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# **Analysis of Measurement Errors in Corn Area Estimation in Isabela Province**

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## **ABSTRACT**

The study involves the analysis of measurement errors in the estimation of corn area in six municipalities of Isabela Province, namely: Benito Soliven, Cabagan, Cauayan, Echague, Ilagan, and Naguilian. A survey was conducted to obtain the measures of farm area, specifically the parcel of land of each selected farmer and compared it with the actual measures determined using the Global Positioning System (GPS). Estimates of measurement errors were computed and analyzed for each farmer by barangay, and by municipality according to: (1) total area planted to corn obtained through interview of farmers versus data gathered from PAO and MAO; and (2) area of the parcel based on GPS measure versus area obtained via interview of farmers. Total area planted to corn obtained from the interview of farmers and gathered from PAO and MAO records in Cauayan and Naguilian gave the highest and lowest under-reporting of the area with 3.22 ha and 0.31 ha, respectively. The total area reported by farmers in Benito Soliven showed the highest overestimation, on the average by 0.33 ha and lowest in Cabagan with an average of 0.07 ha. Results indicate big differences in measurement errors observed from the comparison between the total area obtained through interview of farmers and the area gathered from PAO and MAO. Measured parcels in Cauayan were observed to be highly overestimated on the average by 0.37 ha, while measured area in Naguilian yielded the highest under-reported area with an average of 0.67 ha. Chi-Square test of independence was applied to determine the factors that affect the measurement errors in estimation of corn area. Analysis of different factors considered showed that the nature of respondent, type of land, and ethnic group have significant effects on measurement errors. Differences in measurement errors estimated for each municipality were attributed to these factors.

## **I. Introduction**

### **1.1 Background of the Study**

Agriculture is the backbone of Philippine economy contributing about 5.48 percent of the Gross National Product (GNP) and provides employment to about 11.22 million persons (as of 2003) (<http://www.bas.gov.ph>). From the different agricultural crops produced in the country, corn is the second most important crop, which is generally classified into two types: white corn as the main staple for about 12 million Filipinos, and yellow corn, which is used for feeding animals and accounts for 70 percent of the livestock mixed foods (<http://www.da.gov.ph>). Corn and corn products constitute 4.5 percent of the people's diet quantified at about 13 kilogram per year or roughly 36 gram each day (FNRI, DOST 1993). The province of Isabela located at the upper part of the Cagayan Valley is known as one of the major corn producers in the country.

Agricultural farm data are generally collected through surveys. Survey enumerators visit each holding and interview respondents regarding their land area and other characteristics. However, in some instances, data collected from the survey are not accurate. At times area measurements are overestimated or underestimated. In view of this, satellite-based equipment, specifically the Global Positioning System (GPS), may be used to measure the corn area. GPS is a constellation of U.S. Government Satellites providing the most advanced and accurate positioning and navigation service in the world. Equipped with atomic clocks, twenty-four GPS satellites orbit 12,000 miles above the earth transmitting the exact time and their position in space. With the use of GPS, users can determine positions and display it on the units' electronic map using distances measured from different satellites. GPS receivers then collect signals from satellites in view. They display the user's position, velocity, and time, as needed for their marine, terrestrial, or aeronautical applications. Additional data such as distance and bearing may also be obtained (<http://www.gisdevelopment.net/application/agriculture/yield/mi04035.htm>).

GPS has a variety of applications. Hikers and climbers use GPS to determine their current position. They can log that position and by use of a compass return to that spot with a high degree of accuracy. Moreover, drivers can use mapping and navigation software to superimpose their position onto a map and, through the navigational part of the software, determine the routing to another location. Sportspersons can determine their speed and direction as their GPS system measures the time taken to travel between points and utilizes software to make the calculations. GPS also offers cost savings by reducing set up time at the survey site and providing incredible accuracy. Basic survey units, costing thousands of dollars, can offer accuracies down to 1 meter while the more expensive system can provide accuracies to within a centimeter (<http://www.gisdevelopment.net/application/agriculture/yield/mi04035b.htm>).

Considering its capability of providing accurate, timely and reliable measure of land area, GPS was used in this study to measure the area of sample farms in six selected municipalities of Isabela, namely: Benito Soliven, Cabagan, Cauayan, Echague, Ilagan, and Naguilian. These municipalities represent different corn agroecosystems, namely: upland, lowland, and riverine. The study also analyzed the extent of errors between the actual measurements using GPS with the area declared by farmers.

## **1.2 Statement of the Problem**

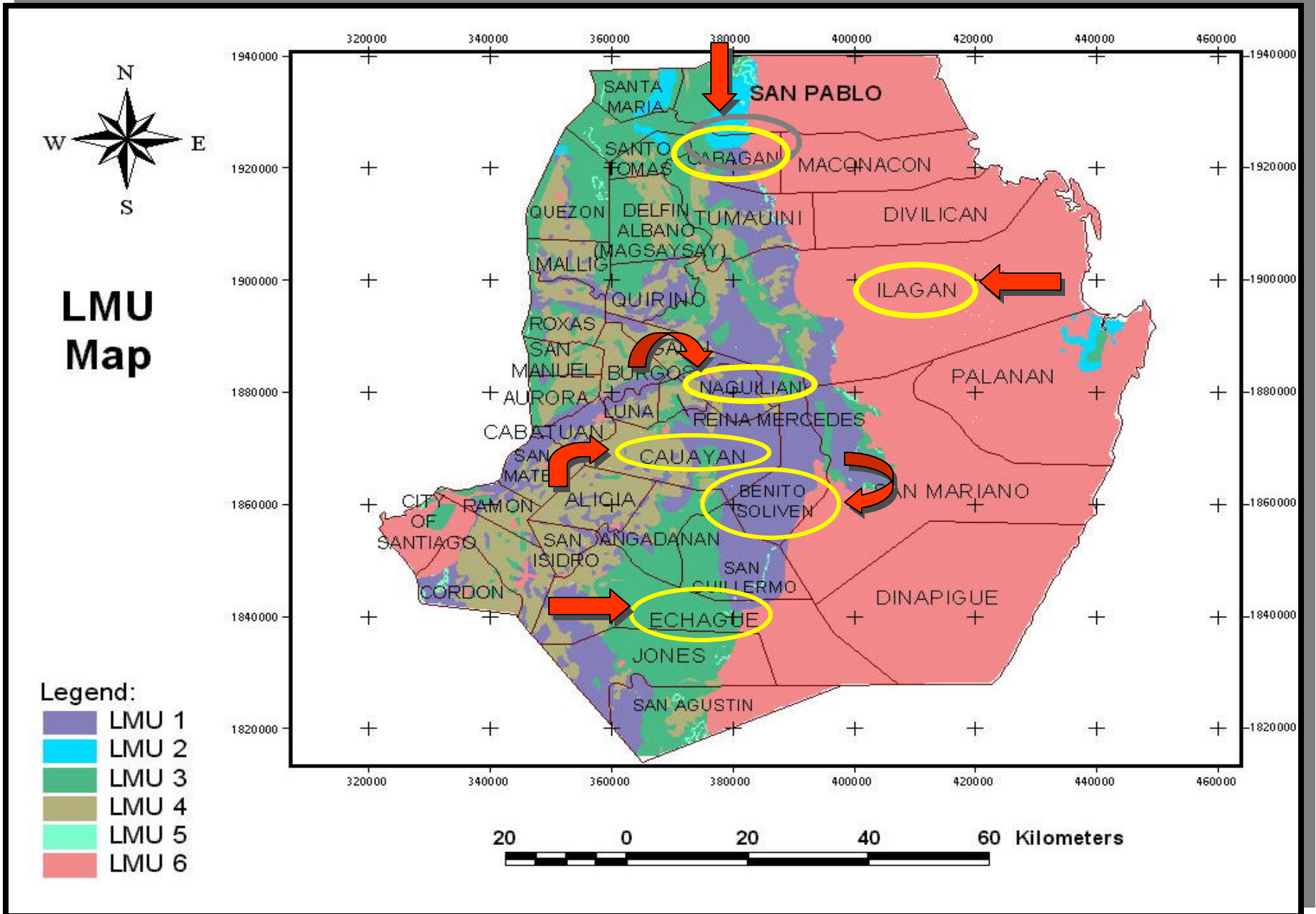
Different statistics concerning agriculture are oftentimes collected through surveys, face-to-face interview with the household head or, in his absence, with any member of the household who in the opinion of the interviewer is knowledgeable about the household farm operations. Other subjective or indirect methods may also be used that are usually based on personal recollection and evaluation. However, in applying these methods, respondents overestimate or underestimate the size of land area. Thus, measurement errors are committed. Moreover, farmers often operate multiple parcels adjacent to each other while others are spread in other barangays. In some situations, farmers plant other crops or convert some parts of the farm to other agricultural enterprise such as piggery or vegetable gardens. Although the farms continue to evolve to include other activities which are agricultural or otherwise, the whole area would still be declared as the total measure of the farm planted to a corn. These often lead to overestimation or underestimation of farm area.

With these deficiencies in the method of data collection and inaccuracies in estimation, forecasts of corn production and agricultural policies such as tax mapping and crop insurances, are affected. Thus, it is only necessary to check them with the data obtained by more objective measurement using GPS. This study was conducted to measure deviations between the area declared by farmers in the survey, and the actual measure obtained using GPS.

## **1.3 Objectives of the Study**

This study aims to analyze the extent of measurement errors committed in the estimation of area planted to corn as declared by farmers when compared to more objective measures obtained using GPS. Specifically, the study (1) analyzed the measurement error in corn area estimates at the farmer, barangay, and municipal level in Isabela province; and (2) determined the factors that may affect the extent of measurement errors.

Area estimation is an important component of production (since production is the product of area and yield). It is also essential in the analysis of impacts of agricultural application (e.g. fertilizer application) and agricultural policies (e.g. tax mapping and determination of premium for crop insurance). This study could give some insights in improving sampling strategy and method of data collection in a census or a survey.



## II. Review of Literature

In the context of production and forecasting of many agricultural crops, different cost-effective sampling survey techniques have been introduced to get timely and reliable information on types of crops grown and their acreages, crop yield and growth that are vital components for many planners, farmers and other concern individual. In 1980, Besa conducted a study comparing the alternative model to the Bureau of Agricultural Economics (BAEcon) RCS-RADDS design that was conducted at Guimbal, Iloilo simultaneously with the RCS-RADDS design and Area Frame Sampling (ASF), which was undertaken in Pangasinan. Based on the result of the alternative model, the BSS number of farm households was found to be a better stratification variable for an agricultural survey design than the BSS relative crop area. The accuracy of the reported number of farms households in the BSS than the reported crop areas, and the stronger correlations of the characteristics considered with the number of farm households than the correlations with the relative crop area, have supported these findings. Thus, stratifying the barangays according to the number of farm household would lead into more internally homogenous grouping of the barangays into strata with respect to the human population, palay and corn harvest areas and number of cattle and carabao.

De Guzman (1987) made a study on the farm parcel approach, which was initially undertaken by the Bureau of Agricultural Statistics (BAS) in 29 provinces in December 1986 as an alternative way of generating agricultural production data. The study elicited the same information asked in the RCS for each individual parcel operated by the farm household. Selected statistics from Cavite, and Pangasinan (palay provinces), Bukidnon and Sultan Kudarat (corn provinces) were presented to provide some initial trends observed. Based on the results in the two palay provinces, FPAS and RCS are much closer in Pangasinan than in Cavite. For single parcels, RCS yielded higher estimates of about 2.9 percent (for area) and 1.8 percent (for production) than FPAS. However, for two parcels, the differences of 12.7 percent (for area) and 14.4 percent (for production) to the FPAS favor; the 3 or more parcel group, the area and production differences were 16.4 and 24.2 percent, respectively. Moreover, the superiority of the FPAS over RCS was greatly observed in the case of Bukidnon and Sultan Kudarat when the differences in area and production exceed a thousand percent for three or more parcels.

In a study by the International Rice Research Institute (IRRI) in 1967, it was found out that rice area obtained through interview was overestimated on the average by 5.6 percent. An overestimation of about 12 and 5 percent (first and last stratum) were observed

on the actual measured area (divided according to size into 3 strata), while 4 percent underestimation was noted in the middle stratum. On the other hand, in a study conducted involving 259 rice farm households, 161 irrigated and 90 non-irrigated (in 21 rice producing provinces), it was found out that the measured area (0.01 ha -0.35 ha) was overestimated by the respondents on both the irrigated and non-irrigated farms. Considering the classification by region, the average overestimation of interview area to measured area for irrigated and non-irrigated systems were 6.5 percent and 4.2 percent, respectively.

In another study conducted from January to June 1982 involving 123 irrigated and 95 non-irrigated farms (BAECON,1982), it was reported that interview area overestimated measured area by 20.2 percent and 13.5 percent for irrigated and non-irrigated farms, respectively. The variable of classification considered was the size of the farm. With respondent as classifying variable, 20.2 percent was the overestimation recorded for irrigated farms with the farmer having the least error, while for non-irrigated farms, the average percentage of overestimation was 13.5 percent. However, compared with the irrigated farms, the farmer has a larger error of 24.3 percent compared to the wife's 5.4 percent.

This study was extended to the time period July-December 1982 and involved 93 irrigated and 69 non-irrigated farms. By size of farm, the average underestimation of the area was 4.2 percent for irrigated farms, and an average overestimation of 4.3 percent for non-irrigated farms. For the variable respondent, the underestimation for irrigated farms was 4.2 percent, while the overestimation for non-irrigated farms at 4.3 percent. When the average areas were compared by respondents, on both irrigated and non-irrigated farms, the wife, son and farmer consistently overestimated the measured area. On the combined data for irrigated and non-irrigated farms, the percentage overestimation of the interview area to measure area was 2.1. In another study (Indab, 1990) which compared interview responses, it was reported that the interview measurements are larger with wife as respondents, for home lot parcels, for owned and rent-free parcels, and parcels with four and five sides.

Several studies were also conducted to compare the area obtained through objective and interview method. It was found out that when the average areas were compared by respondents, the percentage overestimation of interview area to measured area were 17.1 (farmer), 15.9 (wife), 12.7 (son/daughter), 17.9 (other relatives) and 2.4 (other persons) giving an average estimation of 16.4 percent. This indicates that respondents tend to overestimate the measured area. Moreover, combining the data for

year 1982, the interview area overestimated the measured area by 12.9 percent and 12.1 percent for irrigated and non-irrigated farms, respectively, giving an average overestimation by 12.4 (Indab, 1990).

Area estimation in the Philippines is normally obtained through surveys and direct interviews. By contrast, developed countries are using modern satellite-based equipments such as remote sensing, GPS, GIS and related technologies as alternative options to measure the area. In India, remote sensing using aircraft and satellite imageries have been used to assess and monitor crops.

A study was conducted at the Indian Agricultural Statistics Research Institute (ASRI) from 1990-93 to examine the usefulness of spectral data for stratification of crop area based on vegetation indices for improving crop yield estimation surveys. Furthermore, the same study using the GPS was used to identify the exact locations of plots selected for crop-cutting experiment for wheat crops ([http://www.aec.msu.edu/agecon/fs2/Rwanda/mpyisi\\_paper\\_14\\_root\\_tuber\\_crops.pdf](http://www.aec.msu.edu/agecon/fs2/Rwanda/mpyisi_paper_14_root_tuber_crops.pdf)).

### III. Theoretical Framework

#### 3.1 Estimation in Two-Stage Sampling

Stratified two-stage sampling is a popular design in most surveys. In this scheme, the population is divided into non-overlapping subgroups called strata. Each group formed is more homogenous than the whole population and thus, it can increase the precision in estimation. For the first stage, samples (PSU's or also known as first stage units) are drawn from these clusters, and for each sample, secondary sampling units (SSU's) are then obtained. Probability proportional to some measure of size (pps) is applied so that units with the highest measure will also have the highest probability of selection. Under this design, the sample mean per  $i^{\text{th}}$  psu for the  $h^{\text{th}}$  strata and its true variance denoted by  $\bar{y}_{hi}$  and  $V(\bar{y}_{hi})$ , respectively are defined as:

$$\bar{y}_{hi} = \frac{\sum_{i=1}^{n_{hi}} y_{hij}}{n_{hi}} \quad \text{then} \quad V(\bar{y}_{hi}) = \frac{M_{hi} - m_{hi}}{M_{hi}} * \frac{S_{hi}^2}{m_{hi}}$$

where

$$S_{hi}^2 = \frac{1}{m_{hi} - 1} \sum_{j=1}^{M_{hi}} (y_{hij} - \bar{y}_{hi})^2$$

The mean per strata is computed as:  $\bar{Y}_{hi} = \frac{\sum_{j=1}^n Y_{hij}}{M_{hi}}$ , whereas the mean for the whole

population denoted by  $\bar{Y}_h$  is obtain by:  $\bar{Y}_h = \frac{\sum_{i=1}^n P_{hi} \bar{Y}_{hi}}{N}$ . The unbiased estimator of the population mean (the sample mean) and its corresponding measure of precision for the h<sup>th</sup> strata, denoted by  $\bar{Z}_h$  and  $V[\bar{Z}_h]$ , respectively, are defined as:

$$\bar{Z}_h = \frac{\sum_{i=1}^n \bar{Z}_{hi}}{n_h} \quad \text{then} \quad V[\bar{Z}_h] = \frac{s_{hb}^2}{n_h} + \frac{1}{n_h} \sum_{i=1}^{N_h} P_{hi} \left( \frac{M_{hi} - m_{hi}}{M_{hi}} \right) \frac{s_{hi}^2}{m_{hi}}$$

where

$$\bar{Z}_{hi} = \frac{\bar{y}_{hi}}{N_h * P_{hi}}, \quad P_{hi} = \frac{x_i}{\sum x_i}, \quad s_{hi}^2 = \frac{1}{M_{hi} - 1} \sum_{j=1}^n (Y_{hij} - \bar{Y}_{hi})^2,$$

$$s_{hb}^2 = \frac{1}{n_h} \sum_{i=1}^{N_h} P_{hi} (\bar{Y}_{hi} - \bar{Y}_h)^2$$

with

$Y_{hij}$  = RPE of the jth ssu the i<sup>th</sup> psu from the h<sup>th</sup> strata (using SRS)

$M_{hi}$  = total no. of ssu in the i<sup>th</sup> psu from the h<sup>th</sup> strata

$\bar{M}_h$  = average number of ssus per i<sup>th</sup> psu in the hth strata

$m_{hi}$  = sample number of ssus per i<sup>th</sup> psus in the h<sup>th</sup> strata

$N$  = total no. of barangay for the whole population

$n_h$  = sample number of psus in the h<sup>th</sup> strata

$L$  = number of strata

$M_{ho}$  = total no. of ssus in the h<sup>th</sup> strata

$M_o$  = total no. of ssus in the population

$\bar{y}_{hi}$  = Sample mean per psu in the h<sup>th</sup> strata

$\bar{Z}_h$  = Sample mean for each stratum (using PPS)

$\bar{Y}_{hi}$  = Population mean for each strata

$\bar{Y}_h$  = Population mean

$V(\bar{y}_{hi})$  = Variance of the sample mean per psu (using SRS) in the hth stratum

$V(\bar{Z}_h)$  = Variance of the sample mean for each stratum.

### 3.2 Analysis of Measurement Error

In the sample space associated with the survey design, denote the average of the realizations  $\hat{Y}_1, \hat{Y}_2, \dots$  of  $\hat{Y}$  by  $E(\hat{Y})$ . The average error  $b(\hat{Y}) = E(\hat{Y}) - Y$  is 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 the variance of  $\hat{Y}$ . The average of the squares of  $e(\hat{Y})$ , called the mean squared error, is expressible in terms of  $V(\hat{Y})$  and  $b(\hat{Y})$ , i.e.,

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

That is, the total error in a statistic is a sum of two components, i.e. Total error = sampling error + non-sampling error where sampling error is measured by  $V(\hat{Y})$ , 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.

### 3.3 Test of Independence in Contingency Table

The elements of a sample may be categorized according to two or more criteria, and it is then of interest to know whether the classifications are independent. Presumably, the classification may be dependent upon each other. The hypothesis of no contingency (independence) can be tested using summarization called contingency table.

## IV. Methodology

### 4.1 Population and Source of Data

The population under study consists of all the corn farmers in the top six corn producing municipalities of Isabela Province, namely: Benito Soliven, Cabagan, Cauayan, Echague, Ilagan, and Naguilian. Data on the number and list of barangays as well as the listing of corn farmers within each barangay were obtained from the Provincial Agricultural Office (PAO) and Municipal Agricultural Office (MAO) of each of the six municipalities of Isabela.

## 4.2 Sampling Design

A stratified two-stage sampling design was used with municipalities as the strata, barangay as the primary or first sampling unit (psu), and the farmer as the secondary or ultimate sampling unit (ssu). Probability proportional to size (pps) with replacement, with the number of corn farmers residing in each barangay as the measure of size, was applied in the first stage, and simple random sampling (SRS) of farmers on the second stage. Sample farmers with contiguous parcels and with farms located within his/her barangay were the only ones considered in the study.

## 4.3 Sample Size Determination

### 4.3.1 Determining total sample size

According to Murthy (1967), the concept of design effect (DEFF) should be used to simplify the sample size determination. DEFF is the ratio of the variance of the estimate from the procedure, which is stratified two-stage (PPS at first stage and SRS at second) sampling, to the variance of the estimate from a simple random sampling with the same number of observations or samples (Kish, 1965). DEFF is mathematically defined as:

$$DEFF = \frac{Var(P_{st})}{Var(P_{srs})}$$

(1)

where  $Var(P_{st})$  = variance of stratified random sampling, and  $Var(P_{srs})$  = variance of simple random sampling. Thus, sample size can be obtained given the desired DEFF and  $CV(P_{st})$  at a fixed value of  $P$ . Equation (1) can also be written as:

$$\sqrt{DEFF} = \frac{SD(P_{st})/P}{SD(P_{srs})/P} = \frac{CV(P_{st})}{CV(P_{srs})}$$

(2)

where

$SD(P_{st})$  = standard deviation of stratified random sampling

$SD(P_{srs})$  = standard deviation of simple random sampling

$P$  = probability that a certain barangay will be included in the sample.

Equation (2) yields

$$CV(P_{srs}) = \frac{CV(P_{st})}{\sqrt{DEFF}}$$

But

$$CV(P_{srs}) = se(P_{srs})/P \quad (3)$$

Also

$$(4) \quad CV(P_{srs}) \left[ \left( \frac{1}{P} \right) * (N - n) * \left( \frac{PQ}{n} \right) * (N - 1) \right] =$$

$$\text{From (4)} \quad se(P_{srs}) = CV(P_{srs}) * P$$

Given a value of  $se(P_{srs})$ , sample size can be derived from this equation:

$$(5) \quad se(P_{srs}) = \left[ (N - n) * \left( \frac{PQ}{n} \right) * (N - 1) \right]$$

where  $Q = 1 - P$ . Thus, from (5), the final sample size will be:

$$n_o = \left[ \left( \frac{NPQ}{N - 1} \right) * (CV(P_{srs}) * P)^2 \right] + PQ$$

where  $N$  = total number of corn farmers for all the six municipalities;  $P$  = probability that a certain barangay will be included in the sample ( $P = 0.5$ ); and  $Q$  = probability that a certain barangay will not be included in the sample ( $1 - P$ ).

Adjusting for possible non-response, sample size is given by

$$n_{adj} = \frac{n_o}{R}, \quad \text{where } R = \text{expected response rate.}$$

#### 4.3.2 Sample size allocation

The number of samples for each stratum was determined using the proportional allocation scheme, i.e.

$$n_i = n_{adj} ( N_i / N )$$

where

$n_{final}$  = total sample size

$N$  = total number of corn farmers for all the six municipalities

$N_i$  = number of corn farmers per municipality

Table 41 summarizes the values different values for DEFF and  $CV(P_{st})$  considered. A desired DEFF of 50% was chosen to show that the efficiency of using a stratified two-stage

design was twice as that of using a simple random sample. A 10% CV ( $P_{s}$ ) yielded a very small samples ( $n_o = 48.6436$ ). This sample was insufficient to represent the population and to give a precise estimate of the measurement error. Therefore, it was lowered to 5% to increase the efficiency. The resulting sample size was still manageable (in terms of the cost and time allotted).

Table 4 -1. Summary of the sample size determination process.

DEFF	CV( $P_s$ )	CV( $P_{SRS}$ )	$n_o$
1	0.1	0.1	94.65076
	0.05	0.05	326.1347
	0.03	0.03	681.9214
0.7	0.1	0.1195	67.36366
	0.05	0.0598	241.4231
	0.03	0.0359	539.0255
0.65	0.1	0.124	62.73371
	0.05	0.062	226.7559
	0.03	0.0372	512.7637
0.6	0.1	0.1291	58.03486
	0.05	0.0645	211.585
	0.03	0.0387	484.4844
0.55	0.1	0.1348	53.37592
	0.05	0.0674	195.7449
	0.03	0.0405	453.188
<b>0.5</b>	0.1	0.1414	48.64357
	<b>0.05</b>	<b>0.0707</b>	<b>179.7154</b>
	0.03	0.0424	422.998
0.45	0.1	0.1491	43.87074
	0.05	0.0745	163.5046
	0.03	0.0447	389.9579
0.4	0.1	0.1581	39.12571
	0.05	0.0791	146.5739
	0.03	0.0474	355.4906

Out of 7060 total corn farmers for the six municipalities, an initial sample size of 180 was selected. This sample size was further increased to  $n_o = 200$  as the adjustment for non-response was applied. Table 4-2 shows the number of corn farmers for each stratum.

Table 4-2. Summary of the sample size allocation process.

Municipality	Total No. of Corn Farmers ( $N_h$ )	No. of Sample Corn Farmers ( $n_h$ )
Benito Soliven	1204	34
Cabagan	979	28
Cauayan	1094	31
Echague	955	27
Ilagan	1548	44
Naguilian	1280	36
TOTAL	7060	200

Table 4-3 shows the number of sample barangays and their corresponding sample corn farmers.

**Table 4 -3. Number of barangay, sample corn farmers per barangay.**

No.	Municipality	Barangay	No. of Sample Corn Farmer
1	Benito Soliven	District 01	16
		District 02	18
2	Cabagan	Masipi East	10
		Ugad	18
3	Cauayan	Carabatan	18
		Bacareño	
		Carabatan Chica	13
4	Echague	Carulay	13
		Dugayong	14
5	Ilagan	Calamagui 1 <sup>st</sup>	25
		Rugao	19
6	Naguilian	Magsaysay	25
		Minanga	11

#### 4.4 Area Measurement

The sample farmers within each barangay, for each of the six municipalities were interviewed regarding the total area of their farms, the area of each parcel, and the different characteristics of each farmer using a survey questionnaire. Each parcel was measured by walking around the area with the Garmin GPS V at hand. GPS satellites receiver automatically collected signals from its 24 satellites in view. GPS unit determines the current position of the user and the application software stores the information and uses it to make calculations of the area of the parcel. After the tracking of the area, the corresponding waypoints of the parcel created by GPS were then processed using the GPS Trackmaker. In addition, the GIS Arcview 3.2a software was used to obtain the exact area of the parcel measured.

#### 4.5 Analysis of Measurement Error

For each selected farmer the Relative Percent Error (RPE) was computed by comparing the area obtained by actual measurement through GPS and the area declared during the interview of farmers. RPEs were calculated for: (1) GPS versus estimate based on interview of farmer; (2) GPS versus PAO/MAO estimates, as follows:

$$1) RPE_1 = \frac{\text{Interview} - \text{Actual measure using GPS}}{\text{Actual measure using GPS}} \times 100 \%$$

$$2) RPE_2 = \frac{\text{Interview} - \text{Data from PAO/MAO}}{\text{Data from PAO/MAO}} \times 100 \%$$

Values of RPE were averaged, and estimates of errors at the barangay level were determined.

Estimates of measurement error at the barangay level were computed considering pps sampling

design.

#### 4.6 Analysis of Factors Affecting the Measurement Error

From the survey, 14 variables were analyzed to determine the factors that may affect the extent of measurement errors between the area declared by farmers and the actual measure obtained using GPS. These variables include the following:

1. Nature of Respondent- describes the relationship of the alternative respondent to the sample farmer in the list in case the latter is not present. This was categorized as the owner itself, immediate and extended family.
2. Age
3. Sex
4. Civil Status – e.g. single, married, widowed
5. Educational Attainment – e.g. elementary, high school, vocational, college
6. Ethnic Group – e.g. Ilocano, Ibanag, Tagalog, Yoganad
7. Other present occupation
8. Other present sources of income
9. Occupation before farming or previous occupation
10. Number of parcels (by category)
11. Total Area in hectares

12. Number of children or dependents
13. No. of years in farming
14. Tenure Status- e.g. plain, upland, and riverine

Analyses of the relationship among these variables were determined using the Chi-square test of independence.

## V. Results and Discussions

### 5.1 Demographic Properties of Sample Corn Farmers

#### 5.1.1 Nature of Respondent

Majority of the respondents were owner of the farms they till. In the case of absent respondent or farmer (due to some reasons) during the conduct of the survey, an alternate person for that sample farmer was interviewed regarding his or her area. These alternate interviewees were categorized as either an immediate or an extended family member of the sample farmer. A total of 9 and 32 (Table 5-2) of these groups composed the extended and immediate family, respectively. Table 5-1 summarizes the number and percentages of the interviewed respondents for each category and by municipality.

Table 5-1. Frequency distribution of nature of respondents.

Municipality	Nature of Respondents						Total	
	Extended Family		Immediate Family		Farmer/Owner		Number	Percent
	Number	Percent	Number	Percent	Number	Percent		
Benito Soliven	0	0.00	2	5.88	32	94.12	34	17
Cabagan	2	7.14	3	10.71	23	82.14	28	14
Cauayan	0	0.00	2	6.45	29	93.55	31	15.5
Echague	0	0.00	5	18.52	22	81.48	27	13.5
Ilagan	3	6.82	18	40.91	23	52.27	44	22
Naguilian	4	11.11	2	5.56	30	83.33	36	18

**Table 5-2. Total number and percentages of the respondents' classification.**

Nature of Respondent	Total	Percent
Extended Family	9	4.5
Immediate Family	32	16
Farmer/Owner	159	79.5
Total	200	100

### 5.1.2 Gender

Almost half of the respondents, irrespective of gender, belonged to age group 41-60 years old. Results also showed that the highest number of male and female respondents were also in this age group. Sixty-one (or 30.5%) and 40 (or 20%) of the remaining respondents belonged to the age group 20-40 and 61-80, respectively (see Table 5-4).

Table 5-3. Distribution of the 200 respondent farmers according to sex and age (by municipality).

Municipality	Sex	Age Group						Total	
		20-40		41-60		61-80		Total	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	Male	14	56.00	10	40.00	1	4.00	25	12.5
	Female	4	44.44	4	44.44	1	11.11	9	4.5
Cabagan	Male	9	40.91	9	40.91	4	18.18	22	11
	Female	4	66.67	1	16.67	1	16.67	6	3
Cauayan	Male	4	16.00	15	60.00	6	24.00	25	12.5
	Female	1	16.67	4	66.67	1	16.67	6	3
Echague	Male	6	27.27	13	59.09	3	13.64	22	11
	Female	0	0.00	3	60.00	2	40.00	5	2.5
Ilagan	Male	9	33.33	11	40.74	7	25.93	27	13.5
	Female	2	11.76	12	70.59	3	17.65	17	8.5
Naguilian	Male	7	25.00	12	42.86	9	32.14	28	14
	Female	1	12.50	5	62.50	2	25.00	8	4

**Table 5-4. Total number and percentages of the respondents' age group.**

Age Group	Total	Percent
20-40	61	30.5
41-60	99	49.5
61-80	40	20
Total	200	100

### 5.1.3 Civil Status and Number of Children or Dependents

A total of 125 (or 71%) married respondents has a 1-4 children or dependents. Moreover, 27 and 3 percent of these married farmers have children or dependents between 5-8 and 9-12, respectively (Table 5-6). Meanwhile, eight out of 10 single respondents have 0-4 dependents while only two single respondents have 5-9 number of dependents.

Table 5-5. Frequency distribution of farmers' status and number of children or dependents.

Civil Status	Number of Children or dependents						Total	
	1-4		5-8		9-12			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Single	8	80.00	2	20.00	0	0	10	5
Married	125	71.02	47	26.70	4	2.27	176	88
Widowed	10	71.43	4	28.57	0	0	14	7

**Table 5-6. Total number and percentages of the respondents' number of children or dependents.**

Number of Children or Dependents	Total	Percent
1-4	143	71.5
5-8	53	26.5
9-12	4	2
Total	200	100

#### 5.1.4 Ethnic Groups

Ilocano farmers composed the 65% of 200 respondents, while 21.5% and 13.5% of the remainders were Yogads and Ibanags (Table 5-8). Respondents in Benito Soliven, Cauayan, and Naguilian were all Ilocanos. Interviewees in Echague were all Yogads (Table 5-7).

**Table 5-7. Distribution of 200 farmer respondents according to their ethnicity (by municipality).**

Municipality	Ethnic Group						Total	
	Ilocano		Ibanag		Yogad		Number	Percent
	Number	Percent	Number	Percent	Number	Percent		
Benito Soliven	34	100.00	0	0.00	0	0	34	17
Cabagan	10	35.71	18	64.29	0	0	28	14
Cauayan	31	100.00	0	0.00	0	0	31	15.5
Echague	0	0.00	0	0.00	27	100	27	13.5
Iligan	19	43.18	25	56.82	0	0	44	22
Naguilian	36	100.00	0	0.00	0	0	36	18

**Table 5-8. Total number and percentages of the respondents' ethnic group.**

Ethnic Group	Total	Percent
Ilocano	130	65
Ibanag	43	21.5
Yogad	27	13.5
Total	200	100

### 5.1.5 Educational Attainment

Forty-two percent of the 200 total respondents had finished elementary, while 30% and 28 % had completed high school and college, respectively. Four out of 200 farmers (or 2 percent) attained a vocational degree (Table 5-10). Moreover, the number of elementary and high school graduate farmers was both highest on Ilagan, while farmers with college degree were highest on Benito Soliven. Table 5-9 presents the summary of the distribution of the educational attainment of farmers on each municipality.

**Table 5-9. Frequency distribution of farmers' educational attainment, by municipality.**

Municipality	Educational Attainment								Total	
	Elementary		High School		Vocational		College			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	15	44.12	8	23.53	0	0	11	32.35	34	17
Cabagan	11	39.29	7	25.00	0	0	10	35.71	28	14
Cauayan	16	51.61	9	29.03	0	0	6	19.35	31	15.5
Echague	9	33.33	9	33.33	0	0	9	33.33	27	13.5
Ilagan	21	47.73	16	36.36	1	2.27	6	13.64	44	22
Naguilian	12	33.33	11	30.56	3	8.33	10	27.78	36	18

**Table 5-10. Total number and percentages of the respondents' educational attainment.**

Educational Attainment	Total	Percent
Elementary	84	42
High School	60	30
Vocational	4	2
College	52	26
Total	200	100

### Other Occupations

Aside from being a farmer, interviewed respondents also have other jobs. These jobs were categorized into three, namely: (1) none (i.e. pure farmer only); (2) blue collar job (e.g. laborer, carpenter, driver, etc.); and (3) white collar job (e.g. teacher, DA Technician, government employee/clerk, etc.). Sixty-two percent (from Table 5-12) of these interviewees has no other jobs at present. Twenty-five and 13% of these farmers were associated as having blue and white -collar jobs, respectively. Furthermore, none of the interviewed respondents in Ilagan was classified having a white-collar job ( Tables 5-11 and 5-12).

**Table 5-11. Frequency distribution of respondent farmers and their present occupations.**

Municipality	Occupation Other than Farming						Total	
	Pure Farmer		Blue-Collar Job		White Collar-Job			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	20	58.82	5	14.71	9	26.47	34	17
Cabagan	17	60.71	6	21.43	5	17.86	28	14
Cauayan	18	58.06	10	32.26	3	9.68	31	15.5
Echague	14	51.85	9	33.33	4	14.81	27	13.5
Ilagan	33	75.00	11	25.00	0	0.00	44	22
Naguilian	22	61.11	9	25.00	5	13.89	36	18

**Table 5-12. Total number and percentages of the respondents' occupation other than farming.**

Occupation Other than Farming	Total	Percent
Only Farming	124	62
Blue-Collar Job	50	25
White-Collar Job	26	13
Total	200	100

### 5.1.7 Other Sources of Income

Respondents were also asked regarding their other sources of income. From the data gathered, the sources of income were then classified into two groups namely: (i) small-scale business (e.g. piggery, sari-sari store, ice cream business, etc); and (ii) medium-scale business (e.g. furniture making, tobacco farm, etc). It can be noted from Table 5-14 that majority of the farmers' other sources of income was classified as small-scale business, while only 14 % has a medium scale business.

**Table 5-13. Other present sources of income of farmers.**

Municipality	Other Present Sources of Income				Total	
	Small-Scale Business		Medium-Scale Business			
	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	29	85.29	5	14.71	34	17
Cabagan	25	89.29	3	10.71	28	14
Cauayan	26	83.87	5	16.13	31	15.5
Echague	21	77.78	6	22.22	27	13.5
Ilagan	41	93.18	3	6.82	44	22
Naguilian	30	83.33	6	16.67	36	18
Total	172		28		200	100

**Table 5-14. Total and percentages of the respondents' other present sources of income**

Other Present Sources of Income	Total	Percent
Small-Scale Business	172	86
Medium-Scale Business	28	14
Total	200	100

### 5.1.8 Occupation before Farming or Previous Occupation

Similar analysis was also done with 'farmers previous jobs' which were also classified into 'pure farmer since birth', 'blue' and 'white-collar' jobs. It was noted that majority of respondents were ever since farmers. Twenty-two percent of them were categorized as having a blue-collar job and only 13% with white-collar job. The breakdown for these three categories by municipality is summarized in Table 5-15.

**Table 5-15 . Previous occupation of the 200 farmer respondents.**

Municipality	Previous Occupation						Total	
	Pure Farmer		Blue-Collar Job		White-Collar Job		Number	Percent
	Number	Percent	Number	Percent	Number	Percent		
Benito Soliven	28	82.35	4	11.76	2	5.88	34	17
Cabagan	17	60.71	8	28.57	3	10.71	28	14
Cauayan	25	80.65	4	12.90	2	6.45	31	15.5
Echague	12	44.44	7	25.93	8	29.63	27	13.5
Ilagan	26	59.09	13	29.55	5	11.36	44	22
Naguilian	23	63.89	7	19.44	6	16.67	36	18

**Table 5-16. Total and percentages of the respondents' previous occupation.**

Previous Occupation	Total	Percent
Pure Farming	131	65.5
Blue-Collar Job	43	21.5
White-Collar Job	26	13
Total	200	100

### 5.1.9 Number of Parcels and Tenure Status

The highest number of parcels was on the range of 1-2 having a total of 157 or 78.5% followed by 40 (for the range of 3-5 parcels) and 3 (for the range of 6-8 parcels). Results also showed that the average number of parcels of each farmer is two. It can also be observed that for the municipalities of Benito Soliven, Cauayan, and Ilagan, no respondents had owned more than five parcels (Table 5-17). On the other hand, 134 out of 200 farmers (or 67%) owned their farm while only 66 (or 19.7%) are tenant (Tables 5-18 and 5-20).

**Table 5-17. Frequency distribution of the number of parcels, by municipality.**

Municipality	Number of Parcels						Total	
	1-2		3-5		6-8		Number	Percent
	Number	Percent	Number	Percent	Number	Percent		
Benito Soliven	26	76.47	8	23.53	0	0.00	34	17
Cabagan	23	82.14	4	14.29	1	3.57	28	14
Cauayan	27	87.10	4	12.90	0	0.00	31	15.5
Echague	17	62.96	9	33.33	1	3.70	27	13.5
Ilagan	39	88.64	5	11.36	0	0.00	44	22
Naguilian	25	69.44	10	27.78	1	2.78	36	18

**Table 5-18. Total and percentages of the respondents' number of parcels.**

Number of Parcels	Total	Percent
1-2	157	78.5
3-5	40	20
6-8	3	1.5

**Table 5-19. Tenure status of each farmer, by municipality.**

Municipality	Tenure Status				Total	
	Owned		Tenant		Number	Percent
	Number	Percent	Number	Percent		
Benito Soliven	24	70.59	10	29.41	34	17
Cabagan	10	35.71	18	64.29	28	14
Cauayan	26	83.87	5	16.13	31	15.5
Echague	14	51.85	13	48.15	27	13.5
Ilagan	35	79.55	9	20.45	44	22
Naguilian	25	69.44	11	30.56	36	18

**Table 5-20. Total and percentages of the respondents' tenure status.**

Tenure Status	Total	Percent
Owned	134	67
Tenant	66	33
Total	200	100

#### **5.1.10 Total Area Planted To Corn**

The highest total area recorded planted to corn is 14.0 has. in Barangay Dugayong, Echague, whereas the lowest was 0.25 ha. However, the highest frequency of farmers' total area is contained in the interval 0-2 hectares (49%), while the lowest was seen in the interval greater than 4 has. (22%).

**Table 5-21. Distribution of farmers' total area, by municipality.**

Municipality	Total Area Planted to Corn						Total	
	0—2 has.		2—4 has.		greater than 4 has.			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	9	26.47	11	32.35	14	41.18	34	17
Cabagan	15	53.57	7	25.00	6	21.43	28	14
Cauayan	13	41.94	11	35.48	7	22.58	31	15.5
Echague	15	55.56	5	18.52	7	25.93	27	13.5
Ilagan	27	61.36	13	29.55	4	9.09	44	22
Naguilian	19	52.78	11	30.56	6	16.67	36	18

**Table 5-22. Total and percentages of the respondents' total area planted to corn.**

Total Area Planted to Corn (has.)	Total	Percent
0-2	98	49
2-4	58	29
> 4	44	22
Total	200	100

#### **5.1.11 Type of Land**

Majority of corn farms for all six municipalities were located in a plain area. Forty-nine (24.5%) and forty-four (22%) were in a nearby river, and upland area, respectively. This type of land was also based on the location of the municipalities. Benito Soliven and some farms in Ilagan were located in an upland area, while the rest was either situated on a plain or a riverine environment.

**Table 5-23. Distribution of corn area by type of land for each municipality.**

Municipality	Type of Land						Total	
	Plain		Riverine		Upland			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Benito Soliven	0	0.00	0	0.00	34	100.00	34	17
Cabagan	18	64.29	0	0.00	10	35.71	28	14
Cauayan	31	100.00	0	0.00	0	0.00	31	15.5
Echague	27	100.00	0	0.00	0	0.00	27	13.5
Ilagan	20	45.45	19	43.18	5	11.36	44	22
Naguilian	11	30.56	25	69.44	0	0.00	36	18

**Table 5-24. Total and percentages of the corn area by type of land.**

Type of Land	Total	Percent
Plain	107	53.5
Riverine	44	22
Upland	49	24.5
Total	200	100

## 5.2 Area Estimation

### 5.2.1. Total Area Planted to Corn obtained through interview from PAO and MAO

Table 5-25 presents the mean area obtained through interview of farmers, mean area gathered from PAO/MAO, and the mean differences computed (by farmers within barangay). The positives differences obtained in barangay Masipi East of Cabagan (1.60 ha), District 1 and District 2 of Benito Soliven (0.32 ha and 0.30 ha, respectively) and Magsaysay (0.22 ha) indicate an average over-reporting of area by the interviewed respondents. Moreover, it can be noticed that, on the average, majority of the interviewed farmers for other barangays understated their area. Among the municipalities, the two highest underestimation of area planted to corn occurred in Cauayan with 3.22 has. and Echague with 1.30 has. The mean differences obtained for both municipalities are significant at alpha ( $\alpha= 0.05$ ) level of significance. Results summarized in Tables 5-25 through 5-28 indicate the following:

- (1) Farmer's reports of corn farm areas in Cabagan (0.07 ha<sup>rs</sup>) indicate that area declared by farmers in this municipality are more or less accurate. Those in Cauayan (-3.22 ha \*) and Echague (-1.3 ha \*) show a tendency to under-report corn area.
- (2) The correlation between the area obtained through interview of farmers and area gathered from PAO/MAO in Cabagan implies a considerable gains in accuracy, meaning there is less bias or error, and reduced sampling error.
- (3) The high correlation obtained in Cabagan also indicates that the area based on interview is a possible auxiliary variable for stratification.

In addition, measurement error in estimation of total area planted to corn occurred because of the following reasons:

- (1) Farmers tend to report areas to the nearest quarter or third of a hectare (e.g. 0.25, 0.33, 0.5, 0.75, and 1.0)
- (2) Interviewed respondents are not aware of their actual areas and that responses are based on their farm statistics e.g. amounts of seeds they use, planter's fees, harvester's wages, etc.
- (3) Farmers are reluctant to provide the needed information for fear that the survey was for taxation purposes.
- (4) Measurement error can also be attributed to PAO/MAO such as failure to include the area located in another barangay which is also owned by the farmers, and failure to update their records of farmer's total area of corn.

In view of these, the area declared by farmers in the interview, as well as the area recorded in PAO/MAO is not an adequate reference since both failed to give an accurate estimate of the total area planted to corn. One implication of this is evident in forecasting corn production because production is the product of area and yield. Thus, forecasts of corn production may be underestimated or overestimated.

**Table 5-25. Mean and variance of the total area planted to corn (by farmers within barangay) obtained through interview of farmers and the data from PAO/MAO.**

Municipality	Barangay	Mean Area (by Interview)	Mean Area (as per PAO)	Mean Difference of Area Planted to Corn (Int. vs. PAO/MAO)	V(Interview)	V(PAO/MAO)
Benito Soliven	District 1	3.37	3.05	0.32 *	0.4077	0.3942
	District 2	1.99	1.69	0.30 *	0.0775	0.032
Cabagan	Masipi East	3.30	1.70	1.60 *	1.1998	0.0754
	Ugad	1.12	1.33	-0.21 *	0.0272	0.0203
Cauayan	Car Bacareño	1.35	2.36	-1.01 *	0.0191	0.0232
	Car Chica	2.31	3.41	-1.10 *	0.1878	0.1388
Echague	Carulay	0.95	1.62	-0.67 *	0.0321	0.0995
	Dugayong	2.69	3.75	-1.06 *	0.7187	0.9820
Ilagan	Calamagui 1 <sup>st</sup>	1.13	1.32	-0.19 *	0.0128	0.0387
	Rugao	1.72	1.89	-0.17 <sup>ns</sup>	0.1903	0.0986
Naguilian	Magsaysay	1.48	1.26	0.22 *	0.0351	0.0064
	Minanga	0.97	2.18	-1.21 *	0.0455	0.6859

**Table 5-26. Mean and variance of the total area planted to corn (by barangay within municipality) obtained through interview of farmers.**

Municipality	Barangay	Interview	Mean of Interview	Variance of Interview
Benito Soliven	District 1	3.37	2.50	0.0741
	District 2	1.99		
Cabagan	Masipi East	3.30	1.77	0.2374
	Ugad	1.12		

Cauayan	Car Bacareño	1.35	5.60	0.0048
	Car Chica	2.31		
Echague	Carulay	0.95	2.41	0.047
	Dugayong	2.69		
Ilagan	Calamagui 1 <sup>st</sup>	1.13	1.52	0.0082
	Rugao	1.72		
Naguilian	Magsaysay	1.48	1.93	0.0056
	Minanga	0.97		

**Table 5-27. Mean and variance of the total area planted to corn (by barangay within municipality) gathered from PAO/MAO.**

Municipality	Barangay	PAO/MAO	Mean of PAO/MAO	Variance of PAO/MAO
Benito Soliven	District 1	3.05	2.17	0.0693
	District 2	1.69		
Cabagan	Masipi East	1.70	1.70	0.7299
	Ugad	1.33		
Cauayan	Car Bacareño	2.36	8.82	0.0072
	Car Chica	3.41		
Echague	Carulay	1.62	3.71	0.0663
	Dugayong	3.75		
Ilagan	Calamagui 1 <sup>st</sup>	1.32	1.89	0.0056
	Rugao	1.89		
Naguilian	Magsaysay	1.26	2.24	0.0572
	Minanga	2.18		

**Table 5-28. Mean and variance of the total area planted to corn (by barangay within municipality) obtained through interview of farmers and the data from PAO/MAO.**

Municipality	Barangay	Mean Difference of Area Planted to Corn (Int vs. PAO)	Mean Difference	Correlation (Interview vs. PAO/MAO)
Benito Soliven	District 1	0.32 *	0.34 *	0.938
	District 2	0.30 *		
Cabagan	Masipi East	1.60 *	0.07 <sup>ns</sup>	0.709
	Ugad	-0.21 *		
Cauayan	Car Bacareño	-1.01 *	-3.22 *	0.461
	Car Chica	-1.10 *		
Echague	Carulay	-0.67 *	-1.30 *	0.860
	Dugayong	-1.06 *		
Ilagan	Calamagui 1 <sup>st</sup>	-0.19 *	-0.37 *	0.619
	Rugao	-0.17 <sup>ns</sup>		
Naguilian	Magsaysay	0.22 *	-0.31 *	0.79
	Minanga	-1.21 *		
All Combined				0.652

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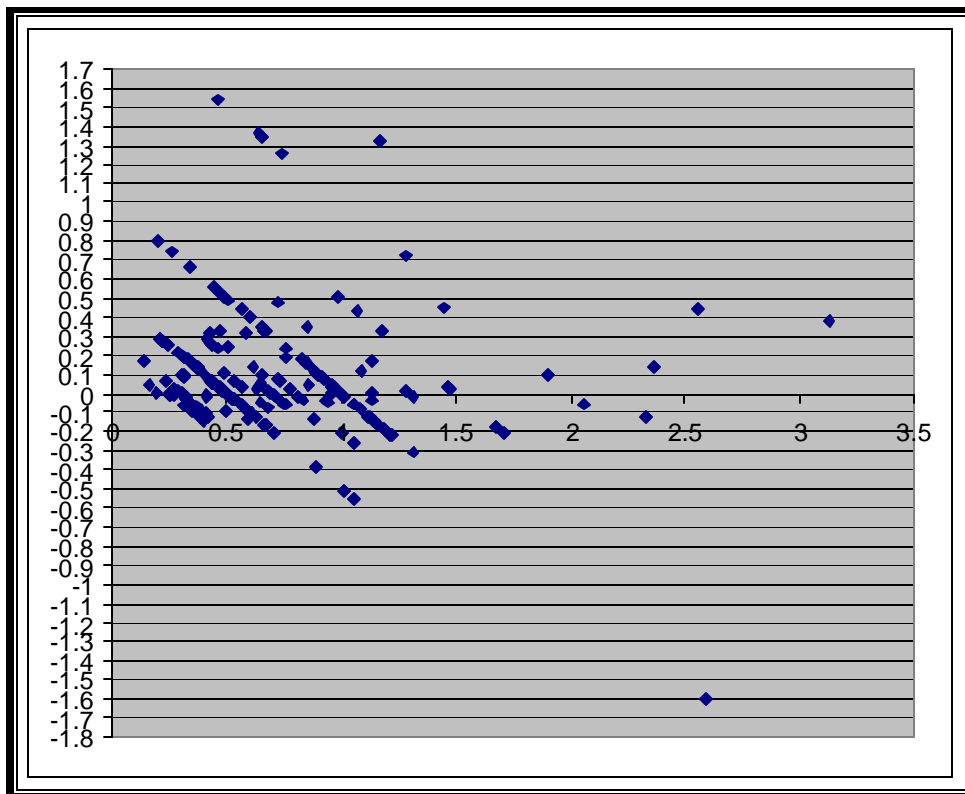
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#### 5.2.1. Comparison of measured area using GPS and via interview of farmers by parcel

Comparison of area obtained through interview versus measured using GPS showed that the highest over-estimation of area is evident in Barangay District 1 of Benito Soliven, on the average, by 0.38 ha; while respondents in District 2, Carulay, and Dugayong under-reported the area by 0.05, 0.01, and 0.004 ha, respectively. The mean difference computed among the municipalities yielded highest in Cauayan which indicate that area was over-reported by the respondents by 0.37 ha. Meanwhile, the highest underestimation of the area

occurred in Naguilian, on the average by 0.67 ha. (Tables 5-29 through 5 -32). Results on the measurement errors imply the following:

1. The area declared by farmers in Cabagan (mean difference 0.02 ha) and Echague (mean difference -0.02 ha) are accurate because of its insignificant differences and high correlations computed for both municipalities.
2. Farmers in Naguilian (-0.67 ha \*) show a significant underestimation of corn area.
3. The high correlation obtained between the measured area using GPS and the interviewed area implies a gain in accuracy (less error or bias and reduced sampling error). It also indicates that the area measured using GPS can be used as an auxiliary information in stratifying these municipalities.



**Figure 1. Graph of measurement error and corn area measured using GPS.**

- (3) Based on Figure 1 above, an inverse relationship exists between the measurement error and the area measured using GPS. This relationship tells us that as the area of corn increases, the measurement error tends to decrease or become smaller. Moreover, the graph shows that most parcels of the corn area which measure 0.13 ha to 1.0 ha have measurement error ranging from -0.3 ha to 0.3 ha. The area declared by

farmers in the interview deviates from the area measured using GPS by about 8.88 percent.

These measurement errors in estimation of corn area are subject of the following:

- (a) Inaccurate approximations or estimation of the farmers and the alternative respondents interviewed.
- (b) Responses of the farmers concerning the area are sometimes based from their land titles, tractor operators' approximation of the area, or either knows or heard about it from somebody like their landlord
- (c) Farmers operate multiple parcels with no accurate measure, thus, approximates of the total area were given instead of the particular parcel asked in the interview. Furthermore, some of the parcels visited have no exact boundaries which lead to conclude that farmers only approximated their area.
- (d) Farmers have no accurate measure of their farms because the payment for land surveying is expensive.

Results imply that the use of more objective method of measuring the area is important to lessen the measurement error in the estimation of corn area.

**Table 5-29. Mean and variance of the area (by parcel) obtained through interview of farmers and measured using GPS, (by farmers within barangay).**

Municipality	Barangay	Mean Area (by Interview)	Mean Area (by GPS)	Mean Difference (Int. vs. GPS)	V(Interview)	V(GPS)
Benito Soliven	District 1	1.37	0.99	0.38 *	0.0376	0.0283
	District 2	0.92	0.97	-0.05 <sup>ns</sup>	0.0089	0.0139
Cabagan	Masipi East	1.09	1.01	0.08 <sup>ns</sup>	0.007	0.064
	Ugad	0.512	0.508	0.004 <sup>ns</sup>	0.0015	0.0020
Cauayan	Car Bacareño	0.81	0.65	0.16 *	0.0045	0.0021
	Car Chica	0.84	0.75	0.09 <sup>ns</sup>	0.0104	0.0120
Echague	Carulay	0.57	0.58	-0.01 <sup>ns</sup>	0.0015	0.0016
	Dugayong	0.710	0.714	-0.004 <sup>ns</sup>	0.0150	0.0160

Ilagan	Calamagui 1 <sup>st</sup>	0.696	0.598	0.098 *	0.005	0.004
	Rugao	0.97	0.90	0.07 <sup>ns</sup>	0.0120	0.006
Naguilian	Magsaysay	0.83	0.67	0.16 *	0.008	0.008
	Minanga	0.43	0.40	0.03 <sup>ns</sup>	0.0016	0.0011

**Table 5-30. Mean and variance of the area (by parcel) obtained through interview of farmers, (by barangay within municipality).**

Municipality	Barangay	Interview	Mean of Interview	Variance (Interview)
Benito Soliven	District 1	1.37	1.11	0.007
	District 2	0.92		
Cabagan	Masipi East	1.09	0.73	0.0015
	Ugad	0.512		
Cauayan	Car Bacareño	0.81	2.51	0.7778
	Car Chica	0.84		
Echague	Carulay	0.57	0.92	0.0011
	Dugayong	0.710		
Ilagan	Calamagui 1 <sup>st</sup>	0.696	0.71	0.0007
	Rugao	0.97		
Naguilian	Magsaysay	0.83	1.03	0.0005
	Minanga	0.43		

**Table 5-31. Mean and variance of the area (by parcel) measured using GPS, (by barangay within municipality)**

Municipality	Barangay	GPS	Mean of GPS	Variance of GPS
Benito Soliven	District 1	0.99	1.06	0.0063
	District 2	0.97		
Cabagan	Masipi East	1.01	0.71	0.0014
	Ugad	0.508		
Cauayan	Car Bacareño	0.65	2.14	0.0005
	Car Chica	0.75		
Echague	Carulay	0.58	0.94	0.0001
	Dugayong	0.714		
Ilagan	Calamagui 1 <sup>st</sup>	0.598	0.80	0.0001
	Rugao	0.90		
Naguilian	Magsaysay	0.67	1.70	0.0002
	Minanga	0.40		

**Table 5-32. Mean and variance of the area obtained through interview of farmers and measured using GPS, (by barangay within municipality)**

Municipality	Barangay	Mean Difference of Area Planted to Corn (Int vs. GPS)	Mean Difference	Correlation (Interview vs. GPS)
Benito Soliven	District 1	0.38 *	0.05 *	0.742
	District 2	-0.05 <sup>ns</sup>		
Cabagan	Masipi East	0.08 <sup>ns</sup>	0.02 ns	0.916
	Ugad	0.004 <sup>ns</sup>		
Cauayan	Car Bacareño	0.16 *	0.37 *	0.732
	Car Chica	0.09 <sup>ns</sup>		
Echague	Carulay	-0.01 <sup>ns</sup>	-0.02 ns	0.977

	Dugayong	-0.004 <sup>ns</sup>		
Ilagan	Calamagui 1 <sup>st</sup>	0.098 <sup>*</sup>	-0.09 <sup>*</sup>	0.639
	Rugao	0.07 <sup>ns</sup>		
Naguilian	Magsaysay	0.16 <sup>*</sup>	-0.67 <sup>*</sup>	0.887
	Minanga	0.03 <sup>ns</sup>		
All Combined				0.796

### 5.2.2 By Nature of Respondents

The highest percentage underestimation among municipalities concerning the different types of respondents was noticed in Cauayan (-9.4 percent) and lowest in Cabagan (-0.79 percent). On the other hand, the highest percentage overestimation was observed in Naguilian and the lowest percentage was in Ilagan (see Table 5-31). These results indicate that measurement error was also due to these alternative respondents. It can be concluded that perhaps some of them has no idea of the accurate measure of the area, thus the owner should not be substituted by any member of the household as respondent in the estimating the farm area.

**Table 5-33a. Comparison between the average areas measured using GPS and determined by interview, for the municipality of Benito Soliven, Cabagan, and Cauayan.**

Respondent	BENITO SOLIVEN					CABAGAN					CAUAYAN				
	Average Area					Average Area					Average Area				
	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE	Interview		GPS Measured		RPE (%)
	ha	n	ha	n		ha	n	ha	n		ha	n	ha	n	
Owner/Farmer	1.06	34	0.91	34	16.31	0.68	23	0.65	23	4.23	0.84	29	0.71	29	27.22
Immediate Family	2.25	2	2.042	2	10.19	1.04	4	0.98	4	5.65	0.5	2	0.547	2	-9.4
Extended Family	-	-	-	-	-	0.25	1	0.252	1	-0.79	-	-	-	-	-

**Table 5-33b. Comparison between the average areas measured using GPS and determined by interview, for the municipality of Echague, Ilagan, and Naguilian.**

Respondent	ECHAGUE					ILAGAN					NAGUILIAN				
	Average Area					Average Area					Average Area				
	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)
	ha	n	ha	n		ha	n	ha	n		ha	n	ha	n	
Owner/Farmer	0.68	22	0.69	22	-1.88	0.77	23	0.75	23	2.45	0.75	30	0.61	30	21.75
Immediate Family	0.49	5	0.47	5	3.74	0.93	18	0.76	18	21.93	0.625	2	0.635	2	-1.497
Extended Family	-	-	-	-	-	0.5	3	0.43	3	15.12	0.45	4	0.34	4	30.72

### 5.2.3 By Type of Land

On the comparison of the average areas measured using GPS and obtained through interview of farmers, according to the type of land (by municipality), it was determined that Benito Soliven, Ilagan (barangay Rugao), and Cabagan (barangay Masipi East) were located in an upland environment (see Table 5-34). However, the RPE computed on barangay Rugao was highest (33.74 percent) that can be accounted for the type of soil present in this barangay. The corn farms visited in Rugao occurs as rolling lands and is crossed by several intermittent streams. The intermittent nature of these streams shows the effect of deforestation of the watershed. The land is also broken by several gullies which further attest to the extreme abuse in the use of land. Moreover, Rugao soils are very susceptible to erosion not only through runoff during heavy rains but also because of its lack of proper vegetative cover.

On the other hand, barangay Calamagui 1st in Ilagan were situated on a riverine area as well as barangay Magsaysay in Naguilian, but estimates of RPE were higher in the latter (see Table 5-27). This is because the corn farms here are flat or nearly so and has a fair drainage. Whenever floods occur, stream bank of erosion results. Moreover, due to its location, farms are oftentimes subjected to inundation when the Cagayan River overflows their banks. Some portions of the area bordering the Cagayan River are usually washed away by floods annually.

Among the plain areas (for all municipalities), it can be observed that the error in Cauayan was the highest. Again, the type of soil present in this municipality may perhaps explain these errors in the measurement. Cauayan

land surface soil was found to be very sticky and plastic when wet. Moreover, swelling and shrinking of the soil occurs alternately in consonance with the weather, and during the rainy season the soil is water-logged because of the lack of natural outlets for the accumulated runoff.

**Table 5-34. Corn agro-environment for each barangay, by municipality.**

No.	Municipality	Barangay	Corn Agroecosystem
1	Benito Soliven	District 1	Upland
		District 2	Upland
2	Cabagan	Masipi East	Upland
		Ugad	Plain
3	Cauayan	Carabatan Bacareño	Plain
		Carabatan Chica	Plain
4	Echague	Carulay	Plain
		Dugayong	Plain
5	Ilagan	Calamagui 1 <sup>st</sup>	Riverine
		Rugao	Upland
6	Naguilian	Magsaysay	Riverine
		Minanga	Riverine

**Table 5-35a. Comparison between the average areas measured using GPS and determined by interview of farmers for municipality of Benito Soliven, Cabagan, and Naguilian.**

Type of Land	BENITO SOLIVEN					CABAGAN					CAUAYAN				
	Average Area					Average Area					Average Area				
	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)
	Ha	n	Ha	n		ha	n	ha	N		ha	n	ha	n	
Plain	-	-	-	-	-	0.512	28	0.508	28	0.66	0.82	31	0.695	31	18.2
Riverine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upland	1.13	34	0.98	34	15.55	1.09	10	1.01	10	7.92					--



**Table 5-36b. Comparison between the average areas measured using GPS and determined by interview of farmers for municipality of Echague, Ilagan, and Naguilian.**

Ethnic Group	ECHAGUE					ILAGAN					NAGUILIAN				
	Average Area					Average Area					Average Area				
	By Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)	Interview		GPS Measured		RPE (%)
	Ha	N	Ha	n		ha	n	ha	N		Ha	n	Ha	n	
Ilocano	-	-	-	-	-	0.94	19	0.9	19	3.36	0.71	36	0.58	36	20.94
Ibanag	-	-	-	-	-	0.696	25	0.597	25	16.43	-	-	-	-	-
Yogad	0.64	27	0.65	27	-	-	-	-	-	-	-	-	-	-	-

### 5.3 ANALYSIS OF FACTORS AFFECTING MEASUREMENT ERROR

The demographic properties of each interviewed farmers presented in the earlier part of this discussion were all considered in this analysis. Different cross tabulations were performed to test which among these factors significantly affects RPE. After performing the Chi-square test of independence, results showed that the nature of respondent, ethnic group and the type of land were dependent on RPE, hence the factors that explained the measurement error. These findings also supported the results of the area estimation on the previous, particularly in the presented estimation in subsections 5.2.3.1 - 5.2.5. To this discuss further, since some of the respondents were the not the owner itself, it can be concluded that perhaps the alternative respondent (either their immediate or extended family) had only approximated or estimated the area, and therefore had lead to the error in the measurement.

Measurement error can also be attributed to its topography. From Tables 5-35a and 5-35b, it can be noticed that RPE was highest for both the upland and riverine farms. As explained earlier, rolling uplands were highly inaccessible because some parts of it were very steep, thus physical movement and communications were also not easy in this kind of terrain. On the other hand, specifically, in Naguilian, the visited farms lie in the active floodplain and have important links to the water dynamics of Cagayan River. Additionally,

some portion of the farm were frequently subjected to floods by the overbank flow of the said river, thus affects the estimation of the area. Stream bank erosion was also identified as one the problems in this type of terrain. The flooding waters are characterized as a major environmental factor that structures the ecosystem and controls functions of these riverine farms.

Lastly, in plain areas, such as Echague and Cauayan, farms in here are very productive but because of their geographical location they were also subjected to yearly floods and overflow of the river, caused by the poor internal and external drainage. Furthermore, since it is the most accessible kind of terrain, cattle raising were often practiced by these farmers as well as vegetation, yet in the survey, the declared total area was the whole land.

For the last factor (ethnic group), it can be concluded that the errors committed were due to their limited background and experience in area estimation. The lack of education background and varying ages can also affect the measurement error; however from the result of the test of independence, it was found out that these two were insignificant on RPE. Table 5-37 presents the summary of the Chi-square test of independence done among the three factors.

**Table 5-37. Summary of the Chi-square test of independence for the different factors**

No.	Demographic Properties	Pearson Chi-Square vs. $\alpha=0.10$
<b>1</b>	<b>Nature of respondent</b>	<b>0.086</b>
2	Gender	0.499
3	Age	0.762
4	Civil Status	0.614
<b>5</b>	<b>Ethnic group</b>	<b>0.012</b>
6	Educational attainment	0.360
7	Other present occupation	0.572
8	Other sources of income	0.870
9	Occupation before farming	0.380
10	Number of parcel	0.831
11	Total area	0.234

12	Tenure status	0.702
<b>13</b>	<b>Type of land</b>	<b>0.098</b>
14	No. of years in farming	0.499
15	No. of children/dependents	0.958

## VI. Summary and Conclusions

The study aimed to analyze the extent of the measurement errors in the estimation of corn area at the farmer, barangay, and municipal levels, and to determine the factors that affect the measurement errors in the estimation of the area by selected farmers. The sample consisted of 200 farmers from the six municipalities of Isabela Province representing different agro-environments. Area measurement using GPS was done by parcel (one parcel per farmer) and was then compared to the area obtained via interview of farmers. Area obtained through interview of farmers was also compared to the data gathered from PAO and MAO. Analysis and computations of measurement errors were made as follows: (1) total area gathered from PAO and MAO versus the total area obtained through interview of farmers; and (2) the area measured using GPS (by parcel) versus the area declared in the interview of farmers (by parcel).

On the **total area planted to corn**, based on the interview of farmers and records of PAO and MAO, showed that the positive mean differences computed in barangay Masipi East of Cabagan (1.60 ha), District 1 and District 2 of Benito Soliven (0.32 ha and 0.30 ha, respectively) and Magsaysay (0.22 ha) indicate a significant over-reporting of the area by the interviewed respondents. Moreover, majority of the interviewed farmers for the remaining barangays understated their area, on the average. Among the municipalities, the two highest underestimation of the area planted to corn occurred in Cauayan (-3.22 ha) and Echague (-1.3 ha). Meanwhile, respondents in Cabagan tended to overestimate the area compared on the records of PAO/MAO. Nevertheless, these results indicate that farmer's reports of corn farm areas in Cabagan are more or less accurate while those in Cauayan and Echague show a significant tendency to under-report corn area.

It can be concluded from these results that the area declared by farmers in the interview, as well as the area recorded in PAO/MAO is not an adequate reference since both failed to give an accurate estimate of the total area planted to corn. Measurement error in estimation of corn area can also affect forecasting of corn production in Isabela.

Moreover, the correlation between the area obtained through interview of farmers and area gathered from PAO/MAO in Cabagan implies a considerable gain in accuracy (less bias or error and reduced sampling error). High correlations also indicate that the area obtained through interview of farmers can be used as an auxiliary variable for stratification of barangays or municipalities. The concomitant use of the area estimate via interviewed area can considerably reduce the between farm variance.

Analysis of measurement error according to the **measured area using GPS and area obtained through interview of farmers** showed that the area declared by farmers in barangay District 1 of Benito Soliven, on the average, over-reported the area by 0.38 ha, while respondents in District 2, Carulay, and Dugayong underreported the area by 0.05, 0.01, and 0.004 ha, respectively. On the other hand, the mean differences computed among municipalities yielded highest in Cauayan which indicate that on the average, respondents overestimated the area by 0.37 ha, whereas respondents in Naguilian, on the average, underestimated the area by 0.67 ha (see Tables 5-29 through 5-32). These results of the measurement error imply the following: (1) the area declared by farmers in Cabagan (mean difference 0.02 ha<sup>ns</sup>) and Echague (mean difference -0.02 ha<sup>ns</sup>) are relatively accurate; (2) farmers in Naguilian show a significant underestimation of the corn area; (3) high correlation obtained on the measured area using GPS and the interviewed area implies a gain in accuracies (meaning less error or bias and reduced sampling error). It also indicates that the area measured using GPS can be used as auxiliary information in stratifying these municipalities; and (4) there is an indirect relationship exists between measurement error and corn area. That is, the larger the farm area, the lower or smaller measurement error. Moreover, most parcels of the corn area which measure 0.13 ha to 1.0 ha have measurement error ranging from -0.3 ha to 0.3 ha. The area declared by farmers in the interview deviates from the area measured using GPS by 8.88 percent. It can be concluded here that the use of more objective method of measuring the area is important to lessen the measurement error in the estimation of corn area.

Analysis of factors showed that: (1) the nature of respondent affects the measurement error in the estimation corn area because some interviewees may often have no idea on the precise measure of the corn area, instead, estimates or approximations were only given; (2) differences in the topography or agro-environment also affects the measurement error in the estimation of corn area; and (3) measurement errors also differ by ethnic group due to their limited knowledge concerning area estimation, educational background, and even their location.

In order to have a more accurate and precise estimates of the measurement error in the estimation of corn area in Isabela, it is recommended that area measurements of parcels and the whole farm be undertaken using other methods (e.g. seeding rate or tractor operators estimates). Furthermore, it is suggested to explore the use of the area obtained through interview of farmers as an auxiliary variable for stratification of barangays or municipalities using double-sampling and employing GPS in the subsample. This is considering the substantial correlation between the measured area using GPS and the area obtained through interview of farmers. Moreover, it is also recommended for future research to consider other factors that may possibly affect the measurement error in the estimation of corn area. Factors such as the farmers' income from farming, taxes imposed on the farm, rent paid by farmers, expenses consumed for the maintenance of the farm (e.g. fertilizers application, payment for tractors, types of seed used by farmers), and other relevant factors.

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