Making of INAHOR Training Data

Using Imagery

May 2026

Improvement of Rice Paddy Area Statistics and
Damage Assessment using Earth Observation Satellites for ASEAN

The Japan-ASEAN Integration Fund (JAIF)

Mr. Kimura Shoji

SEAA Research Limited Liability Company

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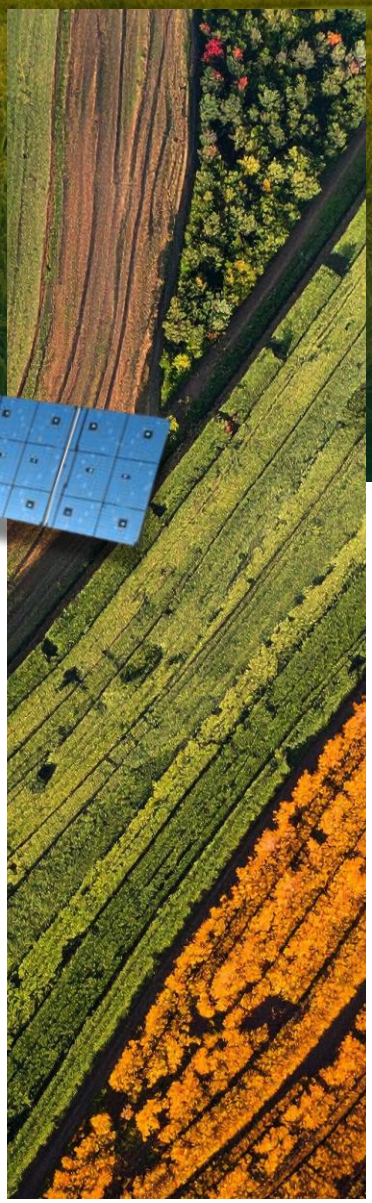
PREFACE

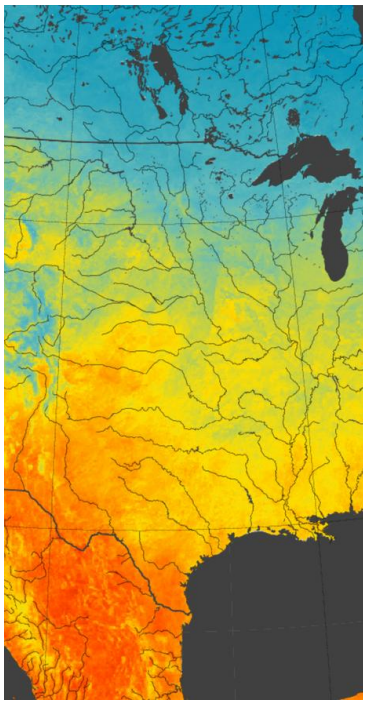


This text provides guidance on the creation of INAHOR training data using image interpretation. It has been prepared for the Hands-on Training Courses for Agricultural Statisticians conducted under the JAIF project, “Improvement of Rice Paddy Area Statistics and Damage Assessment Using Earth Observation Satellites for ASEAN.”

INAHOR is an abbreviation for “International Asian Harvest Monitoring System for Rice,” a software developed by the Japan Aerospace Exploration Agency (JAXA). The system estimates rice planting areas by analyzing satellite images observed by ALOS-2, a Japanese radar satellite.

Training data plays a crucial role in the estimation process of INAHOR. Although the system analyzes satellite observation images, accurate estimation cannot be achieved using images alone. INAHOR first learns the image characteristics of locations where rice is grown and then compares those characteristics with other areas in the observed images in order to determine where rice is likely planted and to estimate the total rice planting area. Therefore, training data, data that identifies locations where rice is grown, is essential, and its quality has a significant impact on the accuracy of the estimation results.

This text is intended to support and enhance the knowledge of INAHOR operators in developing reliable training data through consistent and informed image judgement. By strengthening both technical understanding and practical judgment skills, it aims to contribute to improving the accuracy and comparability of rice area statistics across countries. It is expected that the knowledge and approaches presented in this text will be effectively applied in operational work and further adapted to local agricultural conditions.



I.
OVERVIEW OF TRAINING DATA CREATION

I. Overview of Training Data Creation

Training data identifies the locations where rice is grown; therefore, its accuracy has a significant impact on the accuracy of INAHOR estimation results. For information on how to set up location point data, please refer to the INAHOR operation manual. These location point data generated by INAHOR must be further developed into training data that can be effectively used for area estimation. One practical method is to visually judge the high-resolution images and determine whether the target seasonal rice is planted (“Yes” or “No”) at each location point designated by INAHOR.

There are various perspectives regarding the visual judgment methods. However, unlike statistics compiled through interview surveys, the accuracy of agricultural statistics depends significantly on whether the personnel involved possess sufficient knowledge of agriculture. For example, it is difficult to compile statistics for a crop that the person has never observed. Agricultural statisticians are specialists who enhance statistical accuracy through their knowledge of crop science and their familiarity with the agricultural conditions of the areas they monitor. Therefore, incorporating this expertise into the creation of training data is therefore reasonable and beneficial. In addition, visual judgment does not require specialized tools and is one of the simplest and most cost-effective methods for preparing training data.

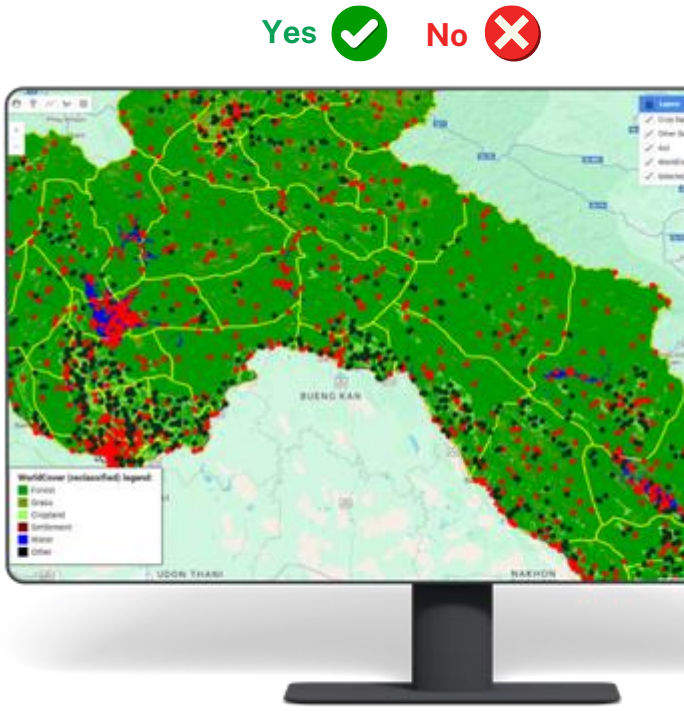
However, it should be noted that the result of visual judgement may be vary among INAHOR operators. In this sense, INAHOR is not a calculation software that produces identical results regardless of the user; rather, the estimation results reflect the operator’s knowledge and experience in judging the agricultural conditions.

The relationship between INAHOR and training data can be summarized as follows:

- **The accuracy of INAHOR estimation value depends on the accuracy of the training data.**
- **The accuracy of the training data depends on the operator’s knowledge and experience.**

Therefore, the accuracy of INAHOR ultimately depends on the operator’s knowledge and experience.

Given this relationship, improving the skills and knowledge of training data operators is essential. This requires not only a solid understanding of field conditions but also the application of standardized judgement criteria and continuous capacity development of operators in judging agricultural land using high-resolution imagery. This text aims to support these efforts by providing practical guidance for accurate and consistent training data creation.



II.
ASSESSMENT OF RICE CULTIVATION PRESENCE
(whether rice is cultivated there?)

II. Assessment of Rice Cultivation Presence
(whether rice is cultivated there?)

In the previous chapter, the objective of “enhancing the knowledge of INAHOR operators” was introduced. The knowledge required for operators can be broadly categorized into the following two aspects.

1. Identify whether the target location is a paddy field.
2. If the location is a paddy field, determining whether rice is cultivated there.

While this text primarily focusses on the first aspect, "Identifying whether the target location is a paddy field." from the perspective of visual judgment, this chapter provides a brief explanation of the second aspect, “determining whether rice is cultivated in a paddy field”.

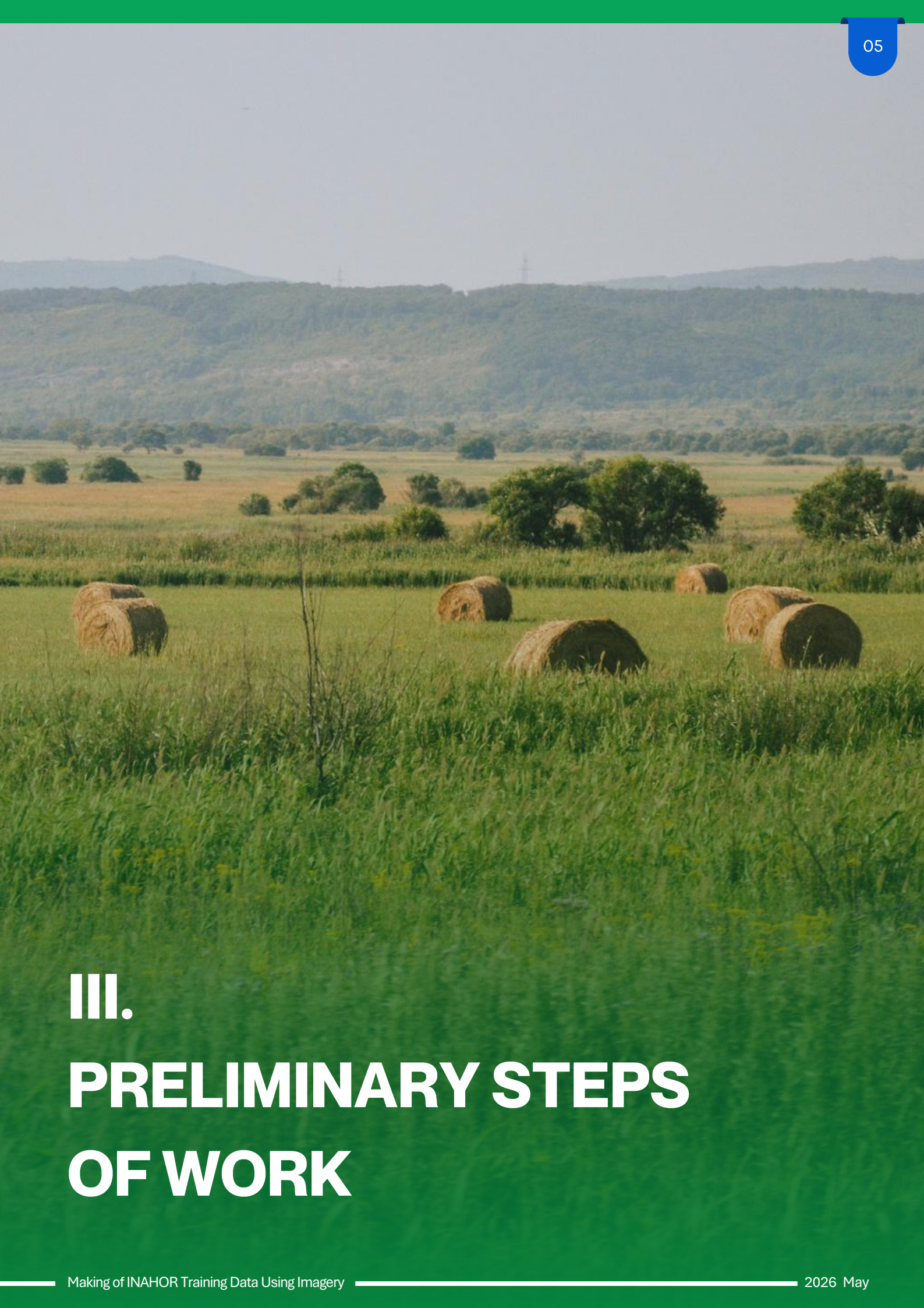
Paddy fields are agricultural fields prepared by farmers primarily for rice cultivation, and rice is typically the main crop grown in these areas. During the rainy season, when there is an abundant water from rainfall, paddy fields are highly likely to be used for rice cultivation. However, when rice prices are low, some farmers may choose to cultivate alternative cash crops such as maize, soybean, and vegetables in their paddy fields instead of rice. Therefore, if high-resolution imagery shows different crops other than rice, field verification may be required, even during the rainy season.

A challenge arises when dry-season rice is included as a target for area estimation. Since dry-season rice cannot rely on rainfall for water supply, it can only be cultivated in irrigated fields. In contrast, rain-fed paddy fields, which depend solely on rainfall, are generally unsuitable for dry-season rice cultivation. Therefore, unlike rainy-season rice, the presence of dry-season rice cannot be determined simply by judging whether an area is a paddy field. Additional consideration of irrigation conditions is required.

If the high-resolution images used for visual judgment are taken during the dry-season rice growing period, it may be possible to make a partial judgment based on crop growth condition image. However, not all images are taken during this period, which limits the reliability of such assessment. Another approach is to examine whether the target paddy fields equipped with irrigation facilities. Identifying agricultural irrigation infrastructure in imagery become relatively easy with experience; however, this only allows you to assess whether the paddy field is suitable for dry-season rice cultivation, not whether rice is actually being grown.

In addition to visual interpretation of satellite imagery, a comprehensive judgment is required to confirm rice cultivation condition in the target area during the dry season. Evern so, the accuracy of the training data for dry-season rice, specifically, whether rice is being cultivated, is inevitably lower than that for rainy-season rice.

To address limitation, JAXA is currently collaborating with agricultural machinery company to obtain location data from combine harvesters during the dry-season rice harvest period, with creating training data for dry-season rice, A detailed explanation of this approach is beyond the scope of this text and will be provide in another opportunity.



III.
PRELIMINARY STEPS OF WORK

III. Preliminary Steps of Work

Iii.1 Land Use Classification

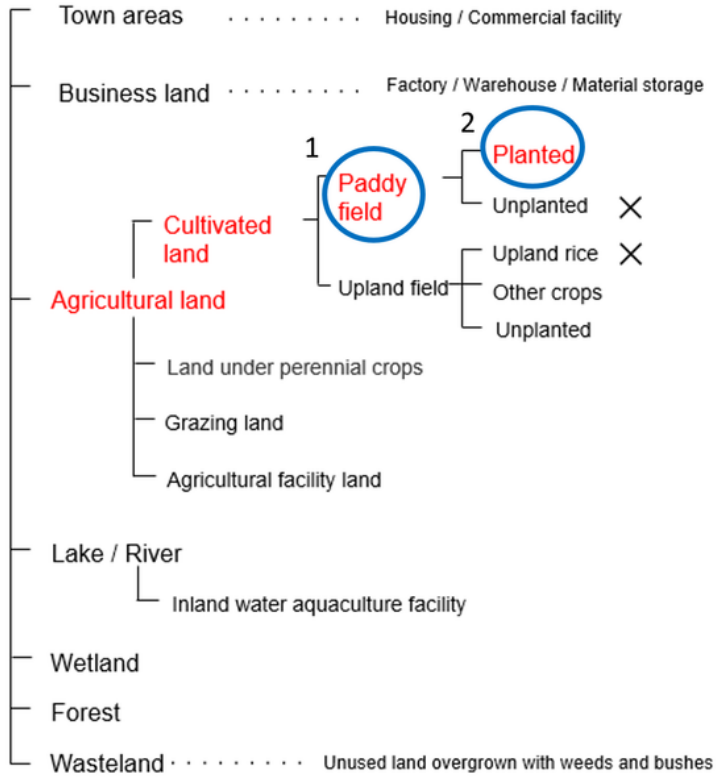


Figure 1: Land Use Categories

Land categories can be classified into urban areas, commercial areas, agricultural land, lakes and rivers, wetlands, forests, and wasteland. Although paddy fields may occasionally occur in categories other than agricultural land, the probability that a randomly selected training data point in these categories corresponds to be a paddy field is extremely low. When generating training data for INAHOR, locations within non-agricultural land categories can therefore be automatically classified as "non-paddy field." Consequently, the INAHOR operator only needs to determine whether the area is "paddy field" or "non-paddy field" for locations classified under the agricultural land category.

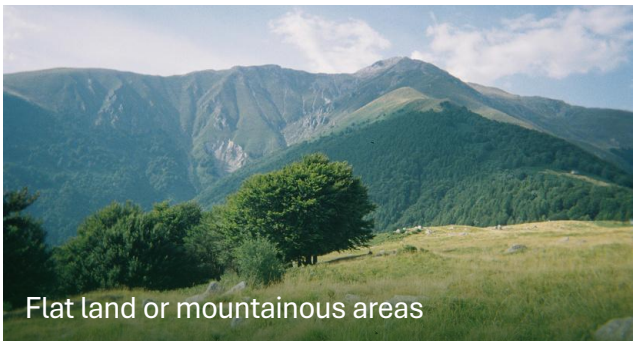
Agricultural land can be further divided into cultivated land, land under perennial crops, grazing land and agricultural facility land. Paddy fields are naturally classified as cultivated land. As you all know, cultivated land also includes upland fields, so the most common challenge in visually judgement for the cultivated land is identifying differences between paddy fields or upland fields. Furthermore, even if it is a paddy fields, areas where rice has actually been planted in the season are identified as "paddy fields" in the training data. However, it is not always possible to visually judge from the imagery alone whether rice has been “planted" or "not planted" in the given season. For this reason, it is necessary for staff who are "familiar with the field," such as field officers who in charge of the areas, to create the training data. When it comes to rainy season rice, since it is unavoidable that paddy fields will be flooded during the rainy season, the paddy fields can be considered as areas under “rice cultivation”

Please note that upland rice is cultivated differently from paddy rice and is classified as the upland crop. Therefore, it is not included in INAHOR estimation and is automatically judged as "non-paddy" when create of training data.

III.2 Understanding the Characteristics of the Target Administrative Area

In Chapter II, it was explained that the accuracy of INAHOR estimates depends on the quality of the training data, which in turn depends on the knowledge of the INAHOR operators. When training data are created by staff at the regional offices within the target administrative area, a higher level of accuracy for the training data can be expected.

However, in most cases, INAHOR software is operated by officials at the ministry headquarters who may not be familiar with the areas. In such situations, the accuracy of the judgment can be improved by recognizing the following points in advance of the imagery judgment. Even within the same type of rice cultivation, distinct regional characteristics are likely to emerge.


Flat land or mountainous areas


Water source for cultivation:
irrigation or rainfed

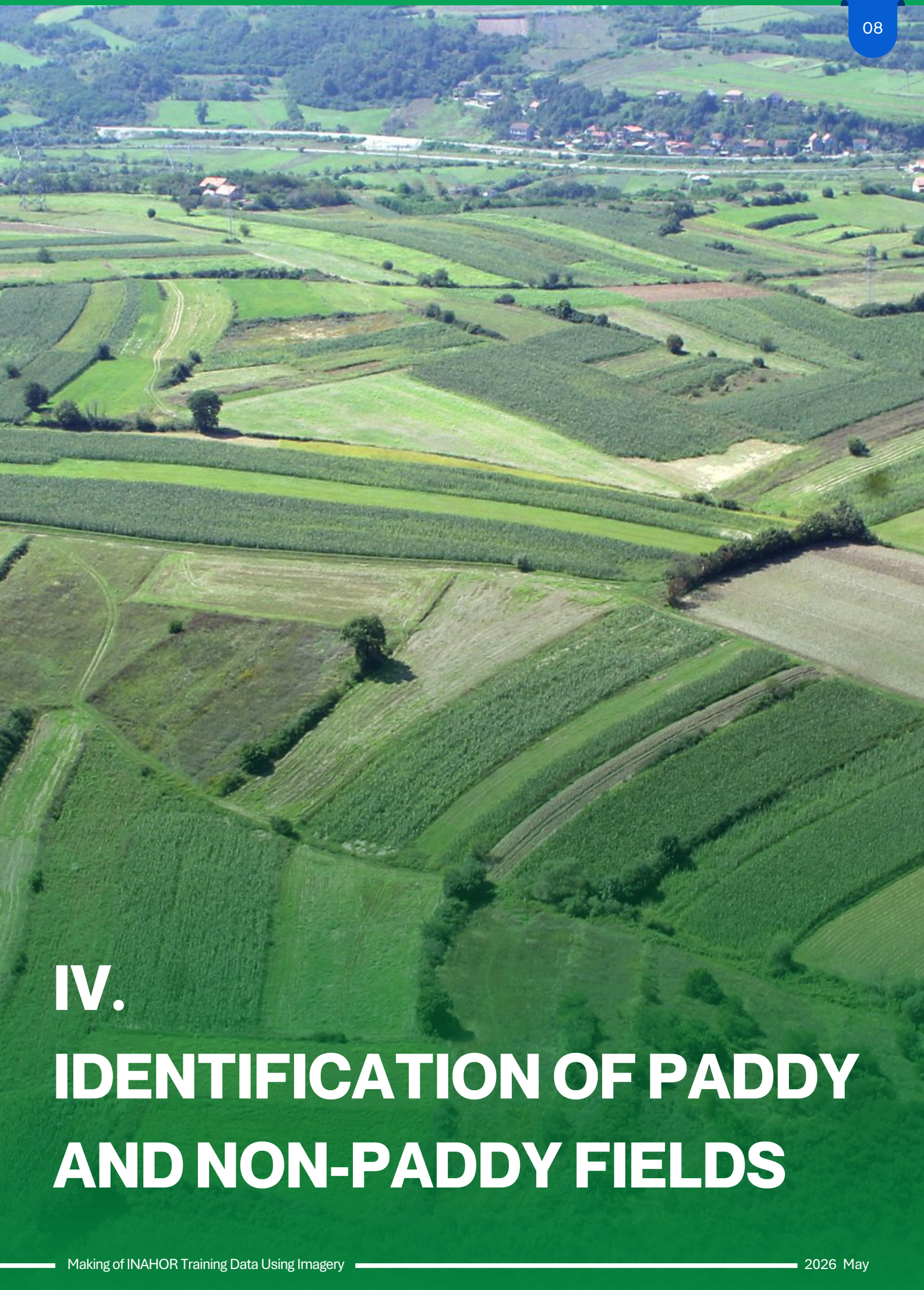

Main agricultural practices:
Labor works or agricultural machinery operations


Proportion of paddy field area


Rice cultivation period


Cultivation conditions during target season
(e.g., normal, flooded, or drought- affected)


Major crops other than rice



IV.
IDENTIFICATION OF PADDY AND NON-PADDY FIELDS

IV. Identification of Paddy and Non-Paddy Fields

IV.1 Basic characteristics of paddy fields

This chapter is the main part of this text. INAHOR operators (training data creators) examine imagery and visually judge whether the location of a given point data corresponds to a "paddy field" or "non-paddy field." However, understanding the fundamental characteristics of paddy fields shown in the imagery can significantly improve the accuracy of the operator's judgement.

The five basic characteristics of paddy field are summarized below.

1. Paddy fields are typically bounded by ridges
2. Most paddy fields are square or rectangular in shape

Figure 2: Ridges and Shape of Paddy Field

Since rice has the characteristics of growing in flooded conditions, it is necessary to construct ridges around the paddy field to retain water. These ridges also serve to divide agricultural pots, and provide access paths for agricultural activities. In high-resolution imagery, such ridges can often be clearly identified. Fields in which ridges can be identified in the imagery can therefore be considered likely to be paddy fields.

In addition, paddy fields are generally designed in square or rectangular shapes to facilitate efficient management of agricultural water and the effective use of agricultural machinery.

3 Paddy fields tend to be smaller compared to fields used for other crops

Figure 3: the Size of Paddy Fields

This characteristic is closely related to the agricultural water management. Rice cultivation requires repeated flooding and drainage throughout the growing period, and it is also necessary to ensure that the fields are flooded evenly. To facilitate efficient water control, paddy fields tend to be smaller than upland fields, making them easier to manage.

Figure 4: Agricultural Fields Other than Rice

In other words, fields of large size are unlikely to correspond to paddy fields.

4 Paddy fields tend to be spatially concentrated within agricultural regions.

Figure 5: Paddy Field Concentration

It is rare to see an isolated paddy field. Instead, paddy fields are typically concentrated, forming landscapes such as rice paddies stretching as far as the eye can see, and the regions with a high density of paddy fields are recognized as an agricultural region. This pattern is also due to the characteristics of rice cultivation. Irrigation infrastructure, which requires substantial investment and effort to construct, is most efficiently utilized when it serves multiple fields. As a results, paddy fields are often concentrated along the irrigation canals and waterways.

5 Paddy fields are cultivated on flat places

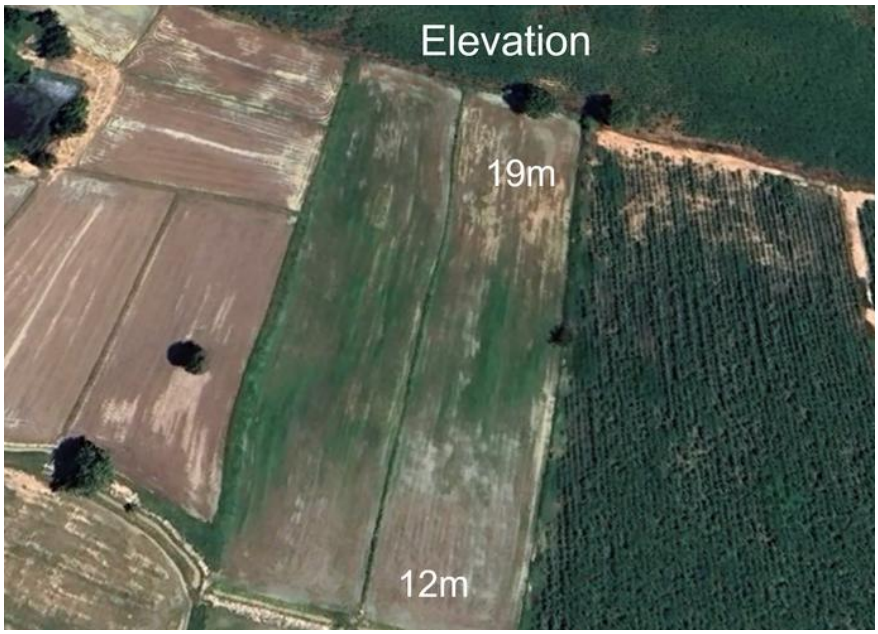


Figure 6: Elevation lands for Paddy Fields

This is a natural consequence of the characteristics of flooded rice cultivation. In order to ensure uniform flooding, paddy field must be level. Even if a field in an image appears to be a paddy field at first glance, if the field is sloped, it cannot retain water evenly and therefore should not be classified as a paddy field. All sloping fields are typically used as upland fields or orchards.

IV.2 Additional Considerations

Five basic characteristics of paddy field have been described in the previous chapter. These characteristics should be kept in mind when judging the imagery classification. By applying them, you will be able to correctly judge whether the field is a "paddy field" or a "non-paddy field" with a relatively high probability.

However, in practice, imagery presents a wide variety of patterns and vegetation conditions, and situation will inevitably arise which classification is not straightforward. In such cases, the basis for such judgement depends on the knowledge of the INAHOR operator (i.e., the person responsible for creating the training data). In here, “Knowledge” refers to familiarity with the agricultural conditions and field characteristics of the areas being analyzed by INAHOR. From this perspective, the accuracy of the training data prepared by the staff of the target regional offices can generally be expected to have higher accuracy. However, in practice, training data are not always created by personnel from the areas under analysis. This section presents several criteria that may assist in making judgments, based on examples encountered during the preparation of INAHOR training data. They are presented in no particular order, without any consideration of the frequency of occurrence or relative importance when making a judgment.

IV.2.1 Variation in Paddy Field Size Depending on Topography

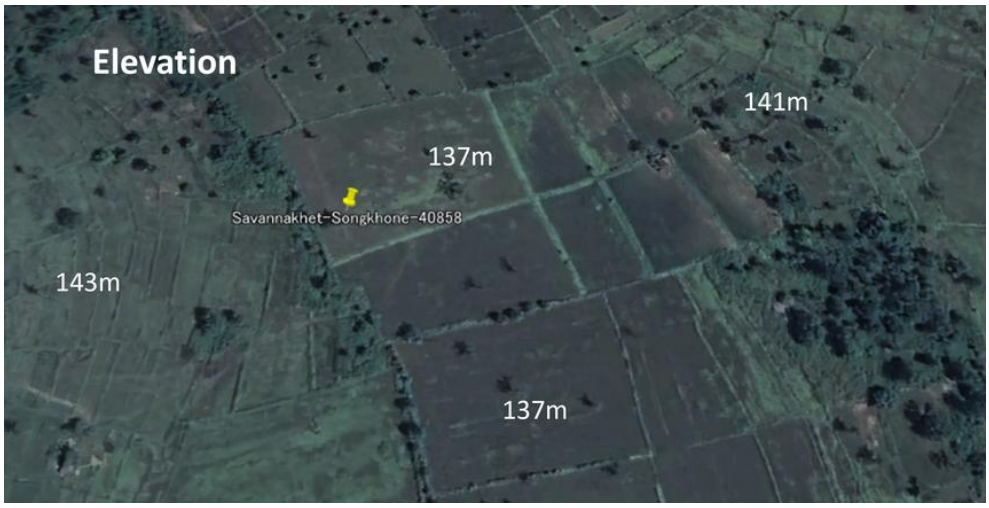


Figure 7: Topography for Paddy Fields

In the third type of characteristics of paddy fields, stated that "Paddy fields tend to be small compared to fields of other crops". Based on this principle, the fields in the center of the image appear larger than the fields on either side. Therefore, they may assume to be fields for other crops. However, the fields in the center are also definitely paddy fields. This raises the question of why field sizes vary. The reason is that the size of paddy fields varies depends on the topography.

The topography of the location shown in this image is a "valley," with the center corresponding to valley floor. When establishing paddy fields in this type of topography, the cultivated fields on the slopes needs to be relatively small to accommodate flooded cultivation, whereas the fields on the relatively flat valley floor can be larger. Accordingly, depending on the topography, it may not possible to judge whether the field is paddy field simply by the size of the cultivated land.

IV.2.2 Avoid Relying Solely on Imagery

Figure 8: Elevation Fields of Other Crops

When judging by imagery, there is a tendency to rely only on the visual information alone. Based on image above, one might assume that rice is being cultivated in paddy fields due to the square shape of the fields and the presence of visible ridges. However, the elevation of this location exceeds 1,600 m, and considering that rice is rarely cultivated at in fields above 1,000 m, it can be judged that these field are not paddy fields, when elevation information is considered alongside the imagery, it can be determined that the fields are used for crops other than rice.

IV.2.3 Refer to Past Conditions When in Doubt

Figure 9 and 10: Previous and Current Conditions of Paddy Field

When field that is considered to be a paddy field has been plowed and no crops are visible, it is difficult to judge whether rice or other crops will be cultivated during the current season. In such case, if historical imagery is available, past cultivation conditions should be reviewed. However, it should be noted that even if crops other than rice were cultivated in the past, as shown in the above image, this does not guarantee that the same crops will be cultivated in the current season as well.

IV.2.4 Types of Crops Cultivated in Surrounding Agricultural Fields

Figure 11: Checking the Surrounding Fields

When a field that is considered to be paddy field has been plowed and no crops are visible, another effective approach for judging whether it is the paddy field is to examine the cropping pattern of the surrounding fields. Rice cultivation requires flooded conditions and, therefore, irrigation facilities are often required. The construction of such large-scale irrigation facilities requires substantial investment and labor, and even at a small-scale. As a result, paddy fields are usually clustered together to enable efficient use of irrigation infrastructure, and it is uncommon for a single paddy field to exist in isolation. If the surrounding fields are cultivated with crops other than rice, as shown in the above image, it is likely that rice is also not being cultivated there.

IV.2.5 Residual Rice Straw After Harvesting

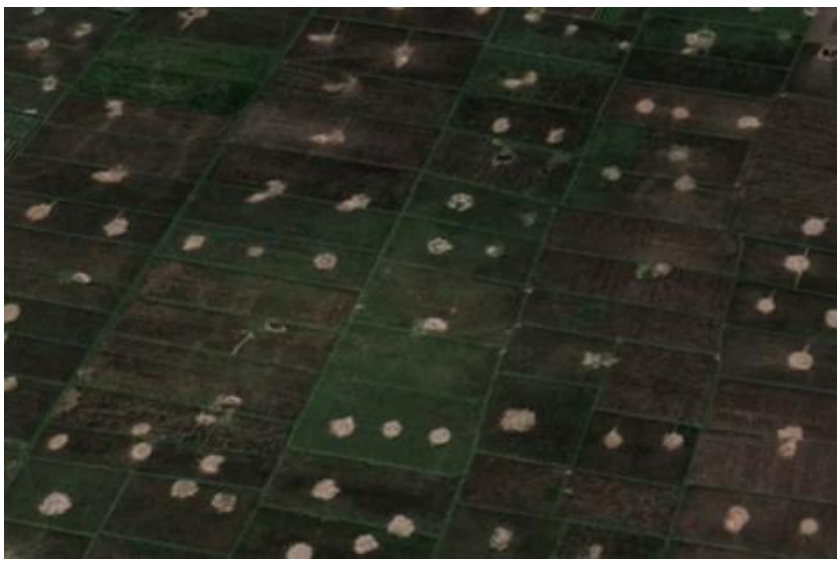


Figure 12: Post-Harvest Rice Straw Residues

It may be difficult to judge whether rice will be cultivated in the field where no crops are currently visible. In such cases, round shapes may be found in the field, as shown in the above image. These features represent pile of rice straw left after harvesting, indicating that the field can be judged as a paddy field. In some instances, there circular feature may appear in black. This is typically due to the burning of rice straw by farmers. Even in such cases, these traces can be assumed that the field was used for rice cultivation.

IV.2.6 Mosaic Patterns in Upland Cropping


Figure 13 and 14: The Different of Mosaic Patterns in Paddy Field and Upland Cropping

Paddy fields and upland fields often have similar shapes, and distinguishing between them is the key aspect of training data creation. When making judgments based on imagery, it is useful to recognize that the clusters of fields exhibiting a mosaic-like pattern are highly likely to represent upland fields. Upland agricultural fields typically involve cultivating of a variety of crops with different planting and harvesting periods. As a results, fields appear in colorful mosaic in imagery. Conversely, when clustered fields appear relatively in one color, it can be judged that rice is being cultivated in paddy fields.

IV.2.7 Fields With Reservoirs Can Be Considered as Upland Crops

Figure 15: Irrigation Reservoir in Agricultural Fields

In case the irrigation reservoir is located within an agricultural field, the field can generally be considered as an upland field. The volume of water stored in the reservoir is insufficient for paddy rice cultivation and is therefore more likely used for irrigating upland crops.

IV.2.8 Post-Flood Rice Cultivation in Submerged Fields

Figure 16: Submerged field in rainy season

Lowland fields (many of which are rainfed paddy fields without drainage facilities) may become submerged during periods of heavy rainfall in the rainy season. In some cases, rice is planted after the water recede, a practice known as recession rice cultivation. Although the growing period for such rice is later than that of typical rainy-season rice, these fields are still classified as rainy-season paddy fields

IV.2.9 Paddy Rice Field Without a Water Source May Indicate Upland Rice

Figure 17 and 18: High-Elevation Upland Rice Fields

Upland rice is cultivated in high-elevation upland fields where irrigation facilities are not present. It should be noted that upland rice is classified as an upland crop and is therefore not considered a paddy field.

IV.2.10 Identification of Perennial Crops by Vegetation Patterns

Figure 19: Vegetation Patterns for Perennial Crops

When judging whether a field is paddy field based on imagery, it is useful to examine the regularity of vegetation patterns. Perennial crops typically exhibit clear and consistent planting arrangements, often forming regular and repetitive patterns in the imagery.

IV.2.11 Artificial Mosaics as Indicators of Aquaculture Ponds

Figure 20: Artificial mosaics Pattern for Aquaculture Ponds

Some aquaculture facilities are built on a large scale in flat coastal areas, where rectangular aquaculture ponds may seem similar to paddy fields in imagery. The key points to distinguish them from paddy fields are the prominent uniform mosaic pattern of the same color, and wider dividers of the aquaculture ponds, which are designed for water storage and operational purposes, unlike the narrower ridges of the paddy fields.

IV.2.12 Confusion Between Paddy Fields and Reservoirs During the Rice Growing Season

Figure 21: Irrigation Ponds in Agricultural Fields

Irrigation ponds are often misidentified for paddy fields during the rice growing season. In the image above, the two central squares represent irrigation ponds. When uncertainty arises, it is necessary to verify the classification by reviewing images from previous period.

IV.2.13 Rainfed Cultivation (Wet-Season Rice Only) in Paddy Fields Without Developed Infrastructure

Figure 22: Rainfed Paddy Field

Cultivated land in which trees are visible within the field typically indicated areas developed through human labor. There is a high possibility that it is a rain-fed paddy field, where rice is cultivated only during the rainy season

V. CONCLUSION

V. Conclusion

The operators might have questions regarding the combination of satellite images, Artificial Intelligence (AI) -based analysis, and "human visual judgment" that forms the basis of INAHOR. There also have been suggestions that training data should be generated automatically, and we are also experimenting with incorporation of external datasets, such as location data from agricultural machinery company.

On the other hand, the process of creating training data through human visual judgment requires INAHOR operators to possess relevant expertise, including agricultural knowledge and familiarity with local conditions. In this sense, INAHOR can be a tool that extends to statistical evaluation, as the accuracy of the estimates may vary depending on the operator's level of expertise.

The INAHOR does not replace statistical values obtained through existing survey methods; rather, it serves as a complementary tool that help bring estimates closer to the true values. Statistical results are not derived solely by INAHOR, but from a combination of tools, including INAHOR. The incorporation of statisticians' knowledge and experience into these processes is therefore highly valuable.

Users are encouraged to develop their own training data and conduct area estimation using INAHOR. Engaging in this process provides an opportunity to validate existing knowledge and to consider subsequent steps and potential improvements.

Mr. Shoji Kimura
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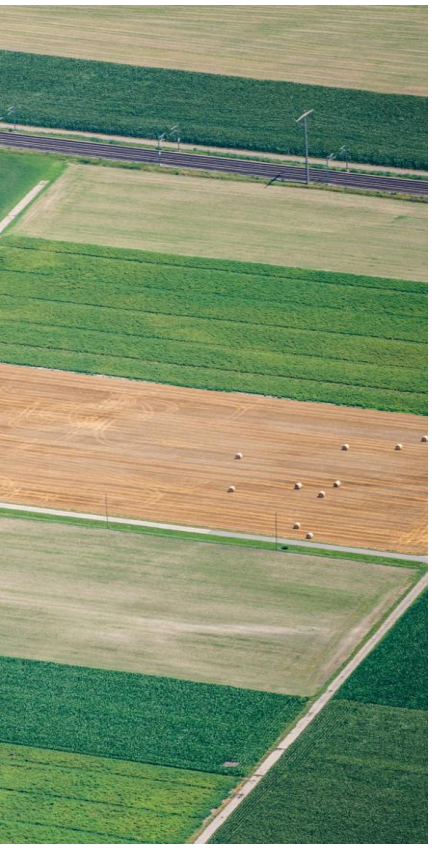

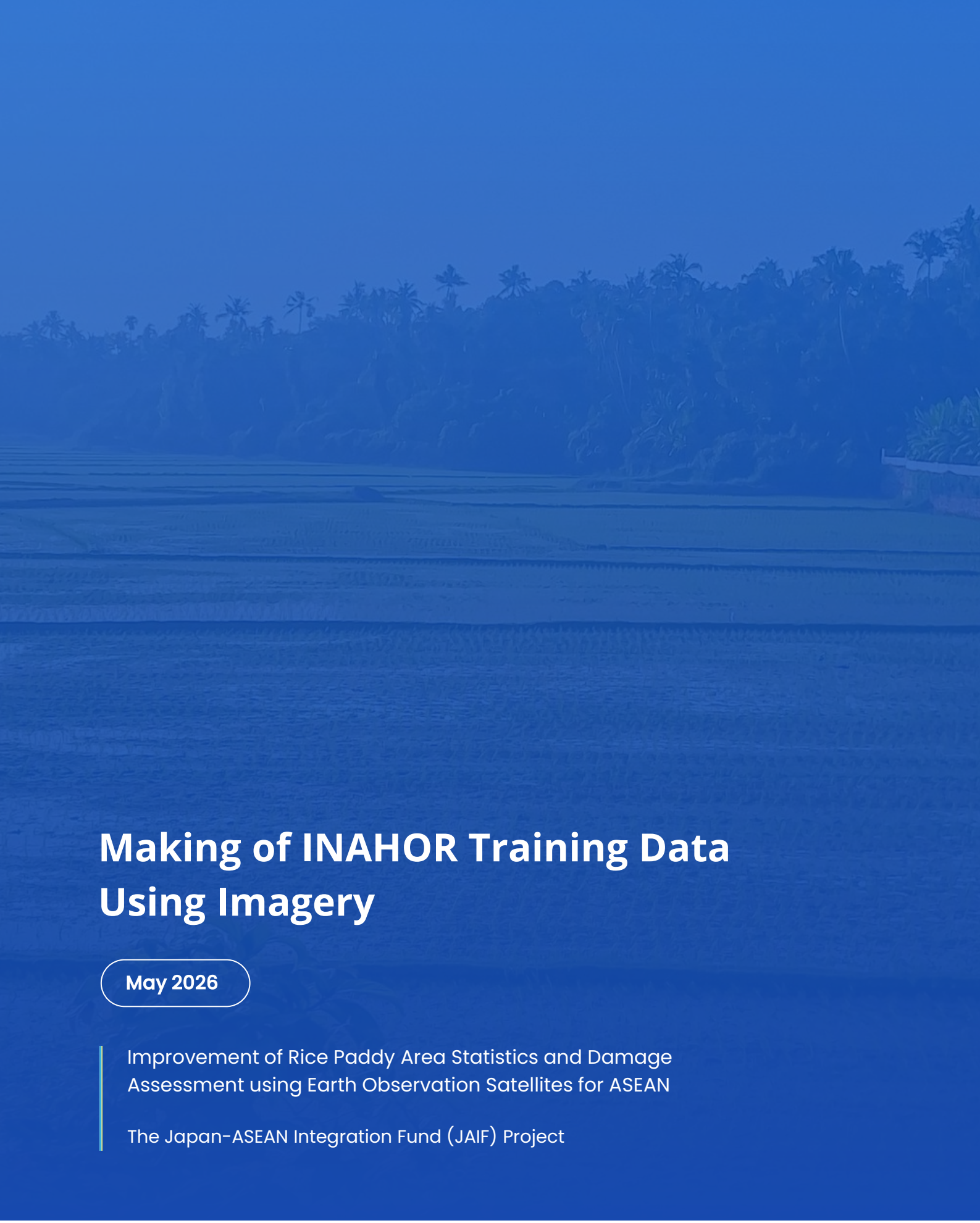

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