4.7.2019	Broadcasting	23.11.2019	Combine	0.98	2.45	60	Yadanar toe	CS	3.2.2019	Broadcasting	7.6.2019	Combine	0.98	1.96	80
142	17.12.2019	Kyar Ni Kan	Pyin Gyi	3	Inle	NCS	7.7.2019	Broadcasting	25.11.2019	Combine	0.54	1.08	45	Yadanar toe	CS	7.2.2019	Broadcasting	4.6.2019	Combine	0.54	1.62	90
143	17.12.2019	Kyar Ni Kan	Htan Kone	3	Inle	NCS	3.7.2019	Broadcasting	21.11.2019	Combine	0.9	2.7	51	Yadanar toe	CS	30.1.2019	Broadcasting	29.5.2019	Combine	0.9	2.25	78
144	17.12.2019	Kyar Ni Kan	Ngwe Paw	3	Inle	NCS	5.7.2019	Broadcasting	22.11.2019	Combine	0.73	1.825	49	Yadanar toe	CS	25.1.2019	Broadcasting	1.6.2019	Combine	0.73	1.46	82
145	17.12.2019	Kyar Ni Kan	Pyin Gyi	3	Inle	NCS	28.6.2019	Broadcasting	19.11.2019	Combine	0.84	2.1	45	Yadanar toe	CS	28.1.2019	Broadcasting	28.5.2019	Combine	0.84	2.52	82
146	18.12.2019	Kyar Ni Kan	Ngwe Paw	3	Inle	NCS	30.6.2019	Broadcasting	23.11.2019	Combine	0.35	0.875	48	Yadanar toe	CS	29.1.2019	Broadcasting	29.5.2019	Combine	0.35	0.875	75
147	18.12.2019	Kyar Ni Kan	Pan Tat Myaung	3	Inle	NCS	4.7.2019	Broadcasting	27.11.2019	Combine	0.21	0.63	52	Yadanar toe	CS	2.2.2019	Broadcasting	2.6.2019	Combine	0.21	0.42	70
148	18.12.2019	Kyar Ni Kan	Mya Ni Gone	3	Inle	NCS	1.7.2019	Broadcasting	21.11.2019	Combine	1.56	3.12	50	Yadanar toe	CS	4.2.2019	Broadcasting	5.6.2019	Combine	1.56	4.68	90
149	18.12.2019	Kyar Ni Kan	pyin Gyi	3	Inle	NCS	25.6.2019	Broadcasting	18.11.2019	Combine	0.35	0.875	45	Yadanar toe	CS	1.2.2019	Broadcasting	3.6.2019	Combine	0.35	0.875	70
150	18.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	3.7.2019	Broadcasting	22.11.2019	Combine	1.08	3.24	50	Yadanar toe	CS	27.1.2019	Broadcasting	27.5.2019	Combine	1.08	3.24	100
151	18.12.2019	Ma Gyi Gone	Inn Gyi	MTO-4R	Inle	NCS	30.6.2019	Broadcasting	23.11.2019	Combine	0.14	0.28	45	Yadanar toe	CS	21.1.2019	Broadcasting	27.5.2019	Combine	0.14	0.28	81
152	18.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	2.7.2019	Broadcasting	20.11.2019	Combine	0.38	1.14	50	Yadanar toe	CS	29.1.2019	Broadcasting	30.5.2019	Combine	0.38	0.76	70
153	18.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	28.6.2019	Broadcasting	19.11.2019	Combine	1.13	2.26	48	Yadanar toe	CS	3.2.3019	Broadcasting	4.6.2019	Combine	1.13	3.39	70
154	19.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	29.6.2019	Broadcasting	17.11.2019	Combine	0.95	1.9	52	Yadanar toe	CS	1.2.2019	Broadcasting	2.6.2019	Combine	0.95	1.9	90
155	19.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	2.7.2019	Broadcasting	21.11.2019	Combine	0.84	2.52	49	Yadanar toe	CS	4.2.2019	Broadcasting	6.6.2019	Combine	0.84	2.52	65
156	19.12.2019	Ma Gyi Gone	Inn Gyi	9	Inle	NCS	6.7.2019	Broadcasting	26.11.2019	Combine	0.27	0.54	50	Yadanar toe	CS	6.2.2019	Broadcasting	2.6.2019	Combine	0.27	0.675	80
157	19.12.2019	Ma Gyi Gone	Inn Gyi	11	Taung Pyan	NCS	30.6.2019	Broadcasting	20.11.2019	Combine	1.04	2.08	45	Yadanar toe	CS	1.1.2019	Broadcasting	29.5.2019	Combine	1.04	2.08	83
158	19.12.2019	Ma Gyi Gone	Inn Gyi	11	Inle	NCS	2.7.2019	Broadcasting	23.11.2019	Combine	1.06	2.65	50	Yadanar toe	CS	3.2.2019	Broadcasting	1.6.2019	Combine	1.06	3.18	80
159	19.12.2019	Ma Gyi Gone	Inn Gyi	11	Inle	NCS	27.6.2019	Broadcasting	19.11.2019	Combine	0.95	2.375	48	Yadanar toe	CS	30.1.2019	Broadcasting	4.6.2019	Combine	0.95	2.85	79
160	19.12.2019	Ma Gyi Gone	Inn Gyi	MTO-5	Yadanatoe	NCS	29.6.2019	Broadcasting	21.11.2019	Combine	0.6	1.8	45	Yadanar toe	CS	25.1.2019	Broadcasting	28.5.2019	Combine	0.6	1.2	81