The Philippine Statistician, 1999
Vol. 48, Nos. 1-4, pp. 65-79

Small Area Estimation for Rice and Corn Statistics[1]

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ABSTRACT

The study focused on the applicability of small area statistics (SAS) in generating municipal level statistics using provincial estimates of the Rice and Corn Production Survey(RCPS) of the Bureau of Agricultural Statistics. Four major SAS estimators were evaluated namely: the synthetic, direct, ratio-type and imputation-like estimators. Among the SA estimators considered, the ratio-type and the imputation-like estimators were relatively more accurate and precise. However, the ratio–type estimator (Ratio Separate and Ratio Combined) was found to be more consistent and reliable for all the municipalities of the two provinces, Isabela and Bukidnon.

Key Words: small area statistics, ratio estimators, imputation-like estimators, %ARD.

1. Introduction

Small area statistics (SAS) refer to statistics generated for a smaller unit of aggregation or subset of the survey domain. For instance, in a national survey where the domain is province, SAS could be municipal estimates. SAS may also refer to statistics generated for a cross-classification of the domain such as age-sex groups.

The need for accurate SAS has become a nationwide concern due to the devolution of policy-making and management functions to the local government. Rather than spending much on collecting information directly at each local level of aggregation, (i.e., municipality and perhaps, on a barangay level) statistics may be generated indirectly at lower levels by using results of surveys and censuses designed to generate estimates for larger design domains.

However, SAS may or may not work for a particular locality. Factors such as a) the sampling design of the survey, b) strength of the relationship between the survey and census data, c) misrepresentation of a municipality in the survey data, affect the accuracy of small area statistics.

This study examined these effects, particularly the strength of relationship of census and survey data as well as the misrepresentation issue on the Rice and Corn Production Survey(RCPS) in Isabela and Bukidnon. Resulting SA estimators were evaluated using samples generated from data of the 1991 Census of Agriculture and Fisheries (CAF) for the two provinces.

2. Methodology

2.1 Choice and Description of Study Domains

[1] Major part of the paper was done as first author's thesis in MS in Statistics.

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The 1991 Census of Agriculture and Fisheries (CAF) for the provinces of Bukidnon and Isabela were used as domains of the study. Isabela in the northern Philippines was chosen because it is one of the major rice producing provinces in the country with total rice area of 264 thousand hectares. On the other hand, Bukidnon of the southern Philippines is considered a major corn producer with total farm area of 334 thousand hectares.

Relevant variables selected in the1991 CAF are: a) effective area planted to palay and effective area planted to corn, denoted as Y_1 and Y_2, respectively, and b) area devoted to agricultural activities, number of parcels owned by the operator, area devoted to palay and area devoted to corn denoted as X_1 to X_4, respectively, as auxiliary variables.

2.2. Sample Generation and Small Area Estimation

To compare and evaluate the potentials of the different SA estimators, 1000 samples with sampling design and sample sizes based on RCPS methodology (see 1996 RCPS Manual of Operation) were generated through the Statistical Analysis System (SAS) software. The RCPS has province as domain and it employs a two-stage sampling design. It is conducted quarterly by the Bureau of Agricultural Statistics (BAS).

2.3. Computation of SAS Estimators

Four major groups of SAS estimators were selected as follows: a) synthetic estimators, b) ratio-type estimators c) direct estimators, and b) imputation-like estimators. Other estimation procedures such as the best linear unbiased predictor (BLUP), was not considered yet due to the complexity that comes along with the complexity of the sampling design of RCPS.

The details of each class of estimators and their members are discussed in the following section. For the variable of interest, Y, the following notations are:

Y_{hqi} – Y- total of i^{th} barangay of q^{th} municipality belonging to h^{th} stratum
Y_{hq} – Y- total of the units in q^{th} municipality to belonging to h^{th} stratum
Y_h – Y- total h^{th} stratum

The auxiliary variable, X, is subscripted in a similar manner.

a. Synthetic estimators

Synthetic estimators refer to statistics computed from estimates of larger area. They require census totals of the auxiliary variable. Synthetic estimators are biased, however the degree of bias decreases as the ratio of variables in the larger area becomes identical to ratios in the small areas.

a.1. Design synthetic(S1).

The design-synthetic (S1) estimator is defined as

$$\hat{T}_{S1} = \sum_{h=1}^{H} \frac{X_{hq}}{X_h} \hat{Y}_h \qquad (1)$$

where X_{hq} the X – total for the h^{th} stratum and q^{th} municipality
$X_{h.}$ the X – total for the h^{th} stratum.

$\hat{Y}_h$ unbiased estimate of stratum totals for a stratified two-stage design(pps-srs).

Equation 1 has the consistency property that the sum of $\hat{T}_{s1}$ for all municipalities is equal to the direct estimator of the provincial total. However, $\hat{T}_{s1}$ is biased unless ratio of Y to X in a stratum is identical to (municipal, stratum) ratio.

a.2. Simple synthetic estimator (S2)

The simple synthetic estimator is defined as

$$\hat{Y}_{S2} = \frac{\hat{Y}}{X_N} X_q \qquad (2)$$

where $\hat{Y} = \sum_h^H \hat{Y}_h$ unbiased estimator of provincial total

X_N provincial total of an auxiliary variable

X_q municipality total of the auxiliary variable

The biased of Equation 2 is zero only when the ratio of Y to X at the provincial level is equal to the ratio at the municipal level, that is $\frac{Y_N}{X_N} = \frac{Y_q}{X_q}$.

b. Ratio Type Estimators

The advantage of the ratio over the synthetic estimator is that it does not require census totals of auxiliary variable over the domain or stratum.

b.1. Separate ratio estimator(RS).

Ratio estimators are first computed separately for each stratum then the weighted sum of stratum ratios is then multiplied with the municipality total of the auxiliary variable. Thus, the separate-ratio estimator of municipal total is

$$\hat{Y}_{RS} = \left(\sum_h^H \frac{\hat{Y}_h}{\hat{X}_h}\right) X_q = \hat{R}_{RS} X_q \qquad (3)$$

where $\hat{Y}_h, \hat{X}_h$ unbiased estimator of Y and X in the h[th] stratum

X_q municipal total for auxiliary variable X.

b.2. Combined ratio estimators (RC)

The estimate of provincial ratio between the variable of interest, Y and auxiliary variable, X is multiplied to the municipal total of the auxiliary variable. The combined-ratio estimator is

$$\hat{Y}_{RC} = \frac{\hat{Y}}{\hat{X}} X_q \qquad (4)$$

where $\hat{Y} = \sum_h^H \hat{Y}_h$, $\hat{X} = \sum_h^H \hat{X}_h$ unbiased estimates of provincial total of Y and X, respectively.

The estimator is biased and its bias becomes zero when the ratio of Y to X at the provincial level is equal to the ratio of Y to X at the municipal level.

c. Direct Estimator(DR)

The direct estimator is unbiased and computes estimates of small area totals by considering the information in units directly taken from the q[th] small area. For a stratified - two stage (pps-srs) design, the direct estimator of total for the qth small area is given by:

$$\hat{Y}_{DR} = \sum_{h=1}^{H} \hat{Y}_{hq} \qquad (5)$$

where $\hat{Y}_{hq}$ estimate of Y-total in (h,q) cell.

The direct estimator (Equation 5) is unbiased for Y_q, however, it does not exist for small areas not represented in the sample.

d. Imputation-like Procedures

Imputation process involves estimation of "missing data" and combining these estimates with the real data to come up with SAS. For instance, in each stratum, the total of the unsampled barangay is estimated(imputed) using some functions of the variables from the sampled barangays. The estimates of the totals of the barangays(sampled and unsampled) belonging to a municipality were then summed to come up with municipal total estimates. The framework of the imputation-like procedures is based on the design of the survey which involve stratifying the barangays. If the stratification process is such that the barangays belonging to the same stratum are more or less homogenous, then the sampled barangays can well approximate the unsampled barangays in that stratum. The imputation-like estimator of Y-total of the q[th] municipality is

$$\hat{Y}_{q'} = \sum_{h}^{H} \sum_{i}^{n_{hqi}} \hat{Y}_{hqi} + \sum_{h}^{H} \sum_{i}^{n_{hqi}'} \hat{Y}_{hqi}' \qquad (6)$$

where $\hat{Y}_{hqi}$ estimate of Y_{hqi} of i[th] sampled barangay belonging to h[th] stratum belonging to belonging to q[th] municipality.

$\hat{Y}_{hqi}'$ imputed value of Y_{hqi} of i[th] unsampled barangay belonging to the h[th] stratum belonging to q[th] municipality.

Several procedures to impute the Y-total of unsampled barangays, $\hat{Y}_{hqi}'$ was evaluated and are presented below.

d.1. Imputation 1 (I 1).

The value of $\hat{Y}_{hqi}'$ is computed as the ratio of the estimate of stratum total of X and Y multiplied by the total of the auxiliary variable, X_{hi} in i[th] barangay. It is defined as:

$$\hat{Y}_{hqi}' = \frac{\hat{Y}_h}{\hat{X}_h} X_{hi} \qquad (7)$$

where $\hat{X}_h, \hat{Y}_h$ are the unbiased estimate for stratum total of Y and X, respectively.

Equation 7 requires that census data on the auxiliary variable be available at the barangay level.

d.2. Imputation 2 (I2)

Instead of obtaining stratum estimates like I1, the ratio of barangay estimates of the total of X and Y is multiplied by the value of the auxiliary variable in the i[th] barangay. The total of the unsampled barangay is then obtained as the average of the sampled barangay estimate. Thus, imputation 2 (I2) is simply the average of ratio estimates in sampled barangays in hth stratum and is defined as:

$$\hat{Y}_{hqi}' = \frac{1}{n_h} \sum \frac{\hat{Y}_{hi}}{\hat{X}_{hi}} X_{hi} \quad (8)$$

where $\hat{X}_{hi}, \hat{Y}_{hi}$ the unbiased estimate of X-total(Y-total) in i[th] barangay belonging to h[th] stratum.

d.3. Imputation 3 (I3)

An ordinary least squares regression estimate without the intercept is fitted to the data of the sampled barangays in h[th] stratum. The equation is then used to estimate barangay totals of unsampled barangays in the stratum. It is defined as:

$$\hat{Y}_{hqi}' = \frac{1}{n_h} \sum \frac{\hat{X}_{hi} \hat{Y}_{hi}}{\hat{X}^2_{hi}} X_{hi} \quad (9)$$

where $\hat{X}_{hi}, \hat{Y}_{hi}$ is the unbiased estimate for Y-total(X-total) in i[th] barangay in h[th] stratum.

d.4. Imputation 4 (I4) and Imputation 5 (I5).

Imputations 4 and 5 are the ordinary regression estimate with intercept, only that the regression coefficients are computed in two ways. The regression imputation is defined as:

$$\hat{Y}_{hqi}' = \hat{\alpha} + \hat{\beta} X_{hi} \quad (10)$$

For imputation 4, the sample regression coefficients($\hat{\alpha}, \hat{\beta}$) are computed based on deviations of household observations from barangay estimates, defined as:

$$\hat{\beta} = \frac{\sum_{j=1}^{n_{hi}} (X_{hij} - \hat{\bar{X}}_{hi})(Y_{hij} - \hat{\bar{Y}}_{hi})}{\sum_{j=1}^{n_{hi}} (X_{hij} - \hat{\bar{X}}_{hi})^2} \quad \text{and} \quad \hat{\alpha} = \hat{\bar{Y}}_{hi} - \hat{\beta} \hat{\bar{X}}_{hi} \quad (11 \text{ and } 12)$$

For imputation 5, the sample regression coefficients($\hat{\alpha}, \hat{\beta}$) are computed based on estimates of deviations of barangay estimates from stratum estimates, thus defined as:

$$\hat{\beta} = \frac{\sum_{i}^{n_h} (\hat{X}_{hi} - \hat{\bar{X}}_h)(\hat{Y}_{hi} - \hat{\bar{Y}}_h)}{\sum_{i}^{n_h} (\hat{X}_{hi} - \hat{\bar{X}}_h)^2} \quad \text{and} \quad \hat{\alpha} = \hat{\bar{Y}}_h - \hat{\beta} \hat{\bar{X}}_h \quad (13 \text{ and } 14)$$

If the stratification procedure was successful in eliminating variability of units within stratum, the regression estimates based on imputation 5 (I5) is expected to yield better estimates.

2.4 Evaluation of Estimators

Evaluation of estimators is done based on comparison of their degree of bias. A measure of the relative bias is the percentage relative absolute difference(%ARD). The %ARD is the difference between the estimate and the true value relative to the true value and is expressed as :

$$\%ARD = \frac{\left|\hat{\theta}_q - \theta_q\right|}{\theta} 100\% \qquad (15)$$

where θ_q and $\hat{\theta}_q$ true value and estimator of Y-total of the q[th] municipality, respectively.

3. Results and Discussion

3.1 Selection of auxiliary variables

Since some of the estimation procedures require data on an auxiliary variable, correlation analysis was used to identify the appropriate auxiliary variables. Auxiliary variables that are highly correlated with the variable of interest are preferred because they make significant improvement on the estimators. For Isabela, area devoted to palay(X_3) was found to have the highest correlation (r=0.9908) with effective area planted to palay(Y_1). Likewise, area devoted to corn(X_4) was found to have the highest correlation(r=0.9907) with effective area planted to corn(Y_1) for Bukidnon. Thus, all estimates of Y_1 and Y_2 were computed using the auxiliary variables, X_3 and X_4, respectively. It should be noted that these pairs give a very high correlation because they are almost a function of the other. While choosing these pairs may not be meaningful in real life, the intent of the study was to isolate the effect of estimators and minimize the effect of the auxiliary variable to the errors of the estimates.

3.2 Evaluation of Different Small Area Estimators

The %ARD form the major part of the comparison and evaluation of the estimates. Accuracy of the different estimates of effective area planted to palay(Y_1) and effective area planted to corn (Y_2) were evaluated through the mean %ARD while precision is measured through the standard deviation of %ARD.

a. SAS for Bukidnon

For Bukidnon, mean and standard deviation of %ARD of the different estimates of effective area planted to corn(Y_2) for the different municipalities are presented in Tables 1 and 2. Results showed that the ratio-type estimators (RS and RC) yielded the lowest mean %ARD for all municipalities ranging from 2.9 to 11.7 and 4.4 to 13.1 percent for RS and RC, respectively. Other estimators such as the Imputation like (I4) gave low % ARD but only for a few municipalities (Figure 1). The accuracy of the ratio-type estimates (RS and RC) is largely attributed to the more or less similar characteristics of the municipalities with respect to Y_2, that is the municipal ratios (of X_4 to Y_2) do not differ from the provincial ratio(which are not presented anymore in the paper).

The standard deviation of %ARD were also computed to evaluate the precision of the estimates. Table 2 revealed that only the ratio-type estimators (RS and RC) have lowest standard deviation of %ARD, and is consistent for all the municipalities (Figure 2). A standard deviation of about 1-14 % only validates the potentials of the ratio type estimators to yield precise estimates.

Table 1. Mean %ARD of the different estimates of municipal effective area planted to corn(Y_2) in Bukidnon.

MUNICIPALITY	ESTIMATORS									
	S1	S2	RS	RC	I1	I2	I3	I4	I5	DR
Baungon	88.4	89.7	3.3	4.5	2368.6	9607.0	2404.0	76.3	2406.3	92.7
Damulog	89.1	89.3	3.7	5.7	221.6	1165.3	226.0	6.0	226.3	98.8
Dangcagan	89.5	89.3	3.4	5.3	384.1	1798.8	391.1	88.6	391.6	98.9
D.Carlos	90.5	89.4	3.0	4.9	395.6	1843.1	402.0	64.8	402.5	96.0
Impasugong	90.4	89.7	3.7	4.6	812.7	3466.9	826.1	76.0	827.0	97.8
Kadingilan	94.3	88.8	7.9	9.6	156.8	910.0	159.1	90.4	159.3	111.2
Kalilangan	92.5	90.0	5.7	5.5	405.2	1866.2	410.5	21.8	411.0	96.8
Kibawe	92.1	89.2	4.2	6.2	198.3	1070.7	201.2	86.6	201.5	91.8
Kitaotao	90.2	89.3	3.6	5.6	246.3	1257.8	250.7	88.5	251.0	97.2
Lantapan	88.9	89.8	3.9	4.6	860.3	3647.8	873.1	83.5	873.8	98.6
Libona	88.1	89.2	3.9	5.9	2164.6	8774.6	2197.5	57.3	2199.2	97.7
Malaybalay	90.7	89.9	5.4	5.4	135.3	790.5	136.8	67.8	136.9	89.8
Malitbog	89.0	89.9	5.1	5.2	1820.9	7443.6	1849.8	63.1	1851.5	98.1
MFortich	88.2	89.5	2.9	4.7	1594.3	6555.6	1618.7	70.6	1620.0	91.2
Maramag	93.6	89.8	4.5	4.9	94.6	636.4	95.1	86.2	95.2	96.9
Pangantocan	90.8	90.0	5.8	5.6	823.9	3519.1	833.9	70.2	834.6	97.7
Quezon	90.7	88.5	11.7	13.1	86.4	628.0	88.3	92.4	88.4	92.0
SFernanado	91.9	90.2	7.9	7.4	421.4	1923.1	424.0	81.3	424.0	98.5
Sumilao	89.3	89.6	3.0	4.5	662.7	2901.2	671.6	75.5	672.2	99.3
Talakag	88.3	89.6	3.2	4.4	3809.8	15274.9	3866.6	59.5	3869.5	92.0
Valecian	92.0	90.1	7.1	6.7	10.4	315.8	11.3	95.3	11.3	51.5
Cabangalasan	91.3	90.0	5.9	5.7	1047.4	4401.8	1064.6	74.2	1066.0	96.8
Minimum	88.1	88.5	2.9	4.4	10.4	315.8	11.3	6.0	11.3	51.5
Maximum	94.3	90.2	11.7	13.1	3809.8	15274.9	3866.6	95.3	3869.5	111.2
Mean	90.5	89.6	4.9	5.9	851.0	3627.2	863.7	71.6	864.5	94.6
Std. Dev.	1.8	0.4	2.2	2.0	956.4	3762.6	970.8	21.7	971.6	10.6
CV	1.9	0.5	43.9	33.8	112.4	103.7	112.4	30.4	112.4	11.2

Table 2. Standard deviation of %ARD of the different estimates of municipal effective area planted to corn(Y_2) in Bukidnon.

MUNICIPALITY	ESTIMATORS									
	S1	S2	RS	RC	I1	I2	I3	I4	I5	DR
Baungon	91.1	93.1	2.4	3.3	2398.0	9702.7	2441.6	64.0	2442.6	96.3
Damulog	92.3	92.8	3.4	5.2	223.7	1169.9	227.9	4.7	228.2	99.3
Dangcagan	92.4	92.8	3.0	4.7	386.5	1805.5	394.1	90.6	394.6	99.0
D.Carlos	93.1	92.9	2.6	4.2	397.7	1848.9	404.3	66.7	405.1	96.6
Impasugong	92.8	93.2	2.9	3.2	816.4	3483.1	830.4	80.3	831.6	98.9
Kadingilan	94.8	92.4	8.1	9.7	157.2	912.7	159.7	92.0	160.0	96.4
Kalilangan	94.5	93.3	5.2	4.2	406.7	1873.1	412.0	23.2	412.5	97.4
Kibawe	94.0	92.7	4.1	5.9	198.9	1072.6	201.7	88.2	202.1	97.7
Kitaotao	92.9	92.8	3.3	5.2	247.9	1262.2	252.4	89.7	252.6	98.1
Lantapan	92.0	93.2	3.1	3.2	868.7	3671.5	883.6	89.2	884.6	99.2
Libona	91.0	92.8	3.6	5.5	2184.5	8826.6	2224.0	60.2	2225.8	98.9
Malaybalay	93.8	93.3	4.8	3.9	136.7	795.0	138.2	68.5	138.3	91.0
Malitbog	92.2	93.3	4.6	3.8	1831.3	7470.8	1865.4	70.3	1869.0	98.7
MFortich	90.9	93.0	2.3	3.9	1614.1	6622.9	1642.7	76.7	1643.7	94.9
Maramag	95.3	93.2	3.8	3.4	94.7	639.8	95.1	87.7	95.0	94.1
Pangantocan	93.6	93.3	5.3	4.3	828.5	3537.4	839.0	74.1	840.0	98.3
Quezon	93.0	92.1	12.2	13.7	87.0	628.6	88.8	93.6	88.9	92.2
SFernanado	94.2	93.5	7.5	6.3	422.3	1928.2	423.3	84.5	423.4	98.7
Sumilao	92.4	93.0	2.2	3.5	668.2	2915.4	676.7	80.0	677.4	99.4
Talakag	91.0	93.1	2.3	3.4	3856.4	15425.7	3925.6	50.8	3927.0	94.5
Valecian	94.4	93.4	6.7	5.6	10.7	317.5	11.8	95.2	11.9	50.8
Cabangalasan	93.5	93.4	5.4	4.5	1052.1	4413.0	1069.9	80.0	1071.3	97.4
Minimum	90.9	92.1	2.2	3.2	10.7	317.5	11.8	4.7	11.9	50.8
Maximum	95.3	93.5	12.2	13.7	3856.4	15425.7	3925.6	95.2	3927.0	99.4
Mean	93.0	93.0	4.5	5.0	858.5	3651.1	873.1	73.2	873.9	94.9
Std. Dev.	1.3	0.3	2.4	2.4	967.6	3797.9	985.3	22.7	985.8	10.1
CV	1.4	0.4	53.6	48.2	112.7	104.0	112.9	31.0	112.8	10.7

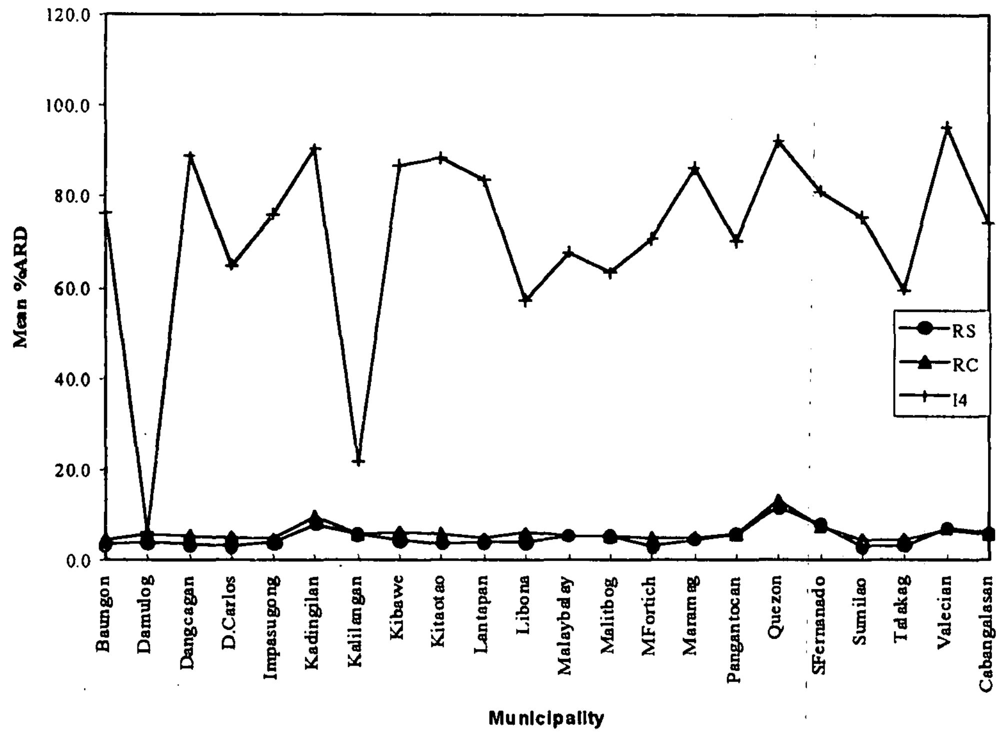

Figure 1. Mean Percent Absolute Relative Difference (%ARD) of selected estimators of effective area planted to corn(Y_2) of the municipalities in Bukidnon.

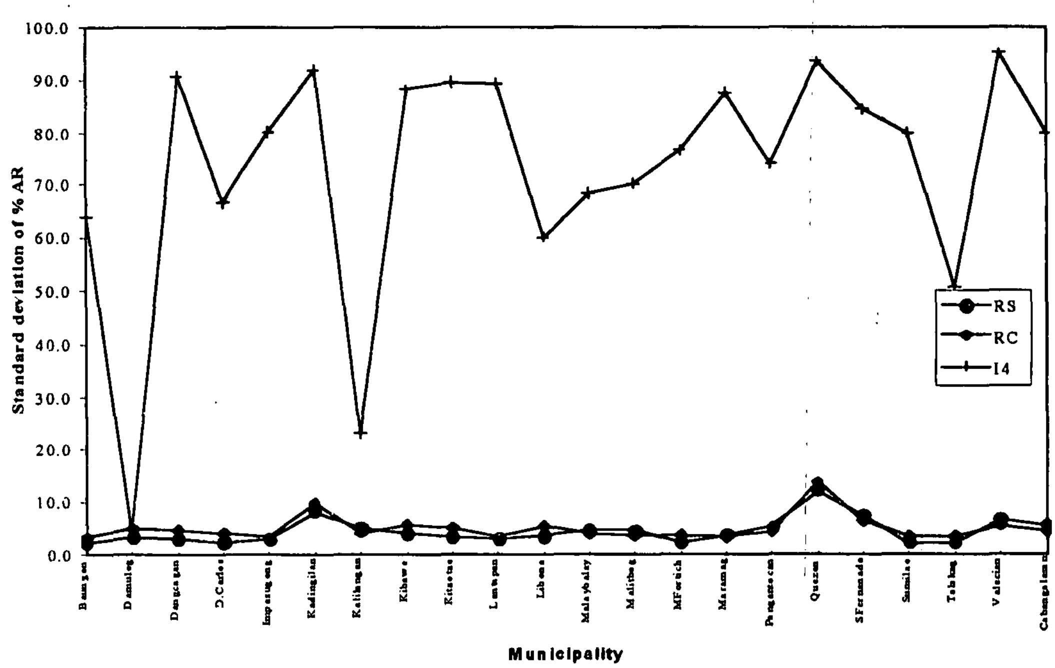

Figure 2. Standard deviation of Absolute Relative Difference (%ARD) of selected estimators of effective area planted to corn(Y_2) of the municipalities in Bukidnon.

b. SAS for Isabela

For Isabela, the mean %ARD of the different estimates of effective area planted to palay(Y_1) and their statistics are found on Table 3. It is evident that the ratio-type(RS and RC) and the imputation-like estimators have relatively lower mean %ARD compared to the other estimators. However, high mean %ARD was observed for the municipalities of Dinapique, Palanan and Sto. Tomas (Figure 3). This result of the RS, RC, I1, I3 and I5 in these towns are perhaps attributed to the large difference in municipal ratio of Y_1 to X_3 to the provincial ratio(which are not presented anymore in the paper). Moreover, the mean %ARD of the imputation-like estimators are further lower than the mean %ARD of the ratio-type estimators(Figure 3). This is evident from the statistics (Minimum, Mean, Maximum) of mean %ARD computed for the municipalities. The average mean %ARD of the municipalities for I1, I3 and I5 is 12 percent

The standard deviation of %ARDs (Table 4) reveals that the Ratio-type(RS, RC) and Impulation-like(I1, I3, and I5) estimates are more precise compared to the other estimators. Furthermore, among these estimators, the variability of I1, I3 and I5 are lowest, between 1.1 to 20 percent for 34 of the 37 municipalities (Figure 4). Also, the municipal average standard deviation %ARD of these estimators were lower compared to the other estimators. Thus, the imputation techniques (I1, I3 and I5) revealed the desirable properties of a good estimator, their low mean %ARD and low standard deviation %ARD indicate their potentials to provide efficient estimates. Aside from the imputation like estimates, the ratio-type estimates (RS and RC) also showed efficient results. The average of the mean %ARD for the different municipalities is 17.5 and 21 percent for RS and RC, respectively and the standard deviations of %ARD do not differ much from that of the imputation estimates.

c. Selecting the best SAE

The statistics of the mean %ARD of the estimators that yielded most accurate and precise estimates are summarized in Table 5. Interestingly, the potential of the ratio-type estimator to provide accurate estimates of Y_1 in Isabela and Y_2 in Bukidnon is consistent. The imputation techniques, I1 I3 and I5 also gave consistently lower mean and standard deviation %ARD but for Y_1 only. The Ratio-type estimators (RS and RC) showed promising estimates of Y_1 and Y_2 and thus could provide reliable estimates of municipal agriculture related characteristics. Also, the auxiliary variables required by the ratio-type estimators are easily available making its application feasible and workable. However, extra caution must be observed in using these estimators since they failed to provide reliable estimates for some municipalities(of Isabela). The conditions for these estimators to yield reliable estimates must first be ensured, by first examining the municipal ratios and provincial ratio of the chosen auxiliary variable and response variable.

Table 3. Mean %ARD of different estimates of municipal effective area planted to palay(Y_1) in Isabela.

MUNICIPALITY	ESTIMATORS									
	S1	S2	RS	RC	I1	I2	I3	I4	I5	DR
Alicia	95.8	91.8	17.5	25.7	4.3	284.6	4.7	65.0	4.8	79.0
Angadanan	86.0	91.2	12.2	21.1	9.9	266.6	11.9	95.8	12.0	98.8
Aurora	89.4	91.8	17.6	25.8	17.3	239.1	19.5	96.5	19.7	98.8
B.Soliven	72.7	89.3	8.3	12.0	9.4	305.3	9.8	94.6	9.9	98.2
Burgos	94.7	91.3	12.6	21.4	2.2	299.4	2.8	98.1	2.9	96.2
Cabagan	77.6	89.2	9.2	11.9	8.0	319.9	8.2	95.1	8.4	97.9
Cabatuan	93.8	91.8	17.7	25.9	7.3	273.6	8.1	96.7	8.2	98.0
Cauayan	94.1	91.4	13.9	22.5	2.4	294.1	3.1	96.6	3.2	89.7
Cordon	93.9	91.5	15.2	23.7	4.5	284.8	5.3	96.6	5.4	92.3
Dinapique	59.9	83.8	62.4	46.3	56.8	522.4	53.0	91.1	52.8	96.2
Divilican	62.7	87.9	21.5	14.6	15.3	335.1	13.4	92.3	13.5	99.6
Echague	82.7	89.1	9.4	11.9	9.2	343.7	7.4	95.3	7.4	97.7
Gamu	91.3	90.8	8.3	17.6	2.9	307.6	3.2	96.3	3.3	99.2
Ilagan	74.5	88.1	19.2	13.7	13.8	363.9	10.8	94.6	10.7	94.3
Jones	70.5	90.0	5.8	13.4	13.8	266.0	16.3	93.3	16.5	94.8
Luna	92.0	91.8	17.3	25.5	10.7	261.9	11.9	96.6	12.1	99.1
Maconacon	62.9	88.2	18.3	13.4	15.2	319.6	14.4	92.2	14.5	99.4
D.Albano	89.1	88.8	12.4	12.1	19.3	385.6	17.3	95.7	17.0	98.4
Mallig	95.5	91.4	13.8	22.4	1.9	299.8	2.3	96.7	2.4	96.6
Naguilian	84.8	90.1	5.8	13.8	4.7	314.0	4.8	95.7	4.9	99.3
Palanan	66.0	83.9	61.8	45.7	51.9	523.3	46.6	93.4	46.2	99.2
Quezon	95.1	91.2	11.8	20.7	2.3	306.4	2.5	96.6	2.6	85.2
Quirino	91.4	91.0	10.4	19.5	6.3	285.1	8.0	96.6	8.2	98.2
Ramon	96.7	91.5	15.3	23.7	1.4	298.3	1.7	96.9	1.8	92.4
R.Mercedes	84.8	91.5	15.1	23.6	17.6	237.8	20.0	96.1	20.2	98.9
Roxas	94.8	91.6	16.0	24.4	5.0	282.6	5.7	96.8	5.8	97.3
S. Agustin	81.9	91.1	10.7	19.8	14.6	251.3	17.5	95.4	17.8	98.5
S.Guillermo	71.8	90.0	5.8	13.6	13.2	266.6	15.8	94.4	16.0	98.4
S.Isidro	95.5	91.5	15.1	23.6	3.2	290.8	3.8	96.8	4.0	98.0
S. Manuel	96.2	91.8	17.6	25.8	3.8	285.5	4.2	96.9	4.2	93.9
S.Mariano	63.8	87.5	25.4	16.4	15.7	354.3	12.8	92.9	12.9	95.3
S.Mateo	95.7	91.7	17.2	25.4	5.8	280.2	6.6	96.9	6.7	94.1
S.Pablo	75.9	89.1	9.8	11.9	8.9	317.7	9.3	94.4	9.5	98.5
S. Maria	68.1	87.4	26.3	17.0	16.8	373.3	13.5	93.6	13.4	99.1
Santiago	94.3	91.5	15.2	23.7	4.8	284.3	5.8	96.7	5.9	97.8
S.Tomas	73.0	85.9	41.1	27.5	38.0	464.1	33.9	93.6	33.6	99.0
Tumauini	91.2	91.3	13.3	22.0	8.8	272.2	10.6	96.3	10.9	97.7
Minimum	59.9	83.8	5.8	11.9	1.4	237.8	1.7	65	1.8	79
Maximum	96.7	91.8	62.4	46.3	56.8	523.2	53	98.1	52.8	99.6
Mean	83.8	90	17.5	21	12.1	315.2	12.1	94.6	12.1	96.4
Std. Dev.	11.9	2.2	12.6	7.9	12.5	66.7	11.3	5.3	11.2	4.2
CV	14.3	2.4	72.3	37.6	103.3	21.2	93.5	5.6	92.1	4.4

Table 4. Standard deviation of %ARD of different estimates of municipal effective area planted to palay(Y_1) in Isabela.

MUNICIPALITY	ESTIMATORS									
	S1	S2	RS	RC	I1	I2	I3	I4	I5	DR
Alicia	96.0	92.7	17.9	26.4	4.1	285.2	4.4	65.0	4.5	94.1
Angadanan	88.2	92.2	12.6	21.6	10.1	266.3	12.1	96.3	12.3	98.9
Aurora	90.2	92.7	18.1	26.6	17.3	239.4	19.6	96.8	19.8	99.1
B.Soliven	76.8	90.5	6.9	11.1	8.8	305.3	9.4	96.1	9.5	98.4
Burgos	95.0	92.2	12.9	22.0	1.8	299.8	2.2	98.3	2.2	97.1
Cabagan	80.6	90.4	8.0	11.0	7.0	320.6	7.1	96.0	7.2	98.1
Cabatuan	94.4	92.7	18.1	26.6	7.3	273.9	8.2	96.9	8.3	98.7
Cauayan	94.6	92.4	14.3	23.2	2.1	294.2	2.7	96.7	2.8	96.3
Cordon	94.3	92.5	15.7	24.4	4.3	285.3	5.1	96.8	5.1	97.4
Dinapique	63.4	85.6	61.6	44.8	56.7	523.5	53.6	93.2	53.5	96.2
Divilican	67.1	89.2	20.9	12.0	13.5	335.0	11.5	94.8	11.6	99.6
Echague	85.2	90.3	8.2	10.9	8.5	343.3	6.3	95.9	6.2	97.9
Gamu	92.1	91.8	8.1	17.4	2.5	308.0	2.6	96.5	2.7	99.4
Ilagan	78.3	89.4	18.6	11.8	12.4	362.5	8.9	95.8	8.6	94.6
Jones	74.9	91.1	5.3	12.4	13.2	265.4	16.6	94.8	16.7	94.9
Luna	92.6	92.7	17.7	26.3	10.4	263.1	11.4	96.7	11.6	99.3
Maconacon	67.2	89.5	17.7	11.6	14.1	319.5	13.3	94.7	13.5	99.4
D.Albano	89.8	90.0	11.7	11.2	19.6	386.8	17.7	95.9	17.4	98.7
Mallig	95.6	92.3	14.2	23.1	1.5	300.8	1.6	96.8	1.7	97.3
Naguilian	87.0	91.2	5.3	13.0	4.0	313.8	4.1	96.2	4.2	99.4
Palanan	69.9	85.6	61.0	44.3	51.0	522.8	46.0	94.9	45.5	99.1
Quezon	95.3	92.2	12.1	21.2	2.1	307.0	2.2	96.8	2.3	97.2
Quirino	91.7	92.0	10.5	19.8	5.7	286.0	7.7	96.8	8.0	98.4
Ramon	96.8	92.5	15.7	24.4	1.1	298.9	1.3	97.1	1.4	92.4
R.Mercedes	86.8	92.5	15.6	24.3	17.6	237.9	20.5	96.7	20.6	99.2
Roxas	95.0	92.5	16.5	25.1	4.8	283.0	5.7	96.9	5.7	97.6
S. Agustin	84.8	92.1	11.0	20.2	14.9	250.4	17.5	96.1	17.7	98.5
S.Guillermo	76.0	91.1	5.4	12.7	12.5	265.6	16.1	96.0	16.3	98.4
S.Isidro	95.6	92.5	15.6	24.3	2.8	291.6	3.3	96.9	3.4	98.2
S. Manuel	96.4	92.7	18.0	26.5	3.5	286.2	3.8	97.0	3.8	95.8
S.Mariano	68.0	88.9	24.7	13.4	12.2	354.3	9.5	95.3	9.6	95.4
S.Mateo	95.7	92.6	17.6	26.1	5.7	280.5	6.6	97.0	6.7	95.5
S.Pablo	79.4	90.3	8.8	10.8	7.8	318.3	8.1	95.4	8.2	98.7
S. Maria	72.4	88.8	25.7	13.9	15.6	372.1	10.5	95.2	10.6	99.4
Santiago	94.7	92.5	15.7	24.4	4.8	284.4	5.7	96.9	5.8	98.1
S.Tomas	76.9	87.5	40.4	25.8	37.5	462.9	32.8	94.8	32.5	99.2
Tumauini	91.9	92.3	13.7	22.7	8.6	272.3	10.4	96.6	10.6	98.4
Minimum	63.4	85.6	5.3	10.8	1.1	237.9	1.4	10.6	1.4	4
Maximum	96.8	92.7	61.6	44.8	56.7	523.5	53.6	98.3	53.5	99.4
Mean	85.4	91	18.6	21.5	12.2	320.1	10.7	72.6	11.6	72.9
Std. Dev.	10.5	2.1	14	8.8	14	73.1	9.7	34.4	11.2	36.3
CV	12.3	2.3	75	40.8	114.4	22.8	90.7	47.4	96.5	49.8

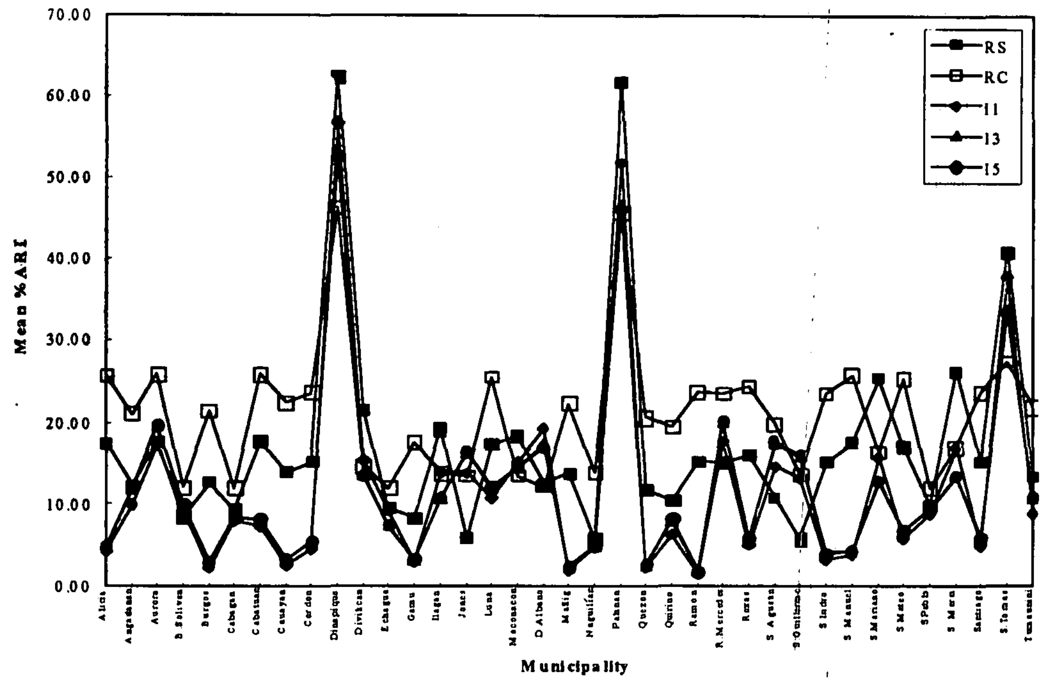

Figure 3. Mean Absolute Relative Difference (%ARD) of selected estimators of effective area planted to palay(Y_1) of the municipalities in Isabela.

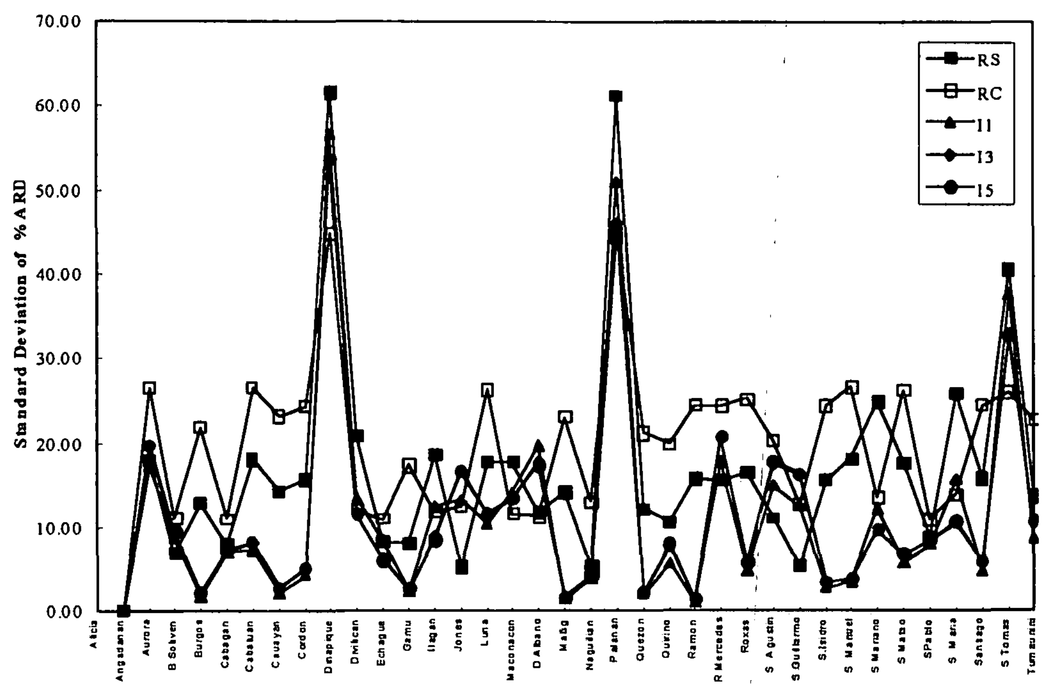

Figure 4. Standard deviation of Absolute Relative Difference (%ARD) of selected estimators of effective area planted to palay(Y_1) of the municipalities in Isabela.

Table 5. Summary statistics of the mean %ARD of the selected estimators of effective area planted to palay(Y_1) and effective area planted to corn(Y_2) in the three provinces.

VARIABLE OF INTEREST	SELECTED ESTIMATOR	STATISTICS OF					
		MEAN %ARD			STD DEV OF %ARD		
		Range	Mean	Std	Range	Mean	Std
Bukidnon							
Y_2	RS	[2.9, 11.7]	4.9	2.2	[2.2, 12.2]	4.5	2.4
	RC	[4.4, 13.1]	5.9	2.0	[3.2, 13.7]	5.0	2.4
Isabela							
Y_1	RS	[5.8, 62.4]	17.5	12.6	[5.3, 61.6]	18.6	14.0
	RC	[11.9, 46.3]	21.0	7.9	[10.8, 44.8]	21.5	8.8
	I1	[1.4, 56.8]	12.1	12.5	[1.1, 56.7]	12.2	14.0
	I3	[1.7, 53.0]	12.1	11.3	[1.3, 53.6]	10.7	9.7
	I5	[1.8, 52.8]	12.1	11.2	[1.4, 53.5]	11.6	11.2

4. Summary, Conclusion and Recommendation

Small area statistics is a quick, cost efficient and a powerful tool for generating information for the locality. The results of this study should encourage the use of survey results(e.g. RCPS) in generating small area estimates.

The study revealed that generating quality small area statistics is feasible using results of existing surveys such as the RCPS. The ratio-type estimators, (Ratio-Separate (RS) and Ratio Combined(RC)) and Imputation like estimators(I1, I3 and I5) could yield desirable estimates of municipal agricultural statistics when relevant auxiliary variables about the municipalities are available. Further study is recommended to examine the best and worst scenario for the ratio-type estimates, and to search for improvements. Also, since the potential of the ratio-type estimators depends largely on the assumption that ratio of X to Y at the small area is equal to the ratio at the larger area, studies to establish the limits of acceptable differences in the ratios may be conducted. It is further recommended that the behavior of the estimators that are seen to yield good results be studied for other survey designs, with varying sample size and stratification variables.

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