Adoption of Agricultural Land Information System (ALIS) for Agricultural Area Estimation

by

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Abstract

The importance of timely and reliable agricultural statistics to achieve food security in the country cannot be overemphasized. The current gaps in the agricultural statistics production system necessitate the adoption of sustainable methodologies that will provide accurate and up-to-date estimates of staple food crops. These challenges has been recognized and addressed by ASEAN member countries through the ASEAN Food Security Information System (AFSIS). One of the methodologies developed under AFSIS is the Agricultural Land Information System (ALIS), which provides estimates of areas planted to major crops using satellite imagery that can be accessed free of charge, supporting area sample survey for countries having non-developed area survey. After its successful implementation in Lao PDR and Cambodia, ALIS was also adopted in the Philippines through the Bureau of Agricultural Statistics to evaluate its use in estimating total agricultural land area and crop planted area.

ALIS was pilot tested in Nueva Ecija. Sample meshes were selected using the simple two-stage sampling technique wherein field validation was done in the second stage to evaluate the accuracy of agricultural land area measurements. ALIS generated an estimate of the total agricultural land area of the province and estimates of total area planted to major crops. Results showed that there are differences between the agricultural land area measurements from Google maps and the field survey. However, the differences can be considered acceptable. Hence, estimates derived using ALIS are considered reliable estimates of the total agricultural land area in the province. For the crop planted area, only the estimate for rice planted areas in the province is considered reliable. To further assess the level of accuracy of the system, another round of validation may be conducted during another cropping season. It is also recommended to evaluate the same system in other provinces in the country. There is also need to further enhance the use of remote sensing technologies in the country in generating agricultural statistics.

Introduction

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Food Security is a priority program of the Department of Agriculture and is one of the agency's most pressing challenges amidst the effects of climate change, demands for natural resources and competing food crop use. The importance of agriculture sector for achieving food security demands that its planning, management, and monitoring be based on sound evidence. This, in turn, requires the sustained availability of comprehensive, reliable and up-to-date statistical data. Having accurate and reliable information will help policy makers in formulating polices and strategies for the development of the sector.

The current agricultural statistics production system in the country is based on administrative reporting system. The reports are filled at the barangay level, by observing harvest or by interviewing experts, and progressively summarized at the municipal, provincial and national levels. Though sustainable and inexpensive, this method is also unreliable and prone to biases and measurement errors. In addition, administrative reporting system does not usually include a validation method that could improve the quality of estimates. Censuses and surveys, on the other hand, can provide better estimates. These methods, however, requires larger budget and usually takes longer time to process. These gaps in the agricultural statistics production system prompted the adoption and institutionalization of appropriate and sustainable methodologies that will provide timely and reliable estimates of staple food crops.

Since the introduction of objective method for estimation of crop statistics, steps have been taken from time to time for improvement of agricultural statistics in terms of coverage, scope, accuracy, standardization and coordination (Narain, 2002). The applications of information technology systems has been widely used and documented. There are many studies using remote sensing data for improving the estimates obtained from area sampling. GPS have also allowed data collection more accurate and consistent than estimating locations or area using paper maps and distance measurement. GIS on the other hand, has important applications which include monitoring of crops, management of precision farming practices and area frame survey support (Martinez, 2013).

The challenge of food security and the issues on the reliability of statistical data has been recognized and addressed by ASEAN member countries through the ASEAN Food Security Information System (AFSIS). AFSIS is one of the interventions of the ASEAN+3 Cooperation Framework, which aim to strengthen food security in the region through the systematic collection, analysis and dissemination of food security related information. The project was started in 2003 with two phases. Phase 1, which was completed in 2007, was focused on data collection, database website development and capacity building activities. Phase II, which is on-going, continues most of Phase I activities but with the addition of more analytical studies that would help guide policy makers in strategizing more rapid achievement of food security in the region.

One of the methodologies developed under AFSIS is the Agricultural Land Information System (ALIS). ALIS is a system that provides estimates of areas planted to major crops such as rice, maize, cassava, sugarcane and soybean using satellite imagery that can be accessed free of charge (e.g Google map), supporting area sample survey for countries having non-developed area survey. ALIS was first adopted and successfully implemented by AFSIS in Vientiane Province, Lao PDR and in Kandal Province, Cambodia (Kimura, 2012).

The Bureau of Agricultural Statistics (BAS) of the Department of Agriculture is mandated to collect, compile and release official agricultural statistics. In pursuit of its mandated tasks, the agency continues to adopt methodologies that will improve the quality of agricultural statistics. This paper aims to study the use of ALIS for agricultural area estimation. Specifically it aims to:

1. apply existing remote sensing technology in estimating agricultural land areas; and
2. estimate total agricultural land area and crop planted area of the pilot province.

BAS adopted ALIS through the support of ADB under its regional policy and advisory technical assistance (R-PATA) 8029: Improving Agricultural and Rural Statistics for Food Security. One of the major activities of R-PATA 8029 is to conduct methodological research through special studies and application of affordable data collection strategies for agricultural and rural statistics. The main functions of ALIS which include (1) the development of agricultural land mesh framework, (2) area estimation, and (3) survey support, are directly related to the objectives of R-PATA 8029.

Conceptual Framework

ALIS was used to compute the estimates of total agricultural land area and crop areas for three crops in Nueva Ecija using Google map which will be explained further in the Methodology section of this paper. This section presents the statistical concepts that were used in deriving and validating the area estimates.

The basic computation of this measurement approach is to divide the provincial area into 24,021 meshes and identify the land use for each of the meshes. Sample meshes are then selected using the simple two-stage sampling technique. Data on agricultural land area for the first sample were measured using only Google maps and the ALIS software, while data for the second sample include validated agricultural land areas from the field survey conducted. Crop area estimates are then derived for the second stage with the estimates based on data from the field survey.

<u>Estimation of total agricultural land area</u>

Estimate of total agricultural land area based on the first sample

Based on initial agricultural land area measurements from Google maps, the ALIS generates a weighted estimate of the total agricultural land area $\hat{\tau}_{agri1}$ in the province computed as

$$\hat{\tau}_{agri1} = \sum_{i=1}^{n_1} x_i \cdot \left(\frac{N}{n_1}\right) \qquad (1)$$

where x_i is the agricultural land area for the ith sampled mesh based on measurements from Google maps, n_1 is the size of the first sample, and *N* is the total number of agricultural land meshes in the province.

To measure the accuracy of this estimate, an estimate of the standard error of $\hat{\tau}_{agri1}$ was computed. The estimate of the standard error of $\hat{\tau}_{agri1}$ is computed as

$$\widehat{SE}\left(\hat{\tau}_{agri1}\right) = \sqrt{N(N - n_1) \cdot \frac{s_x^2}{n_1}} \quad where \quad s_x^2 = \frac{1}{n_1 - 1}\sum_{i=1}^{n_1}(x_i - \bar{x})^2 \qquad (2)$$

The coefficient of variation was also computed as

$$CV(\hat{\mu}_{agri1}) = \frac{\widehat{SE}\left(\hat{\mu}_{agri1}\right)}{\hat{\mu}_{agri1}} \qquad (3)$$

where $\hat{\mu}_{agri1}$ refers to the estimated mean agricultural land area while $\widehat{SE}\left(\hat{\mu}_{agri1}\right)$ refers to the estimate of the standard error of $\hat{\mu}_{agri1}$.

To validate the agricultural land area measurements based on Google maps and to determine the accuracy of these measurements, field verification was done. Agricultural land area measurements from a second set of sample meshes were verified in the field. The second set of sample meshes were selected from the first sample. Based on the result of the field survey and upon completion of the map survey registration in ALIS, a ratio estimate of the total agricultural land area in the province was computed.

Ratio estimate of total agricultural land area

Ratio estimation is a statistical technique that makes use of an auxiliary variable in order to estimate the parameter value of a variable of interest. This statistical technique calls for an auxiliary variable that can be easily measured from the whole population while the response variable is more difficult or more expensive to measure and is usually obtained from a simple random sample of the population.

In this study, the agricultural land area based on measurements from Google maps was used as the auxiliary variable. Using freely available maps from Google and with the use of the ALIS software, agricultural land areas within a province can be easily measured. On the other hand, validated agricultural land areas from the field can be measured only from selected areas in the province because field surveys require more resources and are usually expensive to conduct.

The ratio estimate of the total agricultural land area $\hat{\tau}_{R,agri}$ was computed as

$$\hat{\tau}_{R,agri} = r \cdot \hat{\tau}_{agri1} = \frac{\bar{y}}{\bar{x}} \cdot \hat{\tau}_{agri1} = \frac{\sum_{i=1}^{n_2} y_i / n_2}{\sum_{i=1}^{n_2} x_i / n_2} \cdot \hat{\tau}_{agri1} \qquad (4)$$

where r is the sample ratio, x_i is the agricultural land area for the ith sampled mesh based on measurements from Google maps, y_i is the agricultural land area for the ith sampled mesh based on the field survey, n_2 is the number of meshes in the second sample, and $\hat{\tau}_{agri1}$ is the estimate of the total agricultural land area based on the first sample.

Similarly, estimate of the standard error of $\hat{\tau}_{R,agri}$ and the coefficient of variation were also computed. The estimate of the standard error of $\hat{\tau}_{R,agri}$ is computed as

$$\widehat{SE}\left(\hat{\tau}_{R,agri}\right) = \sqrt{N(N - n_2) \cdot \frac{s_r^2}{n_2}} \quad where \quad s_r^2 = \frac{1}{n_2 - 1} \sum_{i=1}^{n_2} (y_i - r x_i)^2 \qquad (5)$$

while the coefficient of variation is computed as

$$CV(\hat{\mu}_{R,agri}) = \frac{\widehat{SE}(\hat{\mu}_{R,agri})}{\hat{\mu}_{R,agri}} \tag{6}$$

where $\hat{\mu}_{R,agri}$ refers to the ratio estimate of the mean agricultural land area while $\widehat{SE}(\hat{\mu}_{R,agri})$ refers to the estimate of the standard error of $\hat{\mu}_{R,agri}$.

To compute the overall accuracy of the total agricultural land area estimate, and to account for the total variation due to the first and second sampling, the overall standard error and coefficient of variation were computed, respectively, as

$$\widehat{SE}(\hat{\tau}_{overall}) = \sqrt{\widehat{SE}^2(\hat{\tau}_{agri1}) + \widehat{SE}^2(\hat{\tau}_{R,agri})} \tag{7}$$

and $$CV(overall) = \sqrt{CV^2(\hat{\mu}_{agri1}) + CV^2(\hat{\mu}_{R,agri})}. \tag{8}$$

Estimation of total crop planted area

In addition, ALIS also generates estimates of total area planted for selected crops $\hat{\tau}_{crop_j}$ based on crop planted areas validated in the field. Planted areas were estimated for crops including rice, corn, cassava, and others. For each crop, estimate of total area planted was computed as

$$\hat{\tau}_{crop_j} = \sum_{i=1}^{n_2} y_{ij} \cdot \left(\frac{N}{n_2}\right) \tag{9}$$

where y_{ij} is the crop planted area for the i^{th} sampled mesh and the j^{th} crop based on the field survey, n_2 is the number of meshes sampled from the master sample, and *N* is the total number of agricultural land meshes in the province.

Likewise, the standard error and the coefficient of variation of $\hat{\tau}_{crop_j}$ for each crop were also computed. The estimate of the standard error of $\hat{\tau}_{crop_j}$ is computed as

$$\widehat{SE}\left(\hat{\tau}_{crop_j}\right) = \sqrt{N(N-n_2)\cdot\frac{s_{y_j}^2}{n_2}} \quad where \quad s_{y_j}^2 = \frac{1}{n_2-1}\sum_{i=1}^{n_2}\left(y_{ij} - \bar{y}_{.j}\right)^2 \tag{10}$$

while the coefficient of variation is computed as

$$CV(\hat{\mu}_{crop_j}) = \frac{\widehat{SE}\left(\hat{\mu}_{crop_j}\right)}{\hat{\mu}_{crop_j}} \qquad (11)$$

where $\hat{\mu}_{crop_j}$ refers to the estimate of the mean crop planted area of the j^{th} crop, while $\widehat{SE}\left(\hat{\mu}_{crop_j}\right)$ refers to the estimate of the standard error of $\hat{\mu}_{crop_j}$.

Comparison of Agricultural Land Area Measurements

Agricultural land area measurements estimated using only Google maps and the ALIS software were compared vis-à-vis the agricultural land area measurements that were validated from the field. This was done to assess the accuracy of estimates derived using remote sensing technologies, such as the use of Google maps in estimating agricultural statistics, specifically, agricultural land areas.

The difference in agricultural land area measurements was computed as

$$d_i = x_i - y_i; \quad for\ i = 1,2,\dots,n_2 \qquad (12)$$

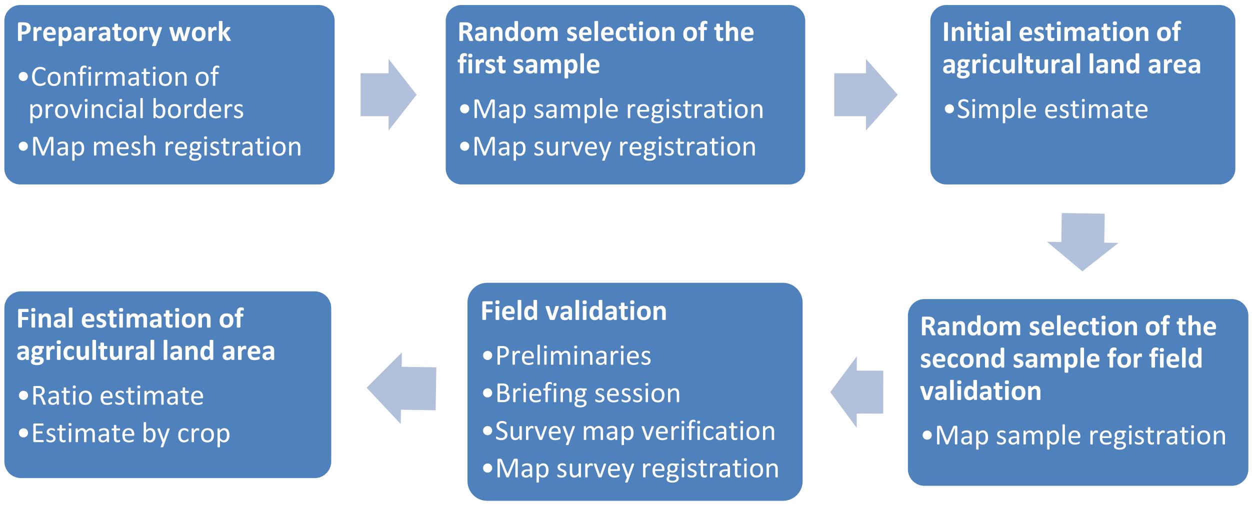
where x_i is the agricultural land area for the i^{th} sampled mesh based on measurements from Google maps, y_i is the agricultural land area for the i^{th} sampled mesh based on the field survey, and n_2 is the number of meshes in the second sample.

The appropriate statistical test for paired samples was done after checking necessary assumptions that the population differences, $d_i's$ are normally distributed with mean μ_D and variance σ_D^2; and that the two samples came from normally-distributed populations.

Methodology

The BAS management initiated the creation of a working group tasked to plan and implement the activities for the adoption of ALIS. The ALIS software was installed at the GIS Laboratory of BAS and can be accessed from five client computers.

Figure 1 **ALIS Workflow**



1. **Preparatory Work**

The province of Nueva Ecija was selected as the pilot province due to its intensive and diverse cropping, and its proximity to the BAS Central Office in Manila. For the selected area, a 300m x 300m area meshes was used. Each mesh has a designated mesh ID. These area meshes were saved in the database as the original mesh file.

Figure 2 **Provincial map of Nueva Ecija**

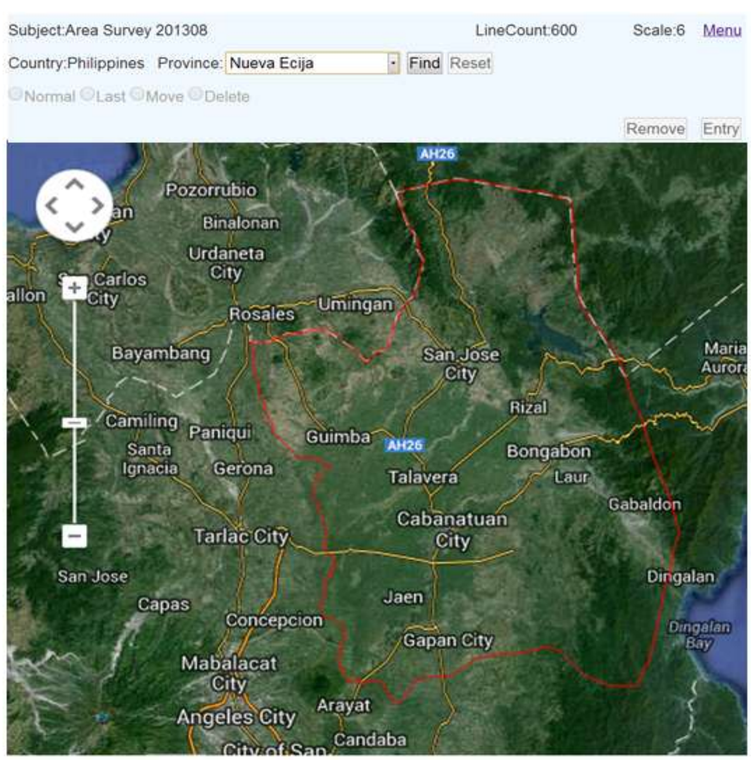
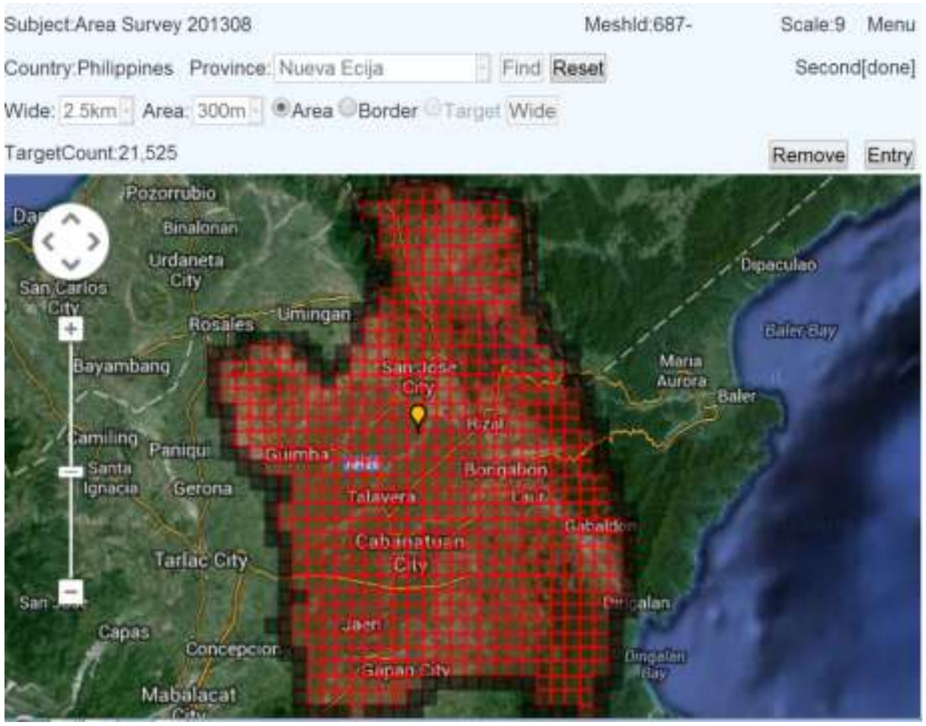


Figure 3 **Provincial map with the 300m x 300m area meshes**



Agricultural land areas were identified in the original mesh file. Meshes having more agricultural areas than non-agricultural were tagged as “agricultural” and identified with the color red, while those which do not show any agricultural land areas were deleted. The criteria used in the mesh classification are in Appendix 1. Map mesh registration took 5 days to complete.

2. Random selection of the first sample

Using the ALIS software, a simple random sample of 5,000 agricultural land meshes were selected from the 24,021 agricultural land meshes in Nueva Ecija province. Inspection of each mesh in the first sample was done to trace the border corresponding to areas identified as agricultural. This process was completed in 8 days.

Figure 4 **Randomly selected sample meshes**

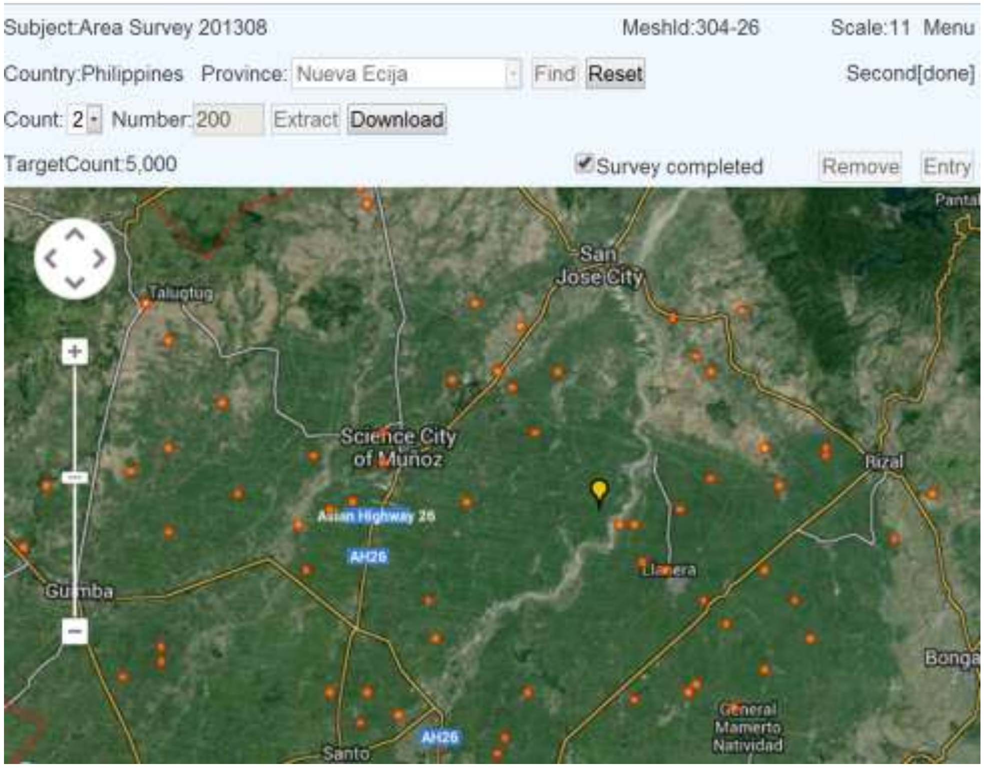
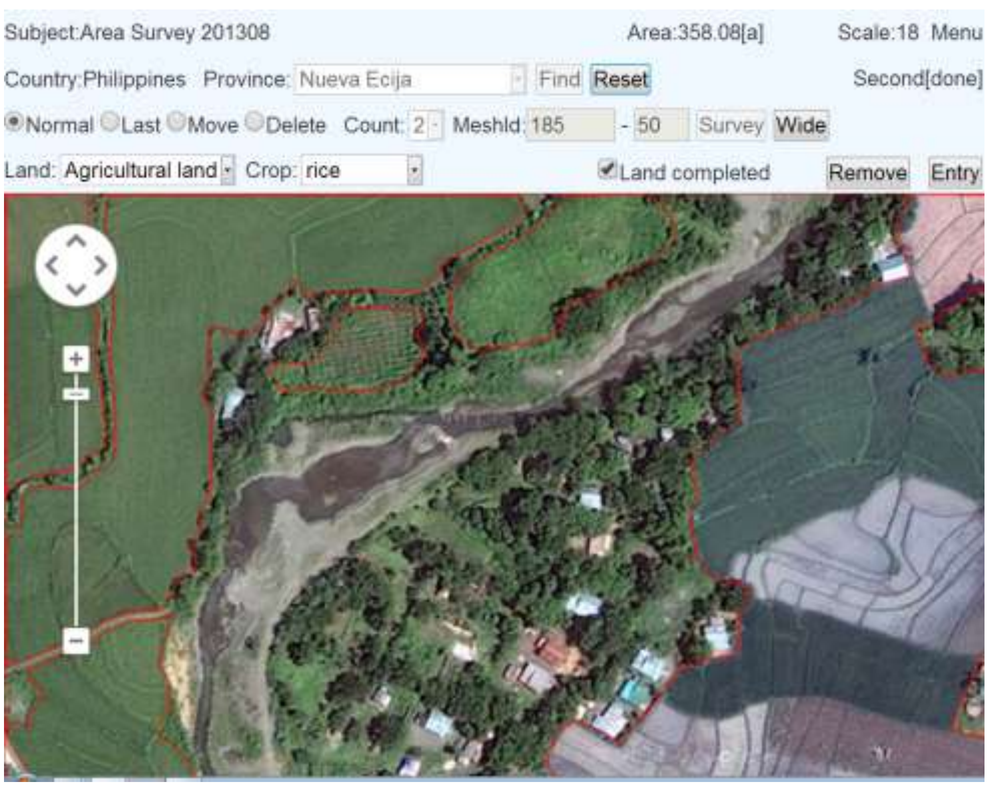


Figure 5 **Identification of agricultural land in the area mesh**



3. Initial estimation of agricultural land area

Based on the first sample, the ALIS generated a simple estimate of the total agricultural land area $\hat{\tau}_{agri1}$ in the province. To measure the accuracy of the estimate of the total agricultural land area, an estimate of the standard error and the coefficient of variation of $\hat{\tau}_{agri1}$ were also computed.

Figure 6 **First sample area estimates**

Agrarian Data Sheet	Issue date	Sept. 26, 2013

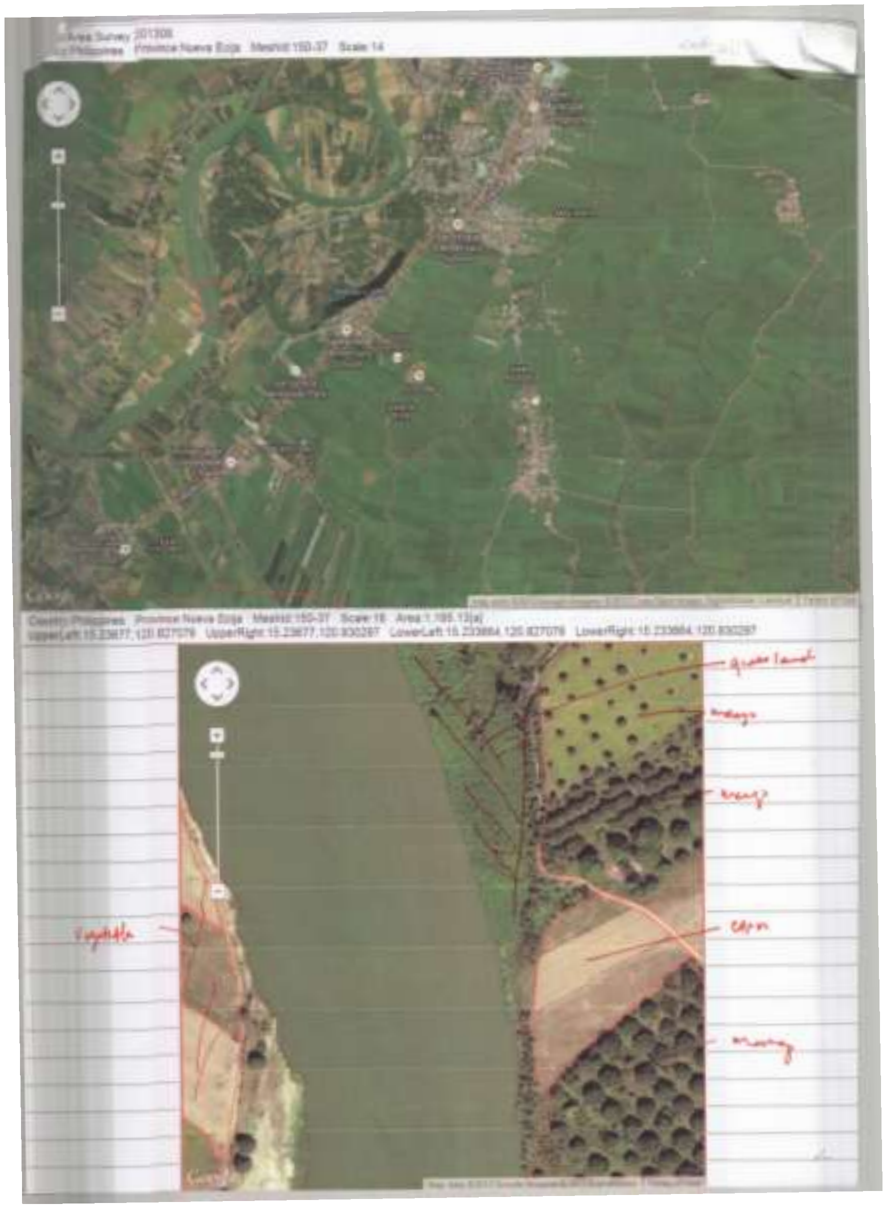
Subject	Area Survey 201308

No	Sampling		Country	Province	MeshWideId	MeshAreaId	Land	Area [a]	
	First	Second						First	Second
1	Yes		Philippines	Nueva Ecija	7	1	Agricultural land	1176.53	0
2	Yes		Philippines	Nueva Ecija	7	4	Agricultural land	1176.64	0
3	Yes		Philippines	Nueva Ecija	7	5	Agricultural land	1179.17	0
4	Yes		Philippines	Nueva Ecija	7	8	Agricultural land	1016.84	0
5	Yes		Philippines	Nueva Ecija	7	15	Agricultural land	1169.07	0
6	Yes		Philippines	Nueva Ecija	7	17	Agricultural land	1110	0
7	Yes		Philippines	Nueva Ecija	7	20	Agricultural land	1152.8	0
8	Yes		Philippines	Nueva Ecija	7	21	Agricultural land	1147.77	0
9	Yes		Philippines	Nueva Ecija	7	22	Agricultural land	918.64	0
10	Yes		Philippines	Nueva Ecija	7	23	Agricultural land	607.62	0
11	Yes		Philippines	Nueva Ecija	7	29	Agricultural land	286.67	0
12	Yes		Philippines	Nueva Ecija	7	31	Agricultural land	1149.14	0
13	Yes		Philippines	Nueva Ecija	7	35	Agricultural land	1037.12	0
14	Yes		Philippines	Nueva Ecija	7	39	Agricultural land	1103.31	0
15	Yes		Philippines	Nueva Ecija	8	6	Agricultural land	1046.62	0
16	Yes		Philippines	Nueva Ecija	8	7	Agricultural land	967.08	0
17	Yes		Philippines	Nueva Ecija	8	9	Agricultural land	695.41	0
18	Yes		Philippines	Nueva Ecija	8	13	Agricultural land	1182.05	0
19	Yes		Philippines	Nueva Ecija	8	21	Agricultural land	960.59	0
20	Yes		Philippines	Nueva Ecija	8	24	Agricultural land	961.72	0
21	Yes		Philippines	Nueva Ecija	8	33	Agricultural land	1025.33	0
22	Yes		Philippines	Nueva Ecija	8	34	Agricultural land	1052.42	0

4. Random selection of the second sample for field validation

From the first sample, a simple random sample of 200 meshes was drawn. Agricultural land areas for these sampled meshes were verified in the field survey. Four copies of each of the survey maps were printed on an A3-sized paper as shown in Figure 6 – (a) the survey district map (upper map); and (b) the survey district map containing information on the coordinates of the survey district (lower map).

Figure 7 **Survey district map**



5. Field Validation

After a briefing session, six teams each comprising of three members were deployed to conduct the survey of the 200 sample meshes. The names of BAS Central Office personnel and provincial statistical officers and their corresponding mesh assignments are listed in Appendix 2. Each team was provided with a GPS device to aid in identifying and matching actual area to the printed area maps. Two copies of the survey maps were also provided to each team – one copy

(Map A) was used during the survey, while the other copy (Map B) was submitted to the regional office with all information from Map A completely transcribed after the survey.

During the survey, the field researchers confirmed the actual topography, crops planted, presence of rivers, road, idle lands, etc. by visual confirmation. Borders were drawn to delineate the area planted to a specific crop for those areas with multiple cropping. In those cases when visual checking cannot be done, the researchers interviewed the farmers/owners in the area to determine its actual land use.

Figure 8 **Survey sheet**

6. Final estimation of agricultural land area

Based on the result of the field survey and upon completion of the map survey registration in ALIS for the 200 sampled meshes, ALIS generates a ratio estimate of the total agricultural land area $\hat{\tau}_{R,agri}$ in the province. Agricultural land area based on measurements from Google map was used as the auxiliary variable. Similarly, estimate of the standard error and the coefficient of variation of $\hat{\tau}_{R,agri}$ were also computed.

Figure 9 **Final agricultural land estimates**

Estimate Result Sheet	Issue date	Sept. 26, 2013

<<Search Condition>>

Subject	Area Survey 201306
Country	Philippines
Province	Nueva Ecija
Land	Agricultural land
Crop	ALL
ExtractCount	2
Order	Land

<<Agricultural Land Mesh>>

[1]	All Mesh in border line	41,664	mesh	
[2]	All Mesh on border line	9,664	mesh	
[3]	Agricultural Land Mesh in border line	21,525	mesh	
[4]	Agricultural Land Mesh on border line	2,496	mesh	* [4] = ([3] / [1]) * ([2] / 2)
[5]	All Agricultural Land Mesh	24,021	mesh	* [5] = [3] + [4]

<<Sampling Mesh>>

[6]	First sampling	4,928	mesh
[7]	Second sampling	200	mesh

<<Sampling Mesh(uninvestigated)>>

First sampling	0	mesh
Second sampling	0	mesh

<<Agricultural Land Area>>

[8]	First sampling on the monitor	4,545,023.82	a	* Aggregate agricultural land area on the monitor
[9]	Second sampling on the monitor	184,712.05	a	* Aggregate agricultural land area on the monitor
[10]	Second sampling in the field	188,126.45	a	* Aggregate agricultural land area in the field

<<Crop Planted Area>>

[11]	Rice	146,909.72	a
	Cassava	477.87	a
	Maize	277.73	a
	Soybean	0.00	a
	Sugarcane	0.00	a
	Other	40,462.12	a
			a

<<Estimate Agricultural Land Area>>

[12]	Simple Estimate	22,154,224.27	a	* [12] = [8] / [6] * [5]
[13]	Ratio Estimate	22,563,744.83	a	* [13] = [10] / [9] * [12]

<<Estimate Crop Planted Area>>

[14]	Rice	17,644,591.92	a	* [14] = [11] / [7] * [5]
	Cassava	57,394.58	a	
	Maize	33,356.75	a	
	Soybean	0.00	a	
	Sugarcane	0.00	a	
	Other	4,859,762.92	a	
		0.00	a	

To compute the overall accuracy of the estimate, the overall standard error and coefficient of variation were computed. In addition, ALIS also generates estimates of total area planted for selected crops $\hat{\tau}_{crop_j}$ including rice, corn, cassava, and others. Likewise, the standard error and the coefficient of variation of $\hat{\tau}_{crop_j}$ for each crop were also computed.

To compare the agricultural land area measurements estimated using only Google maps vis-à-vis the agricultural land area measurements that were validated from the field, appropriate statistical test for paired samples was done.

Results and Discussion

Estimates of total agricultural land area

As shown in Table 1 below, the total agricultural land area in Nueva Ecija is estimated at 221,542.24 hectares. This is based on agricultural land area measurements estimated using Google maps for the 4,928 meshes selected from 24,021 total meshes created in ALIS. The estimate of total agricultural land area has a standard error of 872.5 hectares and a coefficient of variation of 0.39%. Weighted summary statistics calculated from the sample data are also presented in Appendix 3 Table 1.

Table 1. **Total Agricultural Land Area Estimates, Nueva Ecija**
(in hectares)

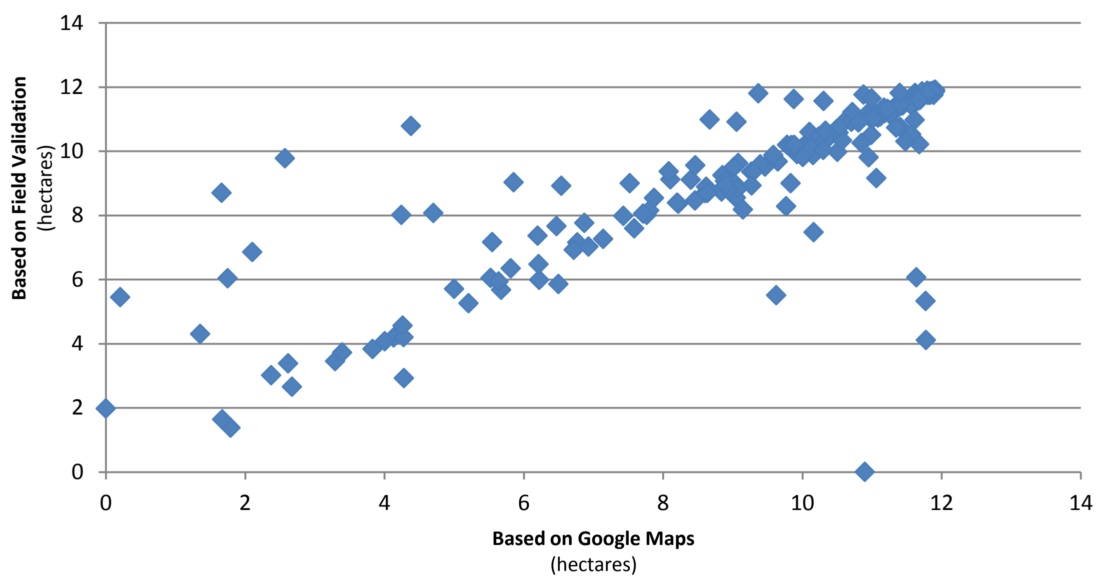
Estimate	Value	Standard Error	Coefficient of Variation	Sample Size
Simple estimate	221,542.24	872.56	0.39%	4,928
Ratio estimate	225,637.45	2,960.24	1.31%	200
Overall measure of precision/variation		3,086.16	1.37%	--

On the other hand, the ratio estimate of total agricultural land area in the province based on data from the 200 sample meshes is 225,637.45 hectares. This has a much higher standard error of 2,960.24 hectares as well as a higher coefficient of variation of 1.31%. However, considering that the size of the first sample is much larger as compared to the number of sample meshes in the second, it is expected that estimates derived from the second sample will have larger standard errors than estimates based on the first sample. As such, the total agricultural land area estimate derived from the first sample seems to be a more reliable estimate than the computed ratio estimate.

To evaluate the accuracy of agricultural land area measurements derived using only Google maps and the ALIS software, 200 meshes from the original sample were randomly selected. From this set of sampled mesh, the initial agricultural land area measurements were either verified or revised based on the researchers' observations in the field.

A scatterplot of agricultural area measurements from the second sample based on Google maps and the field survey is shown in Figure 1 below. It shows that, although, there is a linear relationship between the agricultural land area measurements from Google maps and the field survey, there are also several points wherein large differences between the two measurements are observed. A statistical test comparing data from the paired-samples was then applied to determine if there are significant differences in the agricultural land area measurements derived using the two processes.

Figure 10. **Scatterplot of Agricultural Land Area Measurements from Google Maps and Field Validation**



Upon testing for normality of the populations from which the samples were taken, as well as the assumption of normality of the differences in the agricultural land area measurements from the two samples, a non-parametric test, in particular, the Wilcoxon signed-rank test was done. Results of the normality tests and the Wilcoxon signed-rank test are presented in Appendix 3 Tables 2 and 3, respectively.

Result of the test for differences in agricultural land area measurements based on Google maps and the field survey show that there are significant differences in the measurements derived using the two processes. This implies that measurements of agricultural land areas that are estimated solely based on Google maps differ with the actual agricultural land areas as validated during the field survey. On the average, agricultural land area measurements that were estimated using Google maps are lower by 0.17 hectares per mesh, as shown in Appendix 3 Table 1. In addition, the total agricultural land area estimated from Google maps differed from area measurements validated in the field by about 4,102 hectares, which is only about 2% lower than the field-validated total agricultural land area.

Overall, although there were differences noted in the agricultural land area measurements obtained solely using Google maps vis-à-vis land area measurements that were validated from the field, the differences may be considered acceptable. Hence, the estimate derived from the first sample can be considered a reliable estimate of the total agricultural land area in the province.

Estimates of crop planted areas

Crop planted areas in the province were also estimated for selected crops based on data from the field survey, which was concluded before the end of the third quarter 2013. Table 2 shows a summary of the estimates of areas planted with rice, maize, cassava and other crops in Nueva Ecija province. Almost 80% of the total agricultural land area in the province is planted with rice, with an estimated planted area of 176,445.92 hectares. Compared to available data on harvested areas from the BAS presented in Appendix 3 Table 4, rice area harvested in the province comprise more than 87% of the total crop harvested areas. Total rice area harvested reached 155,275.00 hectares up to end of the third quarter of 2012, while area harvested with maize reached 6,141.00 hectares during the same period.

Table 2. **Crop Planted Area Estimates by Type of Crop, Nueva Ecija**
(in hectares)

Type of Crop	Value	Share (%)	Standard Error	Coefficient of Variation
Rice	176,445.92	78.09	7,015.47	3.98
Maize	333.57	0.15	225.74	67.68
Cassava	573.95	0.25	430.57	75.02
Others	48,597.03	21.51	5,833.48	12.00

Despite comparing estimated planted areas (based on the conducted field survey) with the data on harvested areas from the BAS, it is clear that there is a big difference in the figures pertaining to maize. The estimate of area planted with maize is only 333.57 hectares based on the field survey. However, with a very high coefficient of variation of 67.68%, the crop planted area estimate for maize may not be reliable, similarly for cassava, with a coefficient of variation of 75%. In addition, the high coefficients of variation of the planted area estimates for the two crops may be due to the fact that very few of the sampled meshes were planted with maize and cassava. In general, only the estimate for rice planted areas in the province is considered reliable with a coefficient of variation of only about 4%.

Conclusion and Recommendations

With the use of Google maps as applied in the ALIS, a reliable estimate of the total agricultural land area in Nueva Ecija was derived, despite some noted differences in the agricultural land area measurements from Google map and the field survey. These differences, however, may be considered acceptable, with a difference in the estimated total agricultural land area based on Google maps of only about 2% from field-validated data. As a result, there is definitely a need to enhance and improve the use of remote sensing technologies in the country in generating official agricultural statistics, specifically, agricultural land area estimates.

Another round of field validation may be conducted in the pilot province to further assess the level of accuracy of the agricultural land area measurements derived using Google maps by applying the same system in ALIS during another cropping season. The same system may also be applied in other areas to evaluate how effective the system is in estimating total agricultural land areas in other provinces.

References

ALIS Operation Manual

Kimura, Shoji, 2012. Use of Agricultural Land Information System (ALIS) to Support Sampling Area Survey. Food and Agriculture Organization: Presentation at the 24th Session of the Asia Pacific Commission on Agricultural Statistics. Bangkok, Thailand.

Martinez, Luis Iglesias, 2013. Improving the Use of GPS, GIS and RS for Setting Up a Master Sampling Frame. Food and Agriculture Organization (http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/GS_SAC_2013/Improved_methodologies_for_master_sampling_frames/Improving_the_use_of_GPS__GIS_and_RS_for_setting_up_a_master_sampling_frame_Lit_review.pdf), accessed 23 September 2013.

Narain, Prem, 2002. Estimation of Crop Yields Revisited. National Statistical Commission. New Delhi, India (http://www.isas.org.in/jsp/volume/vol55/issue3/Prem%20Narian%20.pdf), accessed 19 September 2013.

Appendix 1

Mesh Classification Guidelines

a. Areas considered as agricultural include:
   - Areas with images of vegetation
   - Areas planted with permanent crops
   - Vacant lot/idle lands (bur t surrounding areas should be considered in classifying the area as agricultural); Such areas should be validated in the field survey. This means the information will only be reflected in the meshes included in the second sample.

b. Areas not included as agricultural include:
   - Burnt areas in the forest
   - Household gardens
   - Areas on the map covered by clouds

c. Check with regional/provincial officers in cases when there are areas on the maps that are difficult to classify.

Appendix 2

Table 1. Team and Mesh Assignments of BAS Personnel

Team No.	Members	Mesh Assignment	Mesh Location
1	Rodrigo N. Labuguen (CO)		
	Jessica Astovesta(CO)		
	Girlie de Guzman(OC)		
2	Dionisio de Vera (CO)		
	Mary Ann Alcachupas (CO)		
	Jonabel Yu (OC)		
3	Sharon Rose Estrella (CO)		
	Bernabe Mauyao (OC)		
	Rommel Payawal (OC)		
4	Necita De Guzman (CO)		
	Imelda Ornos (CO)		
	Priscillano Jove, Jr. (OC)		
5	Nelson Lagniton (CO)		
	Damaso del Rosario (CO)		
	Isabelita Gamboa (OC)		
6	Juliet Perez (CO)		
	Rey Versula (OC)		
	Aurea Bernardo (OC)		

CO – Central Office
OC – Operation Center

Appendix 3

Statistical Tables

Table 1. **Agricultural Land Area Measurements Summary Statistics**

Indicator	First Sample (Google Map)	Second Sample		
		Google Map	Field Survey	Difference, d_i
Sample size	4,928	200	200	200
Mean	9.22	9.24	9.41	-0.17
Sum	221,542.21	221,848.32	225,949.27	-4,100.95
Standard deviation	6.31	31.98	28.69	18.90
Variance	39.88	1,022.71	823.33	357.23

Table 2. **Test for Normality**

Measurement Process	Test Statistic, W*	p-Value
ALIS using Google Maps	0.827184	<0.0001
Field Survey	0.846084	<0.0001
Difference, d_i	0.626106	<0.0001

*Refers to the Shapiro-Wilk test statistic

Table 3. **Test for Differences in Agricultural Land Area Measurements**

Test	Test Statistic, S*	p-Value
Signed Rank	-2516.5	<.0001

*Refers to the Wilcoxon signed rank test statistic

Table 4. **Area Harvested by Crop Type and Period, Nueva Ecija, 2012**

Type of Crop	Period						Annual	Share (%)
	Quarter 1	Quarter 2	Semester 1	Quarter 3	Quarter 4	Semester 2		
Palay (Rice)	23,720.0	103,925.0	127,645.0	27,630.0	148,914.0	176,544.0	304,189.0	87.6
Corn	2,091.0	1,818.0	3,909.0	2,232.0	262.0	2,494.0	6,403.0	1.8
Cassava	…	…	…	…	…	…	84.0	0.0
Others	…	…	…	…	…	…	36,733.5	10.6
Total	**…**	**…**	**…**	**…**	**…**	**…**	**347,409.5**	**100.0**

Source: Bureau of Agricultural Statistics website, accessed 28 September 2013.
http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=O80LUAHC
http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=P00LUAHO