The Philippine Statistician
Vol. xxvii, Nos. 1 & 2, 1978

NON-SAMPLING ERRORS IN AGRICULTURAL SURVEYS — REVIEW, CURRENT FINDINGS AND SUGGESTIONS FOR FUTURE RESEARCH[1]

By ISIDORO P. DAVID[2]

I. Introduction

Suppose we want to have an indicator of the annual production Y in kilograms, of tomatoes in Nueva Ecija; we run a survey or series of surveys to have an indicator or statistic, $\hat{Y}$. The error in $\hat{Y}$, defined naturally as the gap between $\hat{Y}$ and Y,

$$e(\hat{Y}) = \hat{Y} - Y$$

cannot be observed, and so just like Y, we would want to have an indicator of it. In the sample space associated with the survey design, denote the average of the realizations $\hat{Y}_1$, $\hat{Y}_2$, . . . of $\hat{Y}$ by $E(\hat{Y})$. The average error

$$b(\hat{Y}) = E(\hat{Y}) - Y$$

is also called the bias in $\hat{Y}$. The average of the squared deviations of $\hat{Y}$ about $E(\hat{Y})$,

$$v(\hat{Y}) = E[\hat{Y} - E(\hat{Y})]^2$$

is of course the variance of $\hat{Y}$. The average of the square of $e(\hat{Y})$, called the mean squared error, is expressible in terms

---

[1] Paper for the 1978 Philippine Statistical Association Annual Conference, June 19, Manila.

[2] Associate Professor and Chairman, Department of Statistics and Statistical Laboratory, College of Arts and Sciences, University of the Philippines at Los Banos. The author hereby expresses his sincere thanks to the Bureau of Agricultural Economics for the unselfish access to its data, and particularly to Director J. Alix, Messrs. M. Damasco, D. Besa and B. Villanueva, with whom I share a common goal of upgrading our agricultural statistical system. I also wish to acknowledge the data processing assistance of my colleagues, Prof. S. Alviar and Ms. B. Martinez.

of $v(\hat{Y})$ and $b(\hat{Y})$, i.e.,

$$mse(\hat{Y}) = v(\hat{Y}) + [b(\hat{Y})]^2.$$

This equation has profound implications in applied statistics which, judging from the way we plan and conduct our surveys, are sometimes not well understood nor appreciated.

(a) It states clearly that the total error in a statistic is a sum of two components, i.e.

total error = sampling error + non-sampling error

and sampling error is measured by $v(\hat{Y})$ or its square root which is the standard error, while non-sampling error is synonymous with bias. The first is the error or uncertainty associated with inference concerning the whole target population on the basis of a sample, while the latter catches all others excluding sampling error.

(b) Switching from one survey design to another with no accompanying changes in questionnaire and method of data collection affects sampling error only.

(c) Aside from occasional changes in survey design, increasing the size of the sample is the common way of trying to increase the accuracy of statistics. However, sample size n affects sampling error only; moreover, since the standard error is of order $1/\sqrt{n}$, a point is soon reached wherein increasing n will give reductions in sampling error not commensurate with the increase in cost. For example, starting with $n = 16$, a four-fold increase to 64 is required to reduce the standard error to half its size, and a further four-fold increase to 256 to reduce it once more by one-half. At the same time, non-sampling error, theoretically, is unaffected by sample size; in practice, a bigger sample usually means looser supervision, a bigger field staff and more data to process, all of which may raise non-sampling error. Hence, in survey sampling, increasing the sample size does not necessarily cause a reduction in total error.

The writer is of the opinion that the sample sizes of our major surveys are high enough to reduce sampling errors even of provincial statistics to acceptable levels; the fact that this has not happened yet is due primarily to the inefficiencies of the survey designs currently in use. We also feel that non-sampling errors dominate over sampling errors in our surveys, and that we have not given them the attention they deserve. Whilst the theory of sampling errors is universal, non-sampling errors are highly location—and situation-specific, which adds to the urgency of their study in the local setting.

Going back to our original example, is the total annual production of tomatoes knowable? Will the interview method be an adequate instrument? Can the farmer recall his produce or will his response be subject to memory error? Does he reckon his produce in kilograms or will there be a measurement error problem? Will the farmer, wife, and eldest son give the same response? Will two interviewers get the same information from a respondent? How much non-coverage error is due to exclusion of background production and non-response? Is the estimation procedure faithful to the survey design? We begin to understand the nature and extent of non-sampling errors only after careful scrutiny of these questions.

II. Review of Previous Studies

1. Introduction

The number of past studies on non-sampling errors is testament to our relative neglect of this area: What little had been done was mostly on rice and in four provinces — Laguna, Nueva Ecija, Bulacan and Pangasinan. Granting that rice is our most important crop, it is not difficult to imagine that non-sampling errors should be worse with other crops, livestock and poultry. The area planted to crops vary from year to year depending on the soil moisture condition, availability of planting materials, etc., and farmers of course find no need to know the actual area. Likewise, corn is usually harvested as a queen vegetable and the farmer derives no benefit from figuring out his harvest in sacks of 50 kilos at 14 percent moisture. While statistics on large livestock like carabaos and cattle may be less subject to memory lapse error, this may not be so with small livestock and poultry. It has been noted for instance, that the correlation between chicken counts from one survey round to the next is very low due to the fast disposition of broilers in contract farms and the fact that our major survey rounds—January and June—are in the wake of Christmas, New Year and May festivals. The accounting by interview of poultry production during the year is a problem we do not quite know how to resolve satisfactorily yet. What proportion of our vegetable production comes from backyard gardens with less than 0.1 hectare? This is non-coverage error, also a component of non-sampling errors. What is the extent of measurement error in farm labor and other farm input statistics?

We have already started with a long way to go yet.

2. Rice area

We often train interviewers to elicit information no matter what as soon as he locates the respondent, which is alright if the latter were willing (and farmers generally are cooperative) and knew the answers to the survey questions. In the case of rice area, the farmer either knows, heard about it from somebody like the landlord, or guesses it from seed rate and/or wage paid to planters and harvesters. In the latter situation, the figure he quotes is usually rounded to the nearest quarter or third of a hectare. In 1966, 826 Laguna rice farmers were interviewed and gave their rice area as follows:[3]

22 percent in direct hectarage
74 percent on the basis of seed rate
and 4 percent in local units (not hectares).

The actual areas of a subsample of 68 farmers were measured which when compared to interview areas showed a 5.6% over-estimation by the latter.[4] The percentage over-estimation tended to decrease with increasing actual area. In another study, 182 rice farmers in Manaoag, Pangasinan gave (interview) areas that over-estimated actual areas by an average of 8.1 percent.[5] Again, the degree of over-estimation was found to be lower in bigger farms:

farm size (hectares)	.01-.50	.51-1.00	1.01-1.50	1.51-2.00
% over-estimation	12.7	7.1	5.6	3.4

There were also indications that the magnitude of error is related to tenure status.

3. Rice production

From the same 68 Laguna farmers, the interview response and the actual (observed) palay or unmilled rice production were compared, with the following results:[6]

[3] International Rice Research Institute (IRRI) 1966 Annual Report, p. 262.
[4] IRRI 1969 Annual Report, pp. 221-222.
[5] IRRI 1975 Annual Report pp. 415-416.
[6] IRRI 1967 Annual Report pp. 271-272.

	% of actual	% cum
a. Reported by farmer prior to deeper probing	77.4	77.4
b. Harvester's share based on reported sharing system	13.1	90.5
c. Heaped part on harvester's share	1.3	91.8
d. Other expenses, e.g. irrigation fee, weeder's fee, rent for use of harvesting-drying space, paid with palay	4.6	96.4
e. Gleaned from harvested field	1.8	98.2
f. Given to friends and relatives	1.8	100.0

Components (c) and (e) normally are not reported; some interviewers may fail to ask about (d) and (f). Thus, without deeper probing by the interviewer, assuming that there is no memory lapse error on the part of the farmer, the interview production may under-estimate the actual by three to nine percent. Further accumulated evidence tends to confirm that the unreported component due to heaping of the harvester's share may actually range from 3-5 percent and that which goes to gleaners is from 1-2 percent with a higher value during the wet season, possibly because of the higher incidence of lodging of crops and other conditions that are less conducive to a more thorough job.[7] Earlier, Oñate[8] reported a 3 percent under-reporting by interviews conducted 6-9 months after harvest.

4. Experiments on crop-cutting

One of the early crop-cutting experiments was done by de Ramos[9] in 12 randomly chosen farms in Sta. Maria, Laguna. Two paddies were drawn from each farm and a square, equilateral triangle and circle each 2 square meters in area, were cut from each paddy. While the different cuts did not show any significant differences in yields, these gave yields that were 8 percent higher than the actual (observed) yields. The observed yields, however were based on reported (interview) areas, so the over-estimation in reality could be higher than 8 percent.

The Bureau of Agricultural Economics (BAECON) has done

[7] IRRI 1969 Annual Report pp. 80-81.

[8] Onate, B. T. 1957. Non-sampling Errors in Philippine Field Surveys. Philippine Statistician 6(2).

[9] de Ramos, M. B. 1958. Estimating Rice Production by Using Three Sampling Units. The Philippine Agriculturist 42(6). 210-221.

the most investigations on objective measurement of rice area and production; however, reports on experiments after 1960 are not available (See Section 4 of this paper for a report on BAECON's 1975 experiment). In 1955, five different sizes and shapes of cuts were the subject of 10 trials in Sta. Rosa, Laguna, with the following results:[10]

Square (1 sq. m.)	13% over-estimation
Triangle (1 sq. m.)	15
Circle (1 sq. m.)	26
Square (5 sq. m.)	7
Square (10 sq. m.)	3

These results discourage the use of one square meter cuts and are in agreement with Oñate's[11] finding that bias decreases with increasing area of the cut and becomes negligible for cuts approaching 4m. x 4m. The square cut, which is easier to implement, seems to be subject to smaller bias. On the other hand, IRRI's 1968 study also in Laguna tends to show otherwise;[12] the experiment involved 2 randomly chosen paddies in each of 31 farms and a 5m. x 5m. plot was randomly located in each paddy. The observations from nested plots of sizes 1 x 1, . . . 1 x 2, 1 x 5, 2 x 2, . . . within the 5 x 5 plots were taken separately, resulting in moderately large samples. The actual yields and areas were observed also. The results showed a 16 percent over-estimation by the 1 x 1 plot; all other plots from 1 x 2 to 5 x 5 and an almost constant bias of about 11 percent.

In India, which has the most experience in crop-cutting, it was found that the bias decreases—but at a very slow rate—with increasing plot size, so that the plot used there is about 10m. x 5m.[13], [14]

Finally, a BAECON pilot survey in 1956 involving 100 farms each in Nueva Ecija and Bulacan with 3 crop-cuts (size un-

[10] Gutierrez, J. S. 1960. Objective Yield Estimation Studies and Surveys in the Philippines. The Statistical Reporter 4(1), 1-9.

[11] Onate, B. T. 1970. The New Findings in the Collection of Agricultural Statistics, FAO Commission on Agriqultural Statistics for Asia and the Far East. Periodic Report No. 11.

[12] IRRI 1968 Annual Report, p. 346.

[13] Sukhatme, P. V. 1947. The Problem of Plot Size in Large-Scale Yield Surveys. Jour. of the Amer. Statist. Assoc. 42(238), 297-310.

[14] Mahalanobis, P. C. and J. M. Sengupta, 1951. On the Size of Sample Cuts in Crop-Cutting Experiments in the Indian Statistical Institute: 1939-1950. Bull. Intern. Statist. Institute. 33 Part I, 359-404.

reported) per farm gave the following results.[15]

	Crop-cut Yield + S.D. (Cavans per hectare)	Interview Yield	$\frac{C-I}{C} \times 100\%$
Bulacan	55.73 ± 5.09	42.03	25
Nueva Ecija	56.06 ± 8.5	44.98	20

It is seem that the discrepancy cannot be accounted for by sampling error. The true yield must be somewhere between the crop-cut and interview yields. We need more extensive and sustained studies to know just where it could be.

5. In summary:

Farmers in Laguna and some part in Pangasinan tend to over-report rice area. We need more studies to know about the situation in other places. The interview response errors may be different across provinces, farm sizes and tenure status.

We have ample evidence showing that rice production is under-reported in interview surveys in Laguna. The implication is that yield = estimate of total production ÷ estimate of total area is underestimated even more. However, we have no basis to assume that this is also the case in the other provinces.

Crop-cut yield over-estimates actual yield. Square cuts which are similar to implement compare favorably with other shapes bias-wise. However, other than the fact that one square meter cuts are subject to serious bias and bigger cuts are safer to use, we need further studies to resolve the question of crop-cut size; for this we require estimates of relative costs, sampling error and bias of different sized cuts.

III. The Barangay Captain as a Source of Statistical Information

1. The need for auxiliary information in surveys

Auxiliary information is used in survey sampling perhaps more than in any other branch of statistics. Ideally, for instance, complete frames, i.e. information on a size variable X for every unit of the target population, are required for stratification and probability proportional to size sampling. Stratum or population means of auxiliary variables are required

15 Gutierrez J. S. of cit.

in the more efficient estimation methods like ratio and regression-type estimation. Faced with insufficient background data, survey practitioners sometimes allocate part of their resources to first gather auxiliary information such as in pilot surveys and double sampling.

Two major reasons for having censuses every 5 or 10 years are (a) the need for baseline data and (b) to have and to update frames for the intercensal sample surveys. The first of these is being questioned increasingly in international quarters for reasons of costs and data processing problems especially in developing countries and the fact that results from a census are not guarranted to be more accurate than those from a smaller, carefully supervised, speedily processed sampled survey.[16] Nevertheless, perhaps because of our zealous teaching of the central limit theorem and benign neglect of nonsampling errors in statistics courses, it may take decades, if ever, before we can erase the popular belief that complete or very high enumeration rates must strike more closely to the truth.

The second role of (agricultural) censuses is slowly fading in importance in countries where cadastral surveys had been available and where frames based on aerial and satellite photos are being used increasingly.

In the Philippines, the agricultural censuses had never been used as frames for the agricultural surveys for the simple reason that these are being done by separate agencies and the former's results are published by municipality whereas the agricultural surveys use the barrio (barangay) as primary sampling unit. For seven years now, the Bureau of Agricultural Economics has been relying on the barangay (barrio) captains for auxiliary information in the design of the Integrated Agricultural Surveys (IAS): The Bureau conducted Barangay Screening Surveys (BSS) in 1971, 1974 and 1976, wherein every barangay captain in the country was interviewed about his barangay's number of farm and non-farm households, carabaos, cattle, hogs, chickens, ducks, area under rice and corn, and other crops. So far, these BSS data have been used to construct and update frames for the IAS, particularly in the stratification of barangays in a province by cropping pattern such as according to area under rice, corn and other crops.

16 See e.g. Hathaway, D. E. and K. Bachman, 1976. National and International Framework for Collecting, Analyzing, and Disseminating Agricultural Data: Some Issues and Alternatives. Workshop Paper on Minimum Information System for Agricultural Development in Low Income Countries. Oxford University, December.

How knowledgeable is the captain about his own barangay? How much efficiency, if any, is gained in using BSS data as auxiliary information for stratification—allocation, ratio-type estimation and regression-type estimation? Is it advisable to rely on the barangay captain as primary source of data (as in the case of the **Patwari** of India and **Desalurah** of Indonesia, whose figures are used for direct estimation of crop area)?

1. **Comparison between barangay captains' responses and household listings.**

During each round of the IAS, the Bureau's field staff visits all dwellings in the IAS sample barangays and interviews each household regarding farm size, number of livestock and poultry, thereby observing at the household level the same variables as in the BSS. This operation is called the Household Screening Survey (HSS), which is done to identify farm households from nonfarm households and draw systematic samples from the former. Hence, HSS results which come from interviewers' lists and farm households' interview responses can be used to assess the qualities of the BSS data; we compare here the 1976 HSS and 1976 BSS data from the seven provinces of the Ilocos region, and Bataan, Bulacan and Tarlac in Central Luzon, comprising 894 sample barangays.

We present in Table 1 the differences between BSS and HSS data in percent of HSS values, so that positive and negative differences indicate over-reporting and under-reporting by barangay captains, respectively. We may note that from the standpoint of survey design, the provincial values are more relevant since in the IAS (and other nationally conducted surveys) each province is a separate domain of study. It is seen that:

(a) With the exception of one province, rice and corn area is over-reported by more than 100 percent in Ilocos and 60 percent in central Luzon. With area under other crops, including tobacco in Ilocos and sugarcane in Central Luzon, the gross over-reporting suggests an almost complete lack of knowledge by the barangay captains. These serious differences rule out the use of the barangay captain for direct estimation of crop area.

(b) Household inventories — farm, non-farm and total— tend to be understated in Ilocos and overstated in Central Luzon, although there is no clear pattern in error across provinces particularly with regards to the farm households. This is surprising and alarming, considering that a priori one would think that the barangay captain should know the number of families or dwelling units, if not households, in his barangay. One possible source of error here is perception of the definitions of a household, farm and non-farm household.

(c) There are considerable errors in livestock inventories; the under-reporting rate, when it happens, is usually small, but over-reporting tends to be gross.

(d) The number of chickens generally is under-reported, due perhaps to the large numbers per barrio — with averages of 583 in Ilocos and 684 in Central Luzon. The error is four times higher in Central Luzon. The lack of knowledge about the inventory of ducks, a minor poultry, is worse.

The correlations between HSS and BSS data are shown in Table 2. As indicators of overall reliability of the latter, we should perhaps look at the correlations between the household counts since, as mentioned previously, it is tempting to assume that captains of rural barangays who are elected public officials should be acquainted with their constituent households. It turns out that while some correlations are considerably high, a few are rather low with even a spattering of negative values. Also, the correlations for palay and corn area dissolves close to zero in some provinces. Again, the many low and negative values for other crops and ducks indicate that the barangay captains are not appropriate sources of data for these variables.

3. BSS data as auxiliary information

Stratification brings about sizable reductions in the sampling error of estimates if the stratification variable used correlates substantially, either positively or negatively with the main variables of interest. At the sampling phase of the survey, auxiliary variables used as size measure in varying probability sampling must correlate positively with the main variables. At the estimation phase, ratio estimators are more efficient than simple expansion estimators (for large samples) if

$$p_{y,x} > \frac{1}{2} \frac{CV(X)}{CV(Y)}$$

where X and Y denote the auxilliary and main variables, respectively. Thus, if $CV(X) \simeq CV(Y)$, as when X and Y are the same variables taken at different times or from different sources, then the criterion for using ratio estimator is $p > ½$.

Tables 2a and 2b give the correlations between palay + corn area and number of farm households from the BSS on the one hand, and palay + corn area to number of ducks from the HSS on the other hand.

(e) The use of either BSS palay + corn area (as in the current IAS), or number of farm households as stratification variable will bring about moderate gains in precision of palay + corn area, carabao, cattle, hogs and chicken statistics. However, there is little or no expectation of gain with regards to statistics on other crops, minor poultry like ducks and possibly minor livestock also.

(f) The gains in precision with the use of rice + corn area or number of farm households as size measures in either probability proportional to size sampling or ratio estimation are from negative in some provinces to modest at best in others. Thus, in general, BSS data as auxiliary information should not be used beyond stratification.

4. Correlations within HSS data

How much correlation at the barangay level really exists between agricultural variables? The answer is not much, with the exception of palay + corn area and number of farm households, as shown in Table 4.

(g) Aside from itself, palay + corn area correlates substantially with farm household count and number of carabaos. The number of farm households correlates highly also with livestock and poultry counts. These suggest the use of deep stratification, namely cropping pattern x farm household counts, of barangays for agricultural surveys. With few exceptions, ratio estimation at the barangay level will not be effective in reducing sampling error. The use of ratio and regression-type estimation to reduce non-sampling error, however, is a different issue that needs further theoretical and empirical investigation.

Table 1. RELATIVE DIFFERENCES IN PERCENT: 100 x (BSS - HSS)/HSS.

		Province								Province		
Variable	**Region 1*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Region 3*	*1*	*2*	*5*
Palay + Corn area	113	30	46	40	43	23	0	198	61	95	91	53
Other crops area	288	—4	154	33	1152	138	1199	420	375	164	243	430
All households	—8	—17	—19	—41	—7	—18	—5	—5	16	—5	29	10
Nonfarm households	—21	—4	—45	—12	—3	—37	—2	—23	19	25	46	15
Farm households	3	—1	38	—26	—4	—3	12	8	18	—7	124	8
Carabaos	37	5	—11	65	24	22	5	39	37	—5	88	42
Cattle	40	42	30	110	3	—2	45	60	104	75	250	53
Hogs	23	23	—36	56	4	—13	4	43	20	7	30	16
Chickens	—13	—20	—30	—6	7	—22	0	—16	—56	—13	—90	—23
Ducks	50	16	170	40	104	549	234	7	68	97	—13	37

* Region 1 is Ilocos with provinces 1. Abra (n=58), 2. Benguet (n=32), 3. Mt. Province (n=53), 4. Ilocos Norte (n=60), 5. Ilocos Sur (n=143), 6. La Union (n=90), 7. Pangasinan (n=248); region 3 is Central Luzon with provinces 1. Bataan (n=49), 2. Bulacan (n=63), 5. Tarlac (n=98).

Table 2. CORRELATIONS BETWEEN HSS AND BSS DATA.

		Province								*Province*		
Variable	*Region 1*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Region 3*	*1*	*2*	*5*
Palay + Corn area	.37	.29	.68	.88	.73	.58	.05	.27	.55	.31	.61	.62
Other crops area	.03	—.03	.06	.74	.08	.42	—.05	—.01	.30	.59	.04	.27
All households	.33	.72	—.25	.74	.57	.65	.62	.33	.57	.69	.53	.52
Nonfarm households	.36	.96	—.01	.96	.79	.64	.21	.40	.65	.59	.63	.69
Farm households	.48	.60	.28	.47	.69	.77	.63	.34	.48	.57	.35	.56
Carabaos	.61	.54	.59	.41	.59	.68	.65	.56	.56	.60	.60	.59
Cattle	.50	.51	.31	.07	.69	.52	.47	.50	.35	.40	.63	.31
Hogs	.40	.38	.28	.17	.29	.61	.41	.48	.27	.70	.18	.44
Chickens	.41	.31	.28	.25	.44	.44	.18	.40	.14	.59	.07	.22
Ducks	.35	—.06	—.21	.95	.69	—.08	.14	.34	.18	—.31	.05	.32

Table 3a. CORRELATIONS BETWEEN BSS PALAY + CORN AREA AND HSS DATA.

HSS Variable	*Region 1*	*Province*							*Region 3*	*Province*		
		1	*2*	*3*	*4*	*5*	*6*	*7*		*1*	*2*	*5*
Palay + Corn area	.37	.29	.68	.88	.73	.58	.05	.27	.55	.31	.61	.62
Other crops area	.04	—.04	.16	—.03	.43	.57	.08	—.01	.19	—.09	.07	.24
Carabaos	.42	.31	.45	.69	.53	.58	.29	.44	.48	.48	.50	.50
Cattle	.27	.34	.51	.16	.72	.38	.00	.29	.23	.30	.27	.34
Hogs	.45	.50	.41	.15	.57	.44	.14	.38	.15	.32	.03	.42
Chickens	.36	.47	.19	.13	.69	.42	.12	.20	.22	.24	.09	.40
Ducks	.21	.04	.42	—.02	.17	.08	.90	.09	.25	—.02	—.14	.40

Table 3b. CORRELATIONS BETWEEN BSS NUMBER OF FARM HOUSEHOLDS AND HSS DATA.

		Province								*Province*		
HSS Variable	*Region 1*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Region 2*	*1*	*3*	*4*
Palay + Corn area	.41	.18	.32	.34	.72	.57	.47	.29	.56	.50	.59	.57
Other crops area	.06	.14	—.09	.19	.51	.53	.08	.00	.19	.19	.07	.22
Carabaos	.51	.33	.22	.33	.50	.61	.29	.50	.47	.42	.45	.51
Cattle	.42	.27	.18	.03	.70	.39	.00	.41	.28	.34	.30	.39
Hogs	.50	.34	.32	.25	.60	.40	.14	.49	.18	.55	.09	.46
Chickens	.42	.32	.32	.26	.70	.43	.12	.29	.30	.51	.15	.51
Ducks	.15	.17	.15	.16	.27	—.01	.90	.10	.25	—.03	—.01	.37

Table 4. CORRELATION MATRIX FOR HSS DATA ONLY.
Upper triangle values are for region 1, lower triangle values are for region 3.

		X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*X9*	*X10*
Palay + Corn area,	X1		n*	.32	n	.60	.51	n	n	n	n
Other crops area,	X2	n		n	n	n	n	n	n	n	n
All households,	X3	.35	n		.87	.56	n	n	.47	.37	n
Non-farm households,	X4	n	n	.86		n	n	n	n	n	n
Farm households,	X5	.82	.31	.43	n		.66	.44	.54	.34	n
Carabaos,	X6	.67	.39	n	n	.78		.43	.38	n	n
Cattle,	X7	n	n	n	n	n	n		.31	n	n
Hogs,	X8	n	n	n	n	.35	.31	n		.41	n
Chickens,	X9	n	n	n	n	n	n	n	.67		n
Ducks,	X10	n	n	n	n	n	n	n	n	n	

* A letter n is placed whenever $r < .30$.

These results also highlight the need to pay particular attention to and develop special sampling strategies for, crops other than rice and corn and for minor livestock and poultry.

IV. Recent Findings on Rice Area and Production

1. Introduction

Although the interview method is fraught with non-sampling errors, its chief advantages are (a) low cost, which gives the survey practitioner a big enough sample to (potentially at least) reduce sampling error effectively, and (b) some data like fertilizer use, farmers' attitudes, farm prices, etc., cannot possibly be obtained in some other way. On the other hand, crop-cutting, actual area evaluation and other objective methods of measurement can have less non-sampling error but they (a) require specially trained personnel and (b) are so costly that only relatively smaller samples can be taken, which makes the sampling error something to worry about. Besides, to have accurate aggregate production figures will require not only accurate crop-cut yield (per hectare) estimates but accurate aggregate area estimates as well.

In the Philippines, the eventual choice for agricultural surveys is not between interview or objectives methods but a combination of the two in such a manner that sampling + non-sampling error can be reduced to acceptable levels. Theory tells us what sampling error to expect, in terms of (unknown) parameters of the target population, given a sampling strategy. What we do not know much about are the nature and extent of non-sampling errors. (There seems to be a dearth also of estimates of parameters of target populations, e.g. variance functions and cost functions for different sampling units, that are useful in developing and comparing efficiencies of alternative survey strategies).

2. Some recent data

In 1975, BAECON conducted a pilot crop-cutting survey involving 18, 9, and 15 farms in Nueva Ecija, Iloilo and South Cotabato provinces, respectively. Prior to crop-cutting, each farmer was asked about the area to be harvested, his expected production and amount of seeds used. The area of each paddy in the farm was measured using a plane table and alidade. Depending on the size of the farm, one to two sample paddies were selected; two to six 2m. x 2m. cuts per sample paddy were taken at random, the allocation being dependent on the size of the paddy. Aside from the crop-cut yield and the actual paddy size, the field staff made "eye estimates" of the yield and area of each sample paddy.

The second set of data consists of interview and actual measurements of 25 rice farms in Pangasinan—early returns from an on-going study by BAECON covering one province from each of the ten regions. When completed, this study should offer large-sample indicators of biases in interview area measurements. Unlike the 1975 pilot project where the area of each paddy was determined, however, this latter study divides the farm into as many triangles necessary, and the area of each triangle is measured using a simpler instrument called a rangematic.

2.1. Relationships between actual, interview and "eye estimate" areas and seed rate.

Farmers tend to report areas to the nearest quarter or third of a hectare, e.g., .25, .33, .50, .75, 1.0. It has been observed that in cases where farmers do not know the actual areas, their responses are based on the amount of seeds they use, on the planters' fees or on the harvesters' wages. Likewise, when technicians are made to make an eye estimate of a paddy's area, the guesses tend to be in multiples of 50 sq. meters, e.g. 300, 350, 400. There have been cases of gross overestimates (in South Cotabato) where technicians' eye estimates were 10 to 25 times higher than the actual values, (which were excluded from the analyses); these indicate perhaps some lack of familiarity with assessing the dimensions of a small area, which can be corrected through practice. The results, summarized in Tables 5-7, indicate the following:

(a) Farmer's reports of rice farm areas in Nueva Ecija are accurate; those in Iloilo show a slight over-reporting which is inconclusive on account of the small sample size. Cotabato farmers, surprisingly, show a significant tendency to under-report rice area.

In the case of Pangasinan, the 12 percent over-reporting, though in agreement with earlier reports (8 percent in the IRRI study), is not substantially different from zero at the $\alpha = .05$ size test; this is due to large deviations as much as 200 percent—between the actual and interview areas in a few farms. In general, the Pangasinan data reflected the reduction in accuracy of measurement when the farm is reduced to as few triangles necessary to evaluate the total farm area compared to measuring the area of each paddy, and also of the changes in measuring instrument from alidale to rangematic. (In fact, a few sample farms were discarded for various errors in measurement; these perhaps emphasize the need for especially trained personnel, longer on the spot training, more careful instrument calibration and much closer supervision if and when we attempt a large-scale farm area measurement survey).

The correlation between measured and interview areas range from .74 to .96, and .92 for the combined sample. Considering that $CV(A) \simeq CV(I)$, these correlations foretell considerable gains in accuracy (less bias and reduced sampling error) should ratio or regression-type estimation be employed with double-sampling using interview areas as concomitant information and actual areas from much fewer farms as main information.

(b) The amount of seeds used should be easily remembered by farmers especially since it should remain stable accross seasons and years, unless there is a change in farm size or planting method. Seed rate does change, however, depending on the planting method, on the type of farm (upland or lowland) and on other cultural practices as reflected by the different values in the three provinces in Table 6; the seed rate in Nueva Ecija is only about two-thirds that of Iloilo and South Cotabato. The correlations between seeds used and area range from .60 to .93, which when compared with the ratio of cv's, makes seed rate a potentially effective concomitant variable for improving the precision of area estimates.

(c) The ability to look over a lot or paddy and guess the area to the nearest, say 50 square meters, is a trait that could possibly be acquired by some people after some lengthy experience. With regularly shaped paddies, pacing the sides may help in the estimation if one knows the average length of his pace. Nevertheless, the correlations between actual paddy area and the technicians' eye estimates indicate modest to moderate gains in precision should the latter be used as concomitant information in ratio-type estimation—interview area and seed rate, which could be more reliable, should be preferrable. As seen in Table 7, eye estimates tended to under-estimate paddy area in Nueva Ecija but not so in Iloilo and South Cotabato. We may mention that there were some overly large estimates in South Cotabato: One possible drawback of eye estimation is a sense it might engender among field personnel, namely, that accuracy is not the name of the game—that 500 square meters can be about 500 square meters, and a hectare about a hectare.

2.2. Expected and crop-cut productions

A farmer's expected harvest, his summary statistic quite possibly arrived at from combining his assessment of the current crop stand and years of "prior" observations, has potential use as concomitant information and basis for forecasting production. There is substantive evidence that actual production is somewhere to the right and to the left of interview and crop-cut values, respectively. Where does the farmer's prediction lie? Unfortunately, available data allow a comparison with the crop-cut values only (Table 8).

(d) Farmers' expectations are 25 percent lower than crop-cut values in Nueva Ecija and 37 percent lower in South Cotabato. Fourteen of the 18 sample farmers in Nueva Ecija gave predictions lower than the crop-cut values while all 15 farmers in South Cotabato gave much lower predictions. On the other hand, there was no detectable difference between expectations and crop-cut realizations in Iloilo. Allowing for over-estimation by crop-cuts, it would be interesting and useful to find out from a more extensive sample whether the hypothesis that farmers tend to be conservative in their prediction, which the present data support, will hold out in most provinces. What is more useful is to have estimates, by province, of the differences between the farmer's prediction, interview, crop-cut and actual production. Finally, we may note the appreciable correlation between expected and crop-cut productions, .86 for the combined sample, which implies that the former variable, obtained by interview, may be utilized along with crop-cut values to improve the precision of production estimates at the farm level.

Table 5. RELATIONSHIP BETWEEN ACTUAL (A) AND INTERVIEW (I) AREA.

Province	*Number of farms*	*Average* *I*	*A*	$\frac{I-A}{A} \times 100\%$	*Correlation*
N. Ecija	18	1.11	1.10	0.55^{ns}	0.96
Iloilo	9	0.84	0.81	4.25^{ns}	0.74
S. Cotabato	15	0.68	0.73	—1.13*	0.95
Pangasinan	25	1.45	1.29	12.05^{ns}	0.90
All	65				0.92

* | t-value | > tabular t at α = .05
ns | t-value | < tabular t at α = .05

Table 6. RELATIONSHIP BETWEEN ACTUAL AREA AND SEED RATE.

Province	*Number of farms*	*Seed rate; gantas/hectare*	*Correlation*	$\frac{\text{cv (Seeds)}}{\text{2 cv (Area)}}$
N. Ecija	18	39.02	.60	.38
Iloilo	9	54.67	.93	51.
S. Cotabato	15	55.34	.85	.72
All	42	46.54	.68	.40

Table 7. RELATIONSHIP BETWEEN ACTUAL PADDY AREA (A) AND TECHNICIAN'S EYE ESTIMATE (E).

Province	*Number of Paddies*	*Average Area (sq. m.)* *E*	*A*	$\frac{E-A}{A} \times 100\%$	*Correlation*	$\frac{cv(E)}{2cv(A)}$
N. Ecija	34	334	413	—19	0.66	0.43
Iloilo	14	626	610	3	0.86	0.52
S. Cotabato	11*	381	367	4	0.97	0.49
All	59	412	451	—9	0.90	0.57

* Excluding four observations, which, either due to slips of the pencil or otherwise, had eye estimates running 5 to 25 times more than the actual areas.

Table 8. RELATIONSHIP BETWEEN FARMER'S EXPECTED PRODUCTION (E) AND CROP-CUT PRODUCTION (C).

Province	*Number of farms*	*Average (Cavans/Farm)*		$\frac{E-C}{C}$ x 100%	*Correlation*	$\frac{cv(E)}{2cv(C)}$
		E	*C*			
N. Ecija	18	66.7	88.7	—25**	0.89	0.45
Iloilo	9	35.3	31.9	10ns	0.77	0.31
S. Cotabato	15	47.5	75.0	—37**	0.75	0.70
All	42	53.1	71.6	—26**	0.86	0.46

** | t-value | > tabular t at a = .01
ns | t-value | < tabular t at a = .20

Table 9. RELATIONSHIP BETWEEN CROP-CUT PADDY YIELD (C) AND TECHNICIAN'S EYE ESTIMATE (E).

Province	*Number of farms*	*Average (Cavans/Farm)*		$\frac{E-C}{C}$ x 100%	*Correlation*	$\frac{cv(E)}{2cv(C)}$
		E	*C*			
N. Ecija	31	3.00	3.30	—10	0.70	0.32
Iloilo	14	3.65	2.64	38	0.88	0.35
S. Cotabato	15	4.30	3.83	12	0.26	0.43
All	60	3.48	3.28	6	0.61	0.40

(e) When technicians were asked to guess the yield of a paddy, the responses ranged from 1 to 10 cavans in multiples of 0.5. It can be seen from Table 9 that there are no definite patterns in the results; paddy yield was over-estimated in Iloilo and South Cotabato and underestimated in Nueva Ecija, with very little correlation between values in South Cotabato. Unlike area, eye estimation of rice yield requires not only practice but technical familiarity with the yield potentials of different varieties and their relative performance in different environments. For example, plant stature and vigor may not have much to do with yield; in fact, traditional varieties are generally taller than modern high yielding varieties. Eye estimates of yield, therefore, should not be considered seriously even as concomitant information only, as these may be subject to very high between enumerators variance.

V. Summary and Conclusions

Comparison of interview data from 894 barangay captains and complete enumeration of households in the same barangays revealed gross differences which discourage the use of the former as primary source of data. As a frame for the Integrated Agricultural Surveys, the Barangay Screening Survey can be expected to provide modest to moderate gains in survey design efficiency through stratification but not through other means such as ratio- and regression-type estimation. Correlations within the Household Screening Survey data showed that, with relatively accurate data, deep stratification of barangays, such as rice area x number of farm households at least, will bring about considerable gains in efficiency of the IAS. The results also highlights the need for special survey strategies for minor crops, livestock and poultry. The discrepancies and low correlations between household counts in the BSS and HSS should cause concern particularly since the interviewers in the BSS were the regular BAECON provincial staff and the assumption that barangay captains in the rural areas know their constituents is intuitively appealing to many. How much of the observed discrepancy is due to interviewer error and how much is due to response error? Inevitably, the next question has to be asked: Are non-sampling errors in interview surveys done by casual enumerators hopelessly gross?

Most of our surveys employ two-stage designs with barangays as first stage units and (farm) households as second stage units. In planning sampling strategies for these surveys, a rational approach is to direct variance-reducing efforts at the barangay level, e.g. efficient stratification, and concentrate non-sampling error and to some extent sampling error control at the household level. Others may disagree, but we make a conjecture here that the only way to do this is to break our complete dependence on the interview method. However, a complete switch to "objective" methods at this point in time is economically, operationally and statistically undesirable. A more plausible alternative is double sampling where interview data from a large sample of households are used as concomitant information to "objective" data from a much smaller subsample. Results show substantial correlation between objective and interview rice area and production. Thus, crop-cut production which tends to be positively biased may be made more accurate, bias—and variance-wise, with concomitant use of interview production, which in some cases tends to be negatively biased. Although individual objectively measured rice areas may be accurate, the between farms variance can be reduced considerably with concomitant use of interview area.

There is complete lack of information on non-sampling errors in the statistics of other agricultural variables.

VI. Suggestions for Future Research

With the introduction of modern varieties which ushered the green revolution in Asia, and of complex cropping systems involving different crops on the same plot of land, agriculture in the Philippines is becoming so complicated that planting and harvesting go on in overlapping patterns all year round. This has and will continually cause non-sampling error problems to become worse. For instance, a rice farmer planting in small parcels at two-week intervals so that his family labor will be self-sufficient will be hard pressed in trying to remember how much has been planted and harvested in a given period. A farmer with rice, corn, peanut and mungobean may not be able to tell nor care to know the area devoted to the single crops, the corn-peanut combination, etc.

This agricultural transformation may eventually necessitate a change from the present series of surveys to a continuous survey operation throughout the year in order to be able to account for all agricultural activities and minimize non-sampling error especially coverage error, telescoping, and other response errors. We may have to rely more on crop-cutting and actual area measurement not only with rice but especially with other crops in order to keep measurement and response errors under control. Likewise, the increase in the number of large export crops plantations and integrated livestock and poultry operations alongside backyards and small farms may worsen the problem of keeping up-to-date accurate frames and may eventually require the use of multiple frame schemes.

In our view, intensified research on non-sampling errors is a pre-requisite to really improving the quality of our official statistics. We suggest that the following topics receive high priority.

(a) Crop-cutting and area measurement experiments in corn, legumes and other cash crops and estimation of cuts, parcels, farms and barangay bias and variance. Double sampling as a means to improve accuracy.

(b) Use of panel or master sample of households to monitor backyard production and area of minor crops and livestock and poultry products, with particular attention to the contributions from non-farm households.

(c) Maintenance of accurate frames. We have reservations about the use of remotely-sensed and aerial photos in favor of the farmer; we may explore rotation sampling of primary sampling units as a means to correct and update frames at the barangay level, and the use of multiple frames especially with export crops, livestock and poultry.

(d) Diary or farm record keeping as a means to check on the sampling error of statistics on utilization of farm labor, credit, chemicals, fertilizers and other inputs.

(e) Studies on memory and other response errors in interview surveys. A very recent study in UPLB utilized IAS data from matched farms over a number of years with some success.[17] The same study pointed out the limitations in the use of data collected for a different purpose; hence there is need for more structured experiments which will allow estimation of respondent and interviewer bias and variance in the manner proposed, for example, by Hansen, **et. al.**[18]

The resource requirements of these studies are of the scale that only BAECON and other agricultural agencies with nationwide field networks can do them. At the same time, some technical capability in formulating and analyzing the results of such studies is avaibale in a few acdemic and research institutions. A common goal is served and attained faster if closer cooperation between the agencies of the statistical system and the academic/research centers is sustained. We close with a happy note, that such collaboration now exists between BAECON and UPLB, and we hope to see more of this in the statistical community.

---

[17] Martinez, B. F. 1978. A Study of Response Errors in the Integrated Agricultural Surveys. M. S. Thesis, UPLB.

[18] Hansen, M. H., W. N. Hurvitz and M. A. Bershad. 1961. Measurement Errors in Censuses and Surveys. Bull. Intern. Statist. Institute, pp. 359-374.