MAPPING AND MONITORING RICE AREAS IN THE PHILIPPINES: THE PRISM PROJECT EXPERIENCE

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ABSTRACT The Philippine Rice Information System (PRiSM) project aims to develop a monitoring and information system for rice production in the Philippines. PRiSM uses data from remote sensing, crop models, in-field crop surveys, and other fieldwork to deliver actionable information on rice crop seasonality, area, yield and damages. The service uses multi-temporal Synthetic Aperture Radar (SAR) imagery, automated data processing including knowledge based classification, in-season field monitoring and end-of-season validation to precisely map rice growing areas and monitor the rice seasonal dynamics. Maps of rice area, start of season and rice phenology for the wet season of 2014 were generated using MAPscape-RICE, a dedicated automated processing chain, multi-temporal TerraSAR-X (TSX) ScanSAR 10-meter resolution and multi-temporal COSMO-SkyMed (CSK) Stripmap 3-meter data. Rice yields for one region were estimated using a process-based and weather-driven crop growth model. Monitoring and field activities were carried out from land preparation until harvesting by regional partners using mobile phones.

PRiSM is currently active in seven regions across the Philippines and will cover all other rice growing regions starting the wet season 2015. For the wet season of 2014, overall accuracy of rice area maps was 86%. Accuracy of yield estimates for one province where crop cut experiments were conducted was 86% and agreement with municipal level official statistics was 90%. Issues related to developing an operational system for monitoring rice areas were discussed.

KEY WORDS: rice mapping, rice monitoring, yield estimation, SAR, Philippines

1. INTRODUCTION

Rice plays a crucial role to food security in the Philippines. It is grown on 3.2 million hectares of land, provides livelihood to more than two million farming households and accounts for nearly half of the caloric intake of Filipinos (DA, 2012). There are two pressing reasons to develop a monitoring system for rice production in the country: firstly, for strategic decision making to identify the scale and magnitude of production gaps and then plan interventions accordingly, and secondly to be able to respond rapidly to emergency situations (e.g., flood or drought) based on transparent and accurate information.

The Philippine Rice Information System (PRiSM) project aims to address both concerns by developing an online system that would consolidate and present timely information on the status of the rice crop to policy and decision makers. PRiSM relies on data from remote sensing, crop models, in-season field surveys and end-of-season validation to deliver timely and actionable information on rice crop seasonality, area, yield and damages. It is a collaborative project among the Department of Agriculture (DA)-Philippine Rice Research Institute (PhilRice), International Rice Research Institute (IRRI), DA-Bureau of Plant Industry (BPI) and DA-Regional Field Offices (RFOs). PRiSM is a four year project starting in 2014. It is currently active in seven administrative regions across the Philippines: CAR (Cordillera Autonomous Region), Regions III (Central Luzon), IVB (MIMAROPA), V (Bicol), VI (Western Visayas), VII (Central Visayas), and VIII (Eastern Visayas) (Fig. 1). The combined harvested rice area in these regions accounts for half of total rice area in the country. Starting 2015, the coverage of PRiSM will expand to include other rice growing regions.

This paper describes the methodology and some results for the 2014 wet season.

2. DATA AND METHODS

2.1 Data

Satellite images

We used multi-temporal Synthetic Aperture Radar (SAR) imagery to cover the rice growing season starting from land preparation. Several studies have demonstrated the use of SAR to effectively map rice areas especially in the tropics where cloud cover is pervasive particularly in the monsoon season (Le Toan et al., 1997; Bouvet et al., 2009; Nelson et al., 2014).

Figure 1. Footprints of SAR images acquired over regions covered by PRiSM in 2014.

We acquired multi-temporal X-band SAR Single Look Complex (SLC) data. We used COSMO-SkyMed (CSK) Stripmap (3 m resolution) data from the Italian Space Agency (ASI/e-GEOS) for Region VIII, and TerraSAR-X (TSX) ScanSAR images (10 m resolution) from InfoTerra GmbH for all other regions. Data were obtained in HH polarization with incidence angles ranging from 39 to 48 degrees across sites but consistent in each site. A total of 144 SAR images were obtained.

Field observations

A total of 310 rice fields in 12 provinces within the footprints in the 7 regions were monitored throughout the rice growing season. Rice fields monitored were at least 200m^2 in size, distributed across the footprint, and at least 30m away from paved roads, built-up areas and other large structures. Monitoring and field activities were carried out from land preparation until harvesting by regional partners with the use of mobile phones. Field visits were conducted on or as close as possible to the image acquisition dates.

Open Data Kit (ODK) forms were developed and installed on mobile phones and were used to collect data on: location (latitude and longitude); descriptions and photos of the status of the field; weather conditions; crop growth stage, and; leaf area index (LAI). Data were sent from the phones to a centralized database via the mobile network. LAI measurements were recorded using the PocketLAI smartphone app installed on the mobile phones (Confalonieri et al., 2013). At the end of the season, the information on rice variety planted, water source, crop establishment and management practices including input use (fertilizer and pesticide) were collected from farmers.

Towards the end of the growing season, validation points within the footprint of each image in each region were collected for use in accuracy assessment of the rice map (Section 2.2). Locations were chosen such that the land cover was homogeneous within the surrounding 1 ha area. In addition, the validation points were at least 50m away from roads, built-up areas and other large structures. Aside from location, photos were also taken and the land cover in the area was described. In total, 1,036 validation points were collected in six regions. Only a few validation points were recorded for CAR so this region was not included in the accuracy assessment.

To assess the accuracy of yield estimates, crop cuts were conducted in 19 monitoring sites in Nueva Ecija province (Region III). Municipal level estimates of rice yields were also collected to assess agreement of estimates with official statistics.

2.2 Methods

Rice area mapping

A dedicated automated processing chain including a knowledge based rice detection algorithm implemented in MAPscape-RICE was used following the procedure described in Nelson et al. (2014). Maps of rice area, start of season and rice phenology for the wet season of 2014 were developed.

Yield estimation

Rice yields were estimated using Oryza2000, a process-based and weather-driven crop growth model (Bouman et al., 2001). Oryza2000 was modified to estimate actual yields using input data derived from processed SAR images in addition to weather data, varietal characteristics, soil data and crop management information (Fig. 2).

Accuracy assessment

Rice map. The validation points were classified into two land cover types: rice and non-rice. These were compared to the mode value of 10 pixels around the point. Overall accuracy of the rice/non-rice classification and the kappa values were calculated.

Yield estimates. The yield estimates in each monitoring field in Nueva Ecija were compared with yield derived from crop cut activities. In addition, yield estimates per municipality were aggregated and compared with those from official statistics.

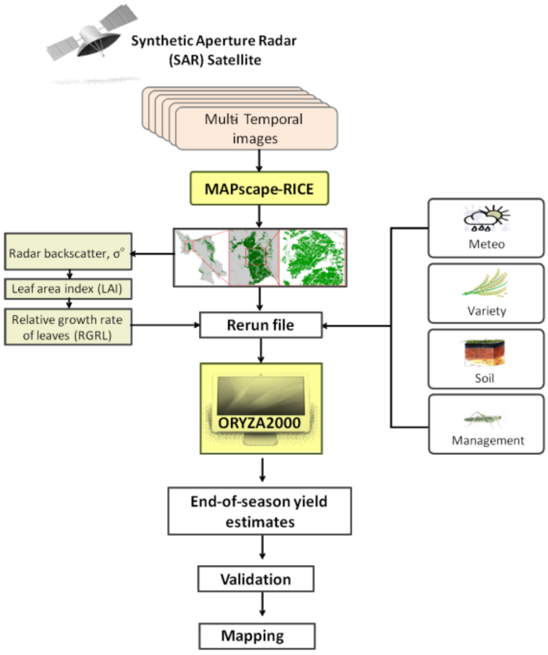

Figure 2. Yield estimation procedure using Oryza2000 and SAR data.

3. RESULTS AND DISCUSSION

3.1 Rice area maps

The 2014 wet season rice map for Region III (Fig. 3) has an accuracy of 88% and kappa value of 0.75 (Table 1). Overall accuracy of rice area maps was 86% (kappa=0.72) and with the exception of Region VI, all regions had accuracies of at least 87% (Table 1). Region VI had the lowest accuracy (74%, kappa=0.48) because a crucial image acquisition coinciding with the peak of land preparation (July 23, 2014) was cancelled. Because of this, some of the areas were misclassified as non-rice.

The start of season map also shows wide variation in planting dates in the region (Fig. 4). Most of the rice areas were planted in July but there were also many areas planted in June or August.

3.2 Yield estimates

The majority of the rice areas have yields ranging from 4-6 t/ha although there were a few areas estimated to have lower than 2 t/ha (Fig. 5). Accuracy of yield estimates for Nueva Ecija was 86% at field level based on crop cuts. The agreement of our yield estimates with municipal level official statistics was 90%.

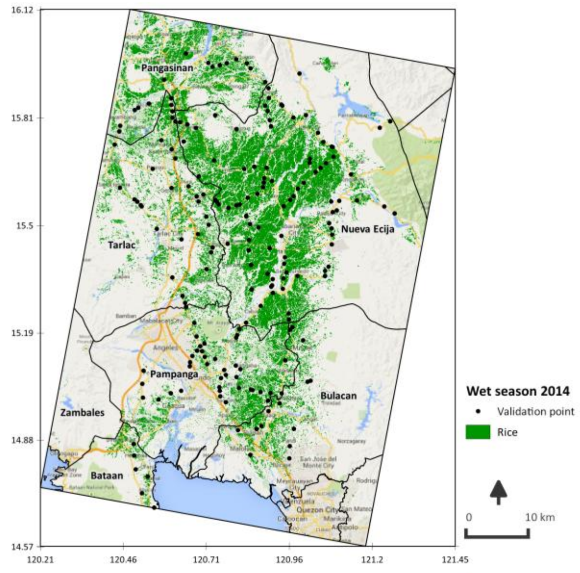

Figure 3. Map of rice areas and validation sites, Region III (Central Luzon), Philippines, wet season 2014.

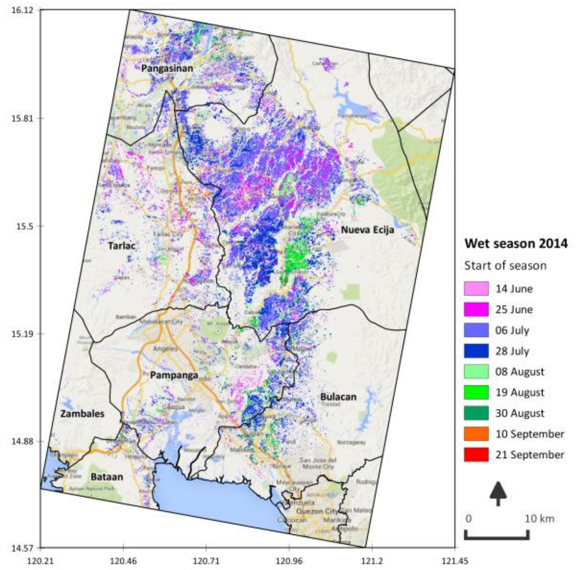

Figure 4. Start of season, Region III (Central Luzon), Philippines, wet season 2014

4. CONCLUSION

We presented results from PRiSM's first year of operation. Accuracies from rice mapping and yield estimation derived are promising and demonstrate the effectiveness of using SAR and the methodology we presented for implementing an operational system for monitoring rice areas.

Table 1. Accuracy of the wet season 2014 rice area map

Region	No. of validation points	Over-all accuracy (%)	Kappa
Region III	202	88	0.75
Region IV-B	96	87	0.73
Region V	345	87	0.73
Region VI	100	74	0.48
Region VII	100	88	0.76
Region VIII	193	88	0.75
All	1,036	86	0.72

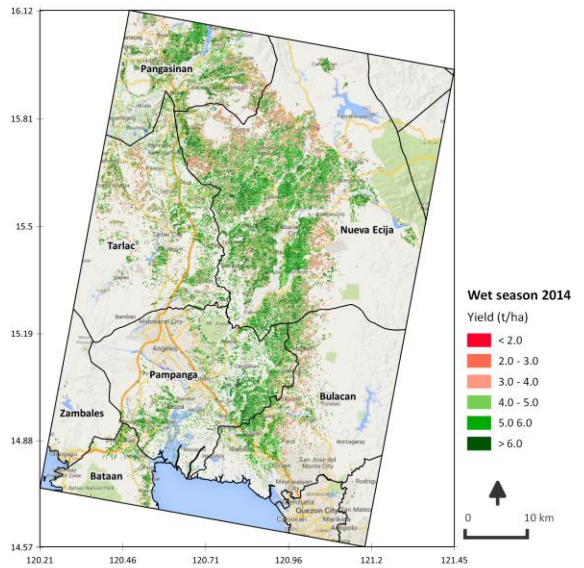

Figure 5. End-of-season yield estimates, Region III (Central Luzon), Philippines, wet season 2014.

We note the importance of acquiring multi-temporal images and especially during land preparation as this greatly affects the accuracy in detecting rice areas.

Field data collection for monitoring and validation of remotely sensed data is important. With the cooperation of DA-RFO and local government unit staff, regular monitoring of the sites were possible. Training in the use of the mobile phones, site selection and monitoring of fields and close interaction to discuss concerns regarding field observations have been an important component of this project.

Here, we presented activities and results relating to mapping and monitoring of rice areas. In addition, PRiSM also includes a component on crop health assessments.

This 2015 wet season, PRiSM will expand to cover all rice growing regions (16 in total).

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