PN-AAN-575
ISN 31761

THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Working Paper No. 60

PROBLEMS AND SOLUTIONS IN THE ANALYSIS OF SURVEY DATA: A PHILIPPINE CASE STUDY

by

Pilar C. Lim
The International Rice Research Institute
Los Baños, Laguna

1983

The Consequences of Small Rice Farm Mechanization Project is supported by the United States Agency for International Development under Contract tac-1466 and Grant No. 931-1026.01 and is being implemented by the International Rice Research Institute and the Agricultural Development Council, Inc.

PROBLEMS AND SOLUTIONS IN THE ANALYSIS OF SURVEY DATA: A PHILIPPINE CASE STUDY*

by

Pilar C. Lim**

INTRODUCTION

Scientists often use the process of inductive reasoning to determine the degree to which a specific finding can be generalized to a larger population. In the biological and physical sciences, this process most often takes the form of replicated experiments conducted under controlled conditions to isolate the effect of a single or a limited number of variables on the level or occurrence of a particular event.

Economists and other social scientists normally do not have the opportunity to carry out research under conditions where variability can be confined to a limited number of variables. The partial solution to this problem has been use of the cross sectional or time series survey or a combination of the two. The objective of a statistically sound survey is to ensure sufficient variability in the data of interest combined with a sample of sufficient size to permit comparisons in means, variances, etc. The procedure most commonly employed by IRRI and many other institutions carrying out investigations in rural areas is the survey where a sampling design is used to obtain a sample that is representative of the population of interest. A crucial assumption in these surveys is the independent nature of sample observations obtained using simple random sampling. Variations on the simple random sampling design are area sampling, stratified sampling and multistage sampling combinations.

The underlying assumption of independence in sample elements has been so widely accepted that we seldom question the results from surveys on these grounds. Though typically assumed, independence is seldom realized in the procedures of actual survey work. In addition, standard statistical methods have been developed on the assumption of simple random sampling. Thus the conventional statistical tests do not provide a basis for evaluating the assumption of independence when a design other than simple random sampling is used.

---

* An earlier version of this paper was presented at the Third National Convention on Statistics, December 13-14, 1982, Philippine International Convention Center, Manila. The author wishes to acknowledge the helpful advice of Dr. Isidoro P. David.

** Senior Research Assistant, International Rice Research Institute.

The present paper attempts to create awareness of the relationship between sampling design and inference, using data from the Farm Mechanization Consequences Survey. Section 2 presents the features of the design used in this survey together with a description of practical constraints and problems, the choices available, and the strategies adopted. Section 3 deals with the different procedures used to estimate certain parameters of interest.

THE FARM MECHANIZATION CONSEQUENCES SURVEY

Purpose

The present paper is concerned with the survey component of the Farm Mechanization Consequences Project, using information from the Philippine site as an example.

The project is a cross-country study involving the Philippines, Indonesia and Thailand. Its primary objective is to measure the effect of small rice farm mechanization on production, income and rural employment. Data gathering consists of two parts: 1) a series of cross-sectional farm level surveys and, 2) complementary record-keeping for selected farms from the main survey, both terminating in two crop years.

Sampling Design

The study employed a modified "multistage" stratified sample because simple random sampling of all farms in the target area would not have included an acceptable number of observations for each level of mechanization: 1) animal, 2) 2-wheel and, 3) 4-wheel tractor.

Two municipalities in the province of Nueva Ecija, Cabanatuan (78 villages) and Guimba (65 villages), were purposively selected using the following criteria: (a) the type and extent of available water control, b) the degree of mechanization used in land preparation and (c) accessibility. In each district, only those villages which were primarily agricultural, based on the number of farm households, were considered: Cabanatuan (49 villages), Guimba (63 villages). The villages in each district were then grouped using unpublished data from the Bureau of Agricultural Economics (BAEcon), Census of Agriculture, 1975, as follows:

1. rainfed, low level of mechanization
2. rainfed, high level of mechanization
3. irrigated, low level of mechanization
4. irrigated, high level of mechanization

Water control was based on the number of hectares of lowland irrigated rice. The indicator for mechanization was the number of tractors/power tillers found in each village. The average number of tractors/power

tillers for all villages was 5 and this is our cut-off point in determining a high and low level of mechanization. Thus, 5 and over is regarded as a "high" level mechanization, while 50 and under, is a "low" level of mechanization. Table 1 shows the distribution of predominantly agricultural villages in Cabanatuan and Guimba. The original intent was to draw one village for each group from each district so that the two districts would each have two irrigated and two rainfed villages in the sample. The lone village in the rainfed high mechanization category was not selected however because it fell in another category. Instead, the village in the rainfed-low mechanization category containing the greatest number of tractors was used, resulting in two villages being drawn from the rainfed-low level mechanization category (see Table 1). A total of eight villages were finally selected.

In early 1979 a complete census of households in the eight villages was conducted to form the list frame used in the selection of sample farm households. The Consequences household census also revealed another discrepancy in the BAECON (1975) data, which is illustrated in Table 2.

The household census of the eight villages covered 1676 households grouped as follows:

Farmers	918
Field labor	231
Non-field	405
Others[1]	122
	1676

The population of interest was the rice farming households.[2] The 918 farm households were pooled and subsequently partitioned based on the type of irrigation and power used for primary tillage during the 1978 wet season. The following strata emerged:

1. rainfed-animal power
2. rainfed-2-wheel tractor
3. rainfed-4-wheel tractor
4. irrigated one cropping season-animal
5. irrigated one cropping season 2-wheel tractor
6. irrigated one cropping season 4-wheel tractor

---

[1] This group consisted of farmers whose land was located outside the physical boundaries of the village.

[2] For a household to qualify as a rice farming household, it should meet the following requirements:

1) grow at least 1000 (0.1 ha.) square meters of rice.
2) made the customary decisions regarding rice production, and
3) contributed some labor to producing rice on the parcel.

7. irrigated 2 or more cropping seasons-animal
8. irrigated 2 or more cropping seasons 2-wheel tractor
9. irrigated 2 or more cropping seasons 4-wheel tractor

The sampling procedures are illustrated in Figure 1. Field labor households were placed in a separate group, called the landless labor category, making a total of 10 different stratification cells.

In classifying the rice farm households, the stratification unit used was the parcel.[3] Parcels located outside the sample villages and parcels or farm holdings of more than ten hectares were excluded. In the case of farmers with more than one parcel, the parcel with the largest area planted to rice was used. If the largest parcel was located outside a sample village, the largest among parcels operated within the village was chosen to characterize the total farm holding. In the event 2 or more parcels were of equal size, that parcel coming first in the list was chosen.

Rice farm households and field labor households were then grouped into the stratification cells shown in Table 3. The 2- and 4-wheel tractor owning categories were not included in the population, resulting in a reduction in the population from 918 to 893 (see Table 3). The sample size to be drawn from each stratum was arbitrarily set at 35.

Sample size for each stratum were slightly greater than 35 to allow for replacement in case of dropouts. Sixty samples were drawn from the landless labor population, with the last 10 serving as replacements. In the case of strata with census populations less than 35, a complete enumeration was made for the stratum.

The survey for the 1979 wet season was conducted in two rounds. Table 4 is the resulting sample distribution at the end of the first round.

Initial returns from the first round revealed that shifts in strata had taken place and some households were no longer members of the stratum being sampled. Also, some households had either transferred to another village or had changed occupation from farmer to non-farmer. Adjustments were made as follows:

1. A household belonging to a different stratum was checked to determine if the change was permanent. If it was permanent, the household was dropped from the sample. If the change was temporary, it was retained.

---

[3] "A parcel is defined as a contiguous piece of land, farmed by the same household, all planted to the same crop or mixture of crops, produced under the same technology, and subject to the same general degree of water control." Consequences Workshop Report, Sept. 11-13, 1978.

2. Households which changed residence or occupation were simply dropped.

Tables 5 to 7 illustrate the reduction in sample size for different strata over three seasons resulting from non-response and changes in residence and occupation.

Tabulation of the survey returns for the 1979 wet season by level of water control and mechanization reveal a gross shift from the original classification (as seen in Table 8) compared with Table 5.

Post Survey Procedures

Since the above partitioning was considered inadequate, a post-survey repartitioning was implemented before analyzing the data. The following strata were developed:

1. rainfed-nonmechanized
2. rainfed-particularly mechanized
3. rainfed-fully mechanized
4. pump irrigated-nonmechanized
5. pump irrigated-partially mechanized
6. pump irrigated-fully mechanized
7. gravity irrigated-nonmechanized
8. gravity irrigated-partially mechanized
9. gravity irrigated-fully mechanized

The criteria used for partitioning were:

1. Irrigation status was based on water control representing the largest percentage of the farm. Hence a farm containing two parcels, one 1.0 ha irrigated and the other 0.5 ha rainfed, would be classified as irrigated. Farms having equal areas of type were classified using the status of highest level of irrigation.

2. Mechanization was based on the use of machinery for land preparation (primary and secondary tillage) over 2 crop seasons.

   a) Farms which used only draft animals were classified as non-mechanized.

   b) Farms which used machinery on at least one parcel for at least one land preparation activity during one season and also used draft animals on one parcel for at least one land preparation activity during one season were classified as partially mechanized.

   c) Farms using only machinery for land preparation on all parcels in both seasons were considered mechanized.

This repartitioning produced the modified sample matrix shown in Table 9.

Comments

The Consequences survey design uses a unique sampling procedure. Use of the design was justified by its convenience and potential efficacy as a survey tool. The important feature of the design is found in the second stage following selection of the sample villages. Stratification and subsequent sample household selection were performed only once on the composite of households from the eight villages instead of being performed eight times.

A second problem exists, however, in the first stage selection of sample villages where selection of only one village from each stratum in each district prohibits estimation of first stage variances. Estimation procedures to correct for this deficiency in the design are not yet available.[4]

Previous discussion indicates that shifts in the classification of farm households occurred after the 1979 census. Recurrence of this phenomenon is expected, owing to changes in the water control and mechanization stratification characterizing successive crop seasons. The question of whether a better stratification scheme could have been used still remains. At survey time the Consequences census became merely a historical account representing out-of-date stratum sizes.

Since we are dealing with an analytic survey designed to determine the causes and consequences of mechanization from season to season, even a census such as the one used by this project provides only a sample of underlying causality. The "superpopulation viewpoint" might be relevant to the discussion.[5] This concept regards the procedure generating a sample of n units as resulting from first, drawing a large sample of size N from an infinite population which is hypothesized to be the underlying causal system and subsequently drawing a sample of size n < N from the sample of size N. In classical finite population sampling theory, inference is based on a sample outcome of n units and is concerned with the average behavior of "repeated inference" based on "repeated sampling" of n units from a fixed finite population of N units. Since we are not concerned with the impact of mechanization on the finite population of farm households in the eight villages at a given instant in time but rather with a conceptual population of rice farm households, the super-population model seems more appropriate in addressing this issue.

---

[4] Procedures to resolve this difficulty are being developed by Dr. I.P. David.

[5] H.O. Hartley and R. L. Sielken, Jr. A SuperPopulation Viewpoint for Finite Population Sampling. Biometrics. 31 June 1975.

Post-survey attempts to repartition the sample into new levels of water control and mechanization is an example of what often occurs in practice - the partitioning of the population for sample selection differing markedly from the partitioning required for data analysis. The consequence of such an action is to produce cells having one or no observations (see Table 9) making estimation impossible for these combinations. Estimates obtained for other cells will have decreased precision. The analysis from a repartitioned sample must not ignore the original stratification. Failure to match strata with domains of interest while developing the survey design invariably results in post-survey adjustments or compromises in the reliability and significance of the estimates obtained.

ESTIMATION PROCEDURES: WEIGHTED VS. UNWEIGHTED

The estimation procedures employed assume the sample is from an infinite stratified population resembling the superpopulation mentioned previously. In this case the first stage sampling of villages is essentially ignored.

Estimation of Subpopulation Proportions

Being confronted with the possibility of out-of-date stratum sizes, we wish to determine the actual distribution of households in the eight villages. Let N'_{ij} be the actual number of households in the ij^{th} cell. We wish to estimate the subpopulation proportions.

$$P'_{ij} = N'_{ij}/N$$

$$P'_{i.} = N'_{i.}/N$$

$$P'_{.j} = N'_{.j}/N$$

Unweighted Estimates

Table 8 gives the number of sample households actually found in each strata during the 1979 wet season. From these, we obtain unweighted estimates as follows:

$\hat{P}_{11}$ = estimated proportion of rainfed-animal farms

= 97/320 (from Table 8)

For any i and j,

$$\hat{P}_{ij} = \frac{n_{ij}''}{320}$$

where $n_{ij''}$ = number of households belonging to cell (i,j)

An estimate of the proportion of animal farms would be:

$$\hat{p}_{.1'} = 97/164$$

The remaining ratios are computed in a similar fashion. These unweighted estimates are biased. Furthermore, their variances cannot be estimated unbiasedly. The usual unweighted estimate of variance is:

$$\text{var}\ (\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n - 1}$$

The results are shown in Table 10.

Design-Unbiased (weighted) Estimates

To illustrate the computation of these estimates, consider rainfed animal powered farms

Define

N_{ij} = stratum size for ij^{th} cell

$N = \Sigma\Sigma N_{ij}$ = total number of rice farm households

$W_{ij} = N_{ij}/N$

n_{ij} = sample size in ij^{th} cell

Let n_{ij}' be the sample frequency of rainfed-animal farms in the ij^{th} stratum. Then, $\bar{p}_{11}$ is unbiased for p_{11}, the true proportion of rainfed animal farms where $\bar{p}_{11}$ is given by

$$\bar{p}_{11} = \sum_i \sum_j W_{ij} \frac{n_{ij}'}{n_{ij}}$$

The sample frequencies n_{ij}' of rainfed-animal farms for each stratum are shown in Table 11. The stratum sizes and sample sizes from the study are given in Tables 3 and 4. Hence,

$$\bar{p}_{11} = \frac{257}{893}\left(\frac{38}{43}\right) + \frac{82}{893}\left(\frac{23}{36}\right) + \ . \ . \ . \ . + \frac{64}{893}\left(\frac{0}{37}\right).$$

The estimate of the variance of $\bar{p}_{11}$ is given by

$$\text{var}(\bar{p}_{11}) = \Sigma\Sigma W_{ij}^{2} \left(\frac{N_{ij} - n_{ij}}{N_{ij}} \right) \frac{(p_{ij}')(1 - p_{ij}')}{(n_{ij} - 1)}$$

where $p_{ij}' = n_{ij}'/n_{ij}$.

To obtain an estimate of the proportion of rainfed farms, let

$$\bar{p}_{1.} = \sum_{j} \bar{p}_{1j}$$

The estimated variance of $\bar{p}_{1.}$ is obtained similarly by summing the variance estimates for $\bar{p}_{1j}$. The results are shown in Table 12. A quick perusal of Tables 10 and 12 indicates an inference based on the unweighted proportions would be drastically misleading. To demonstrate this, consider the rainfed-animal farms. A 95% confidence interval, calculated using the unweighted procedure, for the true proportion of rainfed animal farms is (0.25, 0.35) whereas the weighted procedure yields (0.35, 0.41). A comparison of the proportions for the other cells indicates similar results The direction of the bias in standard errors seems to be positive.

Estimation of the Subpopulation Means of a Random Variable X

A review of Table 8 indicates two cells or strata with only one observation. For analysis, these strata were collapsed into one group. To validate this exercise, the strata to be combined were selected to be as similar as possible to the characteristic being measured. In this case, the "rainfed" and "irrigated single crop" categories were grouped to form the new category "one crop", assuming the two categories have the same "degree" of irrigation and that the benefits to be gained from separating the two are minimal. What follows is a comparison of the weighted and unweighted estimates for the collapsed strata.

Unweighted Estimates

These are obtained in the usual way (simple random sampling procedures). Considering the one-crop animal category with 108 households, the unweighted mean is calculated as

$$\bar{X}_{OA} = \sum_{K}^{108} \frac{X_{(OA)K}}{108}$$

$$= \frac{\text{sum of values of X for cell (one crop, animal)}}{108}$$

The variance was computed in the usual way. The unweighted estimates for the random variable farm household income are given in Table 13.

Weighted Estimates

Estimation of subpopulation means involves estimation of two quantities. Considering one crop-animal farms, an estimate of the number of one crop-animal farms is first required. Denote this by $\hat{N}^{OA}$.

$\hat{N}^{OA}$ is unbiased for N^{OA} and is given by

$$\hat{N}_{OA} = \sum_{ij}\sum N_{ij} \left(\frac{n_{ij}'}{n_{ij}} \right)$$

where the N_{ij}, n_{ij}' and n_{ij} are defined as before. An estimate of the variance is

$$\text{var}\ (\hat{N}^{OA}) = \sum_{ij}\sum N_{ij}\ (N_{ij} - n_{ij})\ \frac{\hat{p}_{ij}'\ (1 - \hat{p}_{ij}')}{n_{ij} - 1}$$

where $\hat{P}_{ij}' = n_{ij}'/n_{ij}$. The numbers are obtained by multiplying the subpopulation proportions of Table 12 by N = 893. The variances are calculated by multiplying the proportion variances by N^2. Table 14 contains the results.

The second quantity to be estimated is the subpopulation total X^{OA}. Define

$$X_{ijk}' = \begin{cases} X_{ijk} & \text{if } k^{th} \text{ sample farm is one crop-animal} \\ 0 & \text{otherwise} \end{cases}$$

Then

$$\bar{X}_{ij}' = \sum_{K}^{n_{ij}} \frac{X_{ijk}'}{n_{ij}}$$

is the mean of X_{ijk}' for cell (i,j). An unbiased estimate of the total for one crop-animal farms is

$$\hat{X}^{OA} = \sum_{ij}\sum N_{ij} \sum_{K}^{n_{ij}} \frac{X_{ijk}'}{n_{ij}}$$

$$= \sum_{ij}\sum N_{ij}\ \bar{X}_{ij}'$$

The variance of $\hat{X}^{OA}$ is given by

$$\text{var}\ (\hat{X}^{OA}) = \sum_{ij}\sum N_{ij}\ (N_{ij} - n_{ij})\ \frac{s_{ij}'^2}{n_{ij}}$$

where

$$S_{ij}'^2 = \text{sample variance of } X_{ijk}' \text{ in cell } (i,\ j)$$

$$= \frac{1}{n_{ij} - 1} \sum_{K}^{n_{ij}} (X_{ijk}' - \bar{X}_{ij}')^2$$

Subpopulation total estimates are given in Table 15 for the random variable "farm household income."

Finally, to estimate μ^{OA}, the mean for one crop-animal farms, use

$$\hat{\mu}^{OA} = \frac{\hat{X}^{OA}}{\hat{N}^{OA}}$$

This estimate is a "combined" ratio estimate and its bias is expected to be small. A consistent first-order estimate of

$$\text{var}\ (\hat{\mu}^{OA}),$$

obtained using a Taylor series expansion, is

$$\text{var}\ (\hat{\mu}^{OA}) = \text{var}\ (\hat{X}^{OA}/\hat{N}^{OA})$$

$$= \text{var}\ (\hat{X}^{OA})\ \left\{\frac{\partial}{\partial \hat{X}^{OA}}\left(\frac{\hat{X}^{OA}}{\hat{N}^{OA}}\right)\right\}^2 + \text{var}\ (\hat{N}^{OA})\ \left\{\frac{\partial}{\partial \hat{N}^{OA}}\left(\frac{\hat{X}^{OA}}{\hat{N}^{OA}}\right)\right\}^2_{X,\ N}$$

$$+ 2\ \text{cov}\ (\hat{X}^{OA},\ \hat{N}^{OA})\ \left\{\frac{\partial}{\partial \hat{X}^{OA}}\left(\frac{\hat{X}^{OA}}{\hat{N}^{OA}}\right)\ \frac{\partial}{\partial \hat{N}^{OA}}\left(\frac{\hat{X}^{OA}}{\hat{N}^{OA}}\right)\right\}^2_{X,\ N}$$

This simplifies to

$$\text{var}\ (\hat{\mu}^{OA}) = \frac{1}{(\hat{N}^{OA})^2}\ \{\text{var}\ (\hat{X}^{OA}) + (\hat{\mu}^{OA})^2\ \text{var}\ (\hat{N}^{OA}) - 2\ \hat{\mu}^{OA}\ \text{cov}\ (\hat{X}^{OA},\ \hat{N}^{OA})\}$$

The quantities var ($\hat{X}^{OA}$) and var ($\hat{N}^{OA}$) have been computed in the preceding tables. The quantity cov($\hat{X}^{OA}$, $\hat{N}^{OA}$)[6] is given by

$$\text{cov}\,(\hat{X}^{OA}, \hat{N}^{OA}) = \Sigma\Sigma\, N_{ij}\,(N_{ij} - n_{ij})\,\frac{\bar{X}_{ij}'\,(1 - p_{ij}')}{n_{ij} - 1}$$

where $p_{ij}' = n_{ij}'/n_{ij}$.

In estimating the mean for one crop farms, a two-step estimating procedure is again used. The total $X^{0}.$ is computed as

$$\hat{X}^{0}. = \hat{X}^{01} + \hat{X}^{02} + \hat{X}^{3}$$

and the total $\hat{N}^{0}.$, an estimate of the total number of one crop farms, is

$$\hat{N}^{0}. = \hat{N}^{01} + \hat{N}^{02} + \hat{N}^{03}$$

Thus,

$$\hat{\mu}^{0}. = \frac{\hat{X}^{0}.}{\hat{N}^{0}.}$$

Its variance is obtained by redefining terms and using the formula for var ($\hat{\mu}^{OA}$). Redefine

$$X_{ijk}' = \begin{cases} X_{ijk} & \text{if } k^{th} \text{ farm in cell } (i,j) \text{ is one crop} \\ 0 & \text{otherwise} \end{cases}$$

n_{ij}' = sample frequency of one crop farms in cell (ij).

$$p_{ij}' = \frac{n_{ij}'}{n_{ij}}$$

The same procedure holds to estimate the means for alternative levels of water control and mechanization. The combined ratio estimates of farm household income means are given in Table 16.

The foregoing discussion indicates that inference based on the unweighted means differs from that based on weighted means. Consider the one crop 4-wheel category. A 95% confidence interval for the true one

---

[6] As derived by Dr. I. P. David.

crop 4-wheel mean using the unweighted procedure is (733,3785) while the estimate based on the weighted procedure is (1098,2549). The bias in standard error appears to be positive for most of the cells. This is one effect of ignoring the initial sampling design.

CONCLUSION

The consequences of simply merging and aggregating sample data without weighting are clear from the discussion presented in the preceding sections. Given these limitations, what might be gained by using weighted or design-unbiased estimation procedures? An important finding is that these procedures yield estimates which possess desirable statistical properties, i.e. unbiasedness or reduced expected bias and minimum variance. The fundamental principles of statistical design and analysis therefore, become applicable. Finally and perhaps more importantly, one learns the art of handling data complexities to produce meaningful results.

Hopefully, this paper will stimulate survey sampling theorists to evolve:

(a) estimation procedures for new designs such as described here; and

(b) alternative sampling plans that are robust and relatively free of assumptions.

Equally important, it reinforces the importance of care and thought in developing sampling designs and statistical treatment of data given the limitations of a particular design.

REFERENCES

Hartley, H. O. and R. L. Sielken, Jr. 1975. "A Superpopulation Viewpoint for Finite Population Sampling". Biometrics. June 31.

International Rice Research Institute. 1978. "The Consequences of Small Rice Farm Mechanization on Production, Incomes and Rural Employment in Selected Countries of Asia". A Workshop Report. Agricultural Engineering Department. Los Banos, Laguna. September 11-13.

Table 1. Distribution of primary agricultural villages in Cabanatuan and Guimba, BAECON Census, 1975.

Water control	Mechanization: Low <5 tractors/ tillers	Mechanization: High >5 tractors/ tillers	Total
	Cabanatuan		
Rainfed	11(2)	1(0)	12(2)
Irrigated	21(1)	16(1)	37(2)
TOTAL --	32(3)	17(1)	49(4)
	Guimba		
Rainfed	44(1)	4(1)	48(2)
Irrigated	8(1)	7(1)	15(2)
TOTAL --	52(2)	11(2)	63(4)

Note: Figures in parentheses are sample villages drawn.

Table 2. Distribution of sample villages.

	BAECON Census	Consequences Census
Cabanatuan		
Rainfed, low mechanized	Kalikid Sur	Kalikid Sur
Rainfed, high mechanized	Lagare	
Irrigated low mechanized	Caalibangbangan	Caalibangbangan
Irrigated, high mechanized	San Isidro	San Isidro, Lagare
Guimba		
Rainfed, low mechanized	Galvan	Galvan
Rainfed, high mechanized	Bunol	San Andres
Irrigated, low mechanized	Narvacan I	Narvacan I
Irrigated, high mechanized	San Andres	Bunol

Table 3. Population of rice farm households and field labor households, Consequences Census, 1979.

	Animal	2-wheel	4-wheel	Total
Rainfed	257	82	54	393
Irrigated 1 crop	25	50	24	99
Irrigated 2 crops	98	239	64	401
TOTAL -	380	371	142	893
Field labor				231
GRAND TOTAL				1124

Table 4. Sample distribution at beginning of wet season, 1979.

	Animal	2-wheel Tractor	4-wheel Tractor	Total
Rainfed	46	37	35	118
Irrigated 1 crop	21	32	19	72
Irrigated 2 crops	42	66	39	147
TOTAL	109	135	93	373

Table 5. Sample distribution at end of wet season 1979.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	44	36	34	114
Irrigated one crop	21	30	19	70
Irrigated two crops	42	65	39	146
Total	107	131	92	330
Landless labor				52
GRAND TOTAL				382

Table 6. Sample distribution at end of dry season 1980.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	43	36	32	111
Irrigated one crop	20	29	18	67
Irrigated two crops	41	64	37	142
Total	104	129	88	320
Landless labor				47
GRAND TOTAL				367

Table 7. Sample distribution at end of wet season 1980.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	43	36	32	111
Irrigated one crop	20	28	18	66
Irrigated two crops	40	64	37	141
Total	103	128	87	318
Landless labor	46			
GRAND TOTAL				364

Table 8. Sample composition after tabulation of results, wet season 1979.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	97	18	13	128
Irrigated single crop	11	1	1	13
Irrigated double crops	56	74	49	79
Total	164	93	63	320

Table 9. Sample distribution after post-survey re-partitioning of farm households.

	Fully mechanized	Partially mechanized	Non mechanized
Rainfed	1	46	78
Pump irrigated	0	15	41
Gravity irrigated	54	79	7

Table 10. Unweighted estimates of subpopulation proportions.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	0.303 (0.026)	0.056 (0.013)	0.041 (0.011)	0.400 (0.027)
Irrigated 1 crop	0.034 (0.010)	0.003 (0.003)	0.003 (0.003)	0.041 (0.011)
Irrigated 2 crops	0.175 0.021	0.231 0.023	0.153 (0.020)	0.559 (0.028)
TOTAL ----	0.512 (0.028)	0.291 (0.025)	0.197 (0.022)	1.0

Note: Figures in parentheses are standard errors.

Table 11. Distribution of rainfed-animal farms in the sample.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	38	23	21	82
Irrigated 1 crop	7	0	2	9
Irrigated 2 crops	6	0	0	6
Total ----	51	23	23	97

Table 12. Design-unbiased (weighted) estimates of sub-subpopulation proportions.

	Animal	2-wheel tractor	4-wheel tractor	Total
Rainfed	0.382 (0.015)	0.051 (0.010)	0.042 (0.011)	0.474 (0.022)
Irrigated 1 crop	0.018 (0.003)	0.002 (0.001)	0.001 (0.001)	0.021 (0.003)
Irrigated 2 crops	0.146 (0.013)	0.240 (0.014)	0.118 (0.012)	0.504 (0.023)
Total	0.546 (0.020)	0.293 (0.018)	0.161 (0.017)	1.0

Note: Figures in parentheses are standard errors.

Table 13. Unweighted estimates of rice farm household income means, 8 villages of Cabanatuan and Guimba, Philippines, wet season 1979.

	Animal	2-wheel	4-wheel	
One crop	889 (323)	1207 (323)	2259 (778)	834 (263)
Two crop	691 (422)	4778 (462)	3657 (637)	3818 (296)
	2163 (258)	4048 (402)	3346 (527)	

Note: Figures in parentheses are standard errors.

Table 14. Design-unbiased estimates of subpopulation numbers.

	Animal	2-wheel	4-wheel	Total
One crop	357 (14)	47 (9)	39 (10)	443 (6)
Two crops	131 (12)	214 (13)	105 (11)	450 (21)
Total	488 (18)	261 (16)	144 (15)	893

Note: Figures in parentheses are standard errors.

Table 15. Design-unbiased estimates of aggregate farm household income, rice farm households in 8 villages of Cabanatuan and Guimba, Philippines, wet season 1979.

	Animal	2-wheel	4-wheel	Total
		(pesos)		
One crop	593199 (91046)	51674 (12520)	71122 (19553)	715995 (90509)
Two crops	343325 (58597)	1033920 (111473)	367292 (56004)	1744540 (115361)
	936523 (107960)	1085600 (112148)	438415 (59232)	

Note: Figures in parentheses are standard errors.

Table 16. Combined ratio estimates of farm household income means, rice farm households in 8 villages of Cabanatuan and Guimba wet season 1979.

	Animal	2-wheel	4-wheel	Total
		(pesos)		
One crop	1662 (248)	1099 (244)	1824 (370)	1616 (203)
Two crops	2621 (354)	4831 (432)	3498 (428)	3877 (255)
	1923 (207)	4144 (378)	3045 (346)	

Note: Figures in parentheses are standard errors.
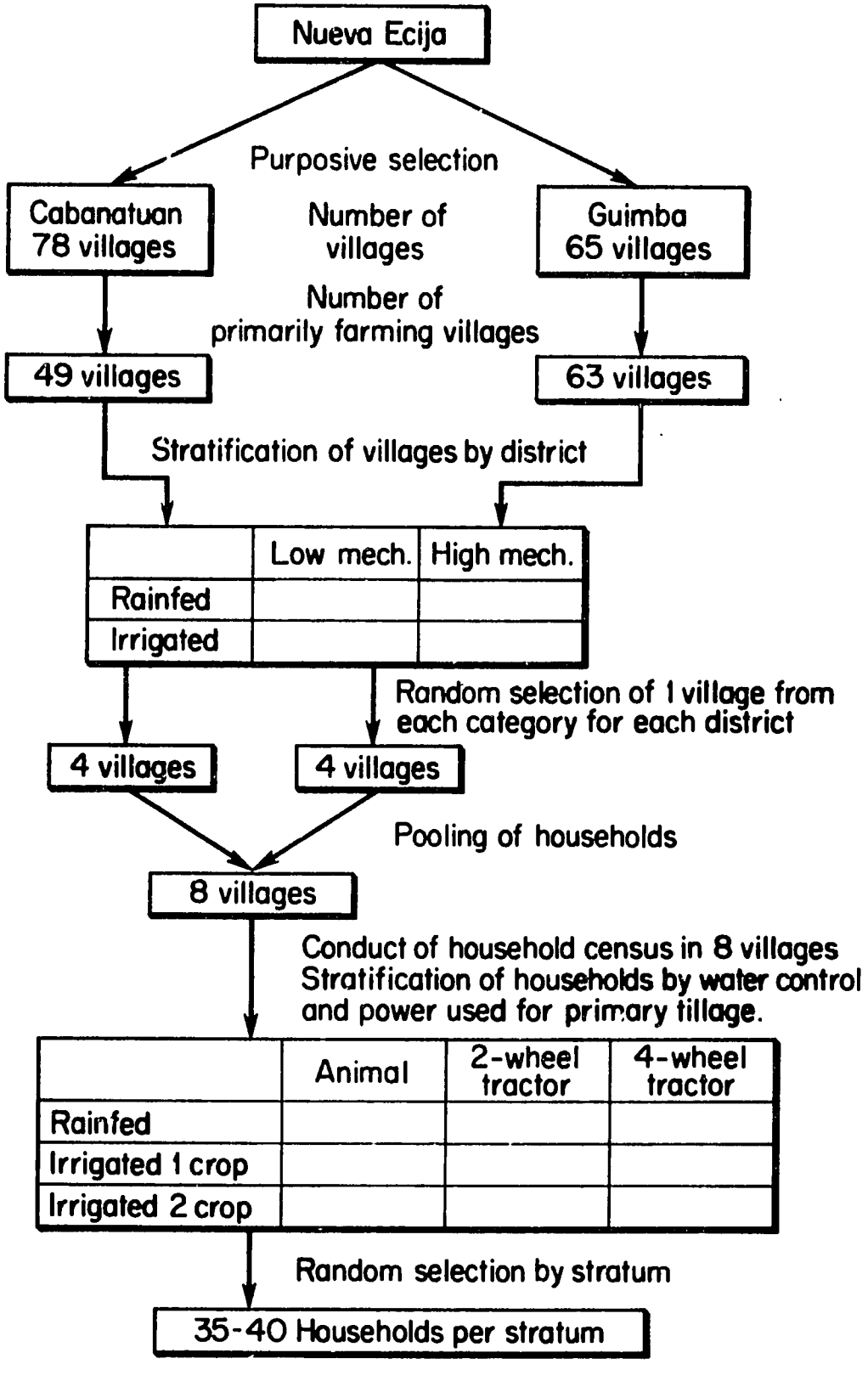
Fig. 1
Farm mechanization consequences sampling procedures.