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A Statistical Approach For Developing Food Security Indicators In Selected Regions In The Philippines[1]

Elenita Vega-Castillo[2]

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ABSTRACT

This study aims to develop food security indicators at the household level using various multivariate statistical techniques, such as factor, cluster, and discriminant analyses, as alternative tools for classifying households according to levels of food security. Data from the FNRI's Fourth National Nutrition Surveys were used in this study. A total of sixty-five (65) variables were considered describing the 1,200 households from the National Capital Region, Region IV, and Region VIII with regards to their food consumption, energy and nutrient intake adequacies, and other socio-economic characteristics. These three regions were selected to represent high-, middle-, and low-income regions. Results showed that the three regions, with different economic conditions, have different food security indicators. Households could thus be classified according to level of food security, in ways unique to each region. The derived statistical models revealed high percentages of correct classification – 99.2% both for NCR and Region IV and 97.2% for Region VIII.

For rapid assessment of food security situation in a particular region, methodology developed in this study is recommended thereby affording faster identification of households that need priority for assistance, and a more timely execution of related projects and programs than presently possible.

KEYWORDS: Food security indicators; Factor analysis; Cluster analysis; Discriminant analysis

I. INTRODUCTION

For more than 30 years since the development of the concept, food security has received wide attention in several developing countries due to its immediate impact on the welfare of the population. It has captured a great interest among research institutions, international aid organizations, government agencies and non-government organizations.

Food security historically referred to the overall regional, national or even global food supply and shortfalls in supply compared to requirements. But with increased observation of disparities in the sufficiency of food intake by certain groups, despite overall adequacy of supply, the term has been applied more recently mostly at a local, household or individual level (Foster, 1992). It has received wide attention in several developing countries due to its immediate impact on the welfare of the population. Identification of households that need improvement on the level of food security becomes an important agenda. These household groups are given priority for support and other benefits that the government could offer.

Food security is a very broad concept. It is defined in hundreds of ways. In fact, FAO/WHO (FAO/WHO, 1992) stated that there were close to 200 different definitions of food security. According to them however, the major components of most common

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[2] Sr. Science Research Specialist, Food and Nutrition Research Institute Department of Science and Technology Bicutan, Taguig, Metro Manila

definitions can be summed as "secure access by all people, at all times to sufficient food for an active, healthy life".

As there are numerous definitions of food security, there are likewise many different approaches in developing ways of measuring it. More so, there are varied ways of classifying whether a household is food secure or not.

Pollisco-Carino (Pollisco-Cariño, 1989) arbitrarily used cut-off points in determining whether a household is food secure or not. A household was considered food secure when the energy consumption of all the members is greater than 80% of the Recommended Dietary Allowances (RDA) and the protein consumption is greater than 70% of the RDA. It was also pointed out in this study some of the food security mechanisms such as food sharing, borrowing, employment, selling of goods and/or personal properties/assets, maintaining home gardens, food trading/barter, food storing/preserving, gambling, and asking from parents.

The major objective of this study was to develop indicators of household food security in three selected regions in the Philippines – The National Capital Region (NCR), Southern Tagalog (Region IV), and Eastern Visayas (Region VIII), using various multivariate statistical techniques. The specific objectives were: 1) to determine the factors related to household food security in the three regions; 2) to form clusters of households and determine their food security levels; 3) to derive statistical models that could classify households according to levels of food security; 4) to determine percentage prevalence of households belonging to the lowest level of food security using the derived models, and 5) to determine the income ranges of households with different levels of food security.

2. MATERIALS AND METHODS

The data used in this study were derived from the 1993 Fourth National Nutrition Surveys – these being the latest FNRI Surveys, which have the Food Consumption Phase. A total of 1,200 households comprised the data set, composed of 384 households of which were from the NCR, 528 from Region IV, and 288 from Region VIII. Sixty five (65) variables were considered describing the households with regards to their food consumption, energy and nutrient percent adequacies, and other socio-economic characteristics.

The three regions were selected to represent high, middle, and low-income regions in the country. Selection was based on the 1991, 1994, and 1997 NSO Survey (Phil. Statistical yearbook, 2000) concerning average household incomes. NCR had the highest average household income while Region VIII had the lowest for the three survey periods. Region IV which represented the middle-income region was arbitrarily chosen.

Various multivariate statistical analyses were employed in this study. First is the *Factor Analysis*. It was used in the determination of factors related to household food security, in checking the appropriateness/aptness of the variables for food security study, and as aid in the reduction of variables. Those variables with factor loadings of < 0.4 were dropped from the data set. These variables did not highly correlate with the factors identified and thus, not were included for further analyses.

The next analysis used was *Cluster Analysis*. It was used in this study in grouping of households which were eventually labeled as first, second, and third level food secure

households based on the results of trend examination of variables found significant in Analysis of Variance (ANOVA) and X^2-Test. The resulting clusters were considered in this study as the "natural grouping" or the "correct" grouping of the households, which were later compared with the household classification derived using discriminant analysis.

The last analysis used was the *Discriminant Analysis*. It was used in the selection of discriminating variables, in derivation of statistical models and, in classifying of households into first, second, and third food security levels based on the derived models. To test the efficiency of the derived models, the sample households were re-classified based on their discriminant scores, and were compared with that derived from cluster analysis.

After classifying them, determination of percentage prevalence of those belonging to the lowest level, (i.e., 3rd level) as well as the income ranges of households with different levels of food security followed.

The procedures described were performed separately for the three regions under study. This was in order to develop indicators unique in each region, capturing their inherent characteristics. These indicators could be used in their respective regional programs/projects, in targeting households that need priority assistance and for proper budget allocation in the region.

However, when comparing the prevalence of households belonging to the third level as well as in comparing total household income ranges for the three regions, data were combined and collectively analyzed using similar procedure in order to have valid comparative results.

To facilitate all statistical analyses employed in this study, the Statistical Packages for the Social Sciences (SPSS Release 9.05) for Windows was used.

Figure 1 below describes the flow of methods employed in this study:

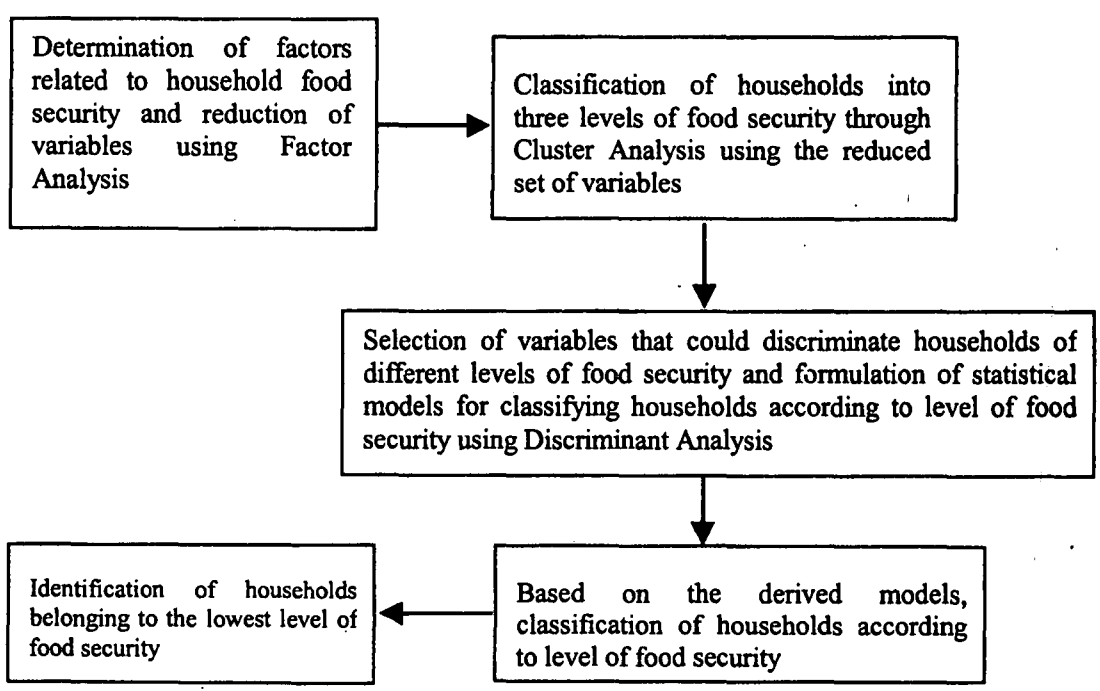

Figure 1. Research framework

3. RESULTS OF THE STUDY

Factor Analysis showed four (4) factors related to food security. These were:

1) Food intake adequacy. It is practically dependent on the household food security condition. A household that is food secure has sufficient supply of food for each member to satisfy his/her food requirements.

2) Socio-economic factor. It correlated highly with variables such as household income, food expenditure, availment of loan, amount of stock, duration of food stock, use of refrigerator, frequency of serving various food items, etc. These variables are important determinants of household food security condition. Households with good economic condition could allot greater amount of money for food, thereby enabling them to have more food stock. These households are also capable to offer their members nutritious food items at a more frequent basis.

3) The third factor identified as related to household food security was household food production. This factor highly correlated with variables such as raising of *palay*, corn, fruits, vegetables, beans and nuts, and raising of domestic animals that could be utilized for food. It also correlated highly with variables such as size of farm and garden, as well as with variables related to household participation in food production activities. These variables affect food security since farming and gardening, raising of animals for food, and participation in food production activities can lead to additional supply of food for the household.

4) The fourth and last factor identified was natural calamities experienced by the household. This factor highly correlates with three variables – CALAMITY (meaning household had continuously experienced calamity for the last 3 years), QUAKE (household was an earthquake victim in 1990), FLOOD (household was a flood victim), and variable TYPHOON (meaning the household became a typhoon victim). These variables are believed to have negative effect on the household food security condition. Calamities tend to decrease the food production capacity of the household. These also adversely affect household economic condition since members have a tendency to absent from their work during time of calamities.

The factors extracted demostrated the appropriateness/aptness of the set of 65 variables considered, for food security study.

In the process of factor extraction, variables that do not load high on the factors were dropped from the data set. These are the variables with factor loadings that were less than 0.4. Ten variables for NCR were dropped 7 for Region IV, and 5 for Region VIII. The reduced sets of variables were then used in the succeeding analysis, which is Cluster analysis.

Cluster analysis formed three household clusters. It also identified outliers, which were dropped from the data set. The three household clusters were labeled based on the results of trend examination of variables found significant in Analysis of Variance (ANOVA) and X^2-Test. Cluster 1 was labeled as first level food secure household, cluster 2 as second level food secure and Household Cluster 3 as third level food secure. First level food secure

households were the most food secure relative to other households in the region while households belonging to the third level are considered food insecure relative to other households in the region.

Labeling of household clusters was based on the following trends:

- Household per capita adequacies for energy, protein, thiamine, retinol, riboflavin, and Vit. C have decreasing trends from Household Cluster (HC) 1 to HC 3;
- Serving of food items like pork, chicken, beef, mango, sugar, cooking oil, and yellow vegetables were found to be most frequent in HC 1 and least in HC 3;
- Rice consumed by households per day has decreasing trend from HCs 1 to 3;
- Greatest volume of rice stock was observed in HC 1 and the least in HC 3;
- Household cluster 1 has the highest income while cluster 3 has the lowest;
- The use of refrigerator was most evident in HC 1 and rarely observed in HC3;
- Largest proportion of households in HC 3 buy cooked food for either lunch or supper, while smallest proportion was observed in HC 1;
- Largest proportion of households in HC 1 had stock of staple food that lasts for a month;
- Greatest proportion of households in cluster 3 served processed fish;

Discriminant analyses performed after identification of household clusters for the three regions provided the following discriminating variables:

For NCR, the discriminating variables were TOTINC (Total Annual Household Income, HHSIZE (Household size), REFSTOR (Use of refrigerator for food storage), RSERTCRP (Raising of rootcrops in homeyard/farm), RSEBNANA (Raising of banana), and GROCERY (Buying food from the Grocery).

For Region IV, we have: TOTINC (Total Annual Household Income), REFSTOR (Use of refrigerator for food storage), MARKET (Buying food from Market), GROCERY (Buying food from Grocery), MANGO (Frequency of serving Mango), and Percent Adequacy for Retinol (RET-ADEQ). For Region VIII, we have again TOTINC (Total Household Income), PORK (Freq. of Serving Pork), and PFISH (Frequency of serving Processed Fish).

Discriminant Analysis provided the following models or classification functions:

For NCR:

$H_1 = 0.146\ HHSIZE + 0.00048\ TOTINC - 22.672\ RSERTCRP + 19.142\ RSEBNANA - 0.101\ GROCERY - 3.025\ REFSTOR - 98.371$

$H_2 = 1.091\ HHSIZE + 0.00015\ TOTINC - 3.494\ RSERTCRP + 4.716\ RSEBNANA - 1.292\ GROCERY + 0.725\ REFSTOR - 18.934$

$H_3 = 1.145\ HHSIZE + 0.00003\ TOTINC - 1.253\ RSERTCRP + 2.578\ RSEBNANA + 1.729\ GROCERY + 0.514\ REFSTOR - 7.032$

For Region IV:

H_1 = 0.00058 TOTINC + 0.0869 RET-ADEQ + 0.262 MANGO + 6.481 MARKET – 0.654 GROCERY – 4.518 REFSTOR – 74.671

H_2= 0.00024 TOTINC + 0.422 RET-ADEQ + 1.297 MANGO + 4.54 MARKET + 0.310 GROCERY – 0.072 REFSTOR – 19.158

H_3= 0.000074 TOTINC + 0.207 RET-ADEQ + 1.711 MANGO + 4.264 MARKET + 0.522 GROCERY – 0.135 REFSTOR – 8.663

For Region VIII:

H_1 = 0.00073 TOTINC + 5.908 PORK + 10.972 PFISH – 75.7

H_2= 0.0003 TOTINC + 5.872 PORK + 8.292 PFISH – 24.673

H_3= 0.00012 TOTINC + 6.771 PORK + 7.388 PFISH – 18.179

where H_1, H_2 , H_3 and refers to first, second, and third level food secure households, respectively.

Using these statistical models, discriminant scores were obtained and households were classified into the group with the highest discriminant score. For example, if we want to know the level of food security of Household A, the values for the variables TOTINC, HHSIZE, REFSTOR, RSERTCRP, RSEBNANA, and GROCERY are plugged in the equations, thereby obtaining values for H_1, H2 and H3. Household A is then classified to the group with the highest score. Let's say H2 is the highest score then Household A is second level food secure.

Tables 1 to 3 shows comparison of results of cluster and discriminant analyses for NCR, Region IV, and Region VIII, respectively.

Table 1. Comparison of the Results of Cluster and Discriminant Analyses, NCR

ACTUAL GROUP	NATURAL GROUPING BASED ON CLUSTER ANALYSIS	PREDICTED LEVEL OF FOOD SECURITY BASED ON DISCRIMINANT ANALYSIS		
		FIRST	SECOND	THIRD
First Level	13	13 (100.0%)[1]	0 (0.0%)	0 (0.0%)
Second Level	74	0 (0.0%)	74 (100.08%)	0 (0.0%)
Third Level	296	0 (0.0%)	3 (1.0%)	293 (99.0%)
Total	383	13	77	293

[1]( ) Percent of households in actual group

Table 2. Comparison of the Results of Cluster and Discriminant Analyses, Region IV

ACTUAL GROUP	NATURAL GROUPING BASED ON CLUSTER ANALYSIS	PREDICTED LEVEL OF FOOD SECURITY BASED ON DISCRIMINANT ANALYSIS		
		FIRST	SECOND	THIRD
First Level	21	21 (100.0%)[1]	0 (0.0%)	0 (0.0%)
Second Level	111	0 (0.0%)	109 (98.2%)	2 (1.8%)
Third Level	390	0 (0.0%)	2 (0.5%)	388 (99.5%)
Total	522	21	111	390

[1]( ) Percent of households in actual group

Table 3. Comparison of the Results of Cluster and Discriminant Analyses, Region VIII

ACTUAL GROUP	NATURAL GROUPING BASED ON CLUSTER ANALYSIS	PREDICTED LEVEL OF FOOD SECURITY BASED ON DISCRIMINANT ANALYSIS		
		FIRST	SECOND	THIRD
First Level	22	22 (100.0%)[1]	0 (0.0%)	0 (0.0%)
Second Level	66	1 (1.5%)	62 (93.9%)	3 (4.5%)
Third Level	199	0 (0.0%)	4 (2.0%)	195 (98.0%)
Total	287	23	66	198

[1]( ) Percent of households in actual group

Assuming that cluster analysis results provided the natural groupings or "correct" household classification, results showed high percentages of correct classification: 99.2% for NCR (or 380 out of 383 households were correctly classified, meaning only 3 households out of 383 were misclassified by the derived functions); also 99.2% for Region IV (i.e, 518 out of 522 households were correctly classified (only 4 out of 522).

For Region VIII 97.2% of households were correctly classified (279 out of 287 households) or only 8 households were misclassified.

Table 4 presents the distribution of households by level of food security for the three regions using the derived models:

Table 4. Distribution of Households from the Three Regions by Level of Food Security

LEVEL OF FOOD SECURITY	NCR		REGION IV		REGION VIII	
	Frequency	%	Frequency	%	Frequency	%
First Level	13	3.4	21	4.0	23	8.0
Second Level	77	19.3	111	21.3	66	23.0
Third Level	293	77.3	390	74.7	198	69.0
Total	383	100.0	522	100.0	287	100.0

Note that distributions of households in the three regions were derived separately, thus, grouping was relative to the households in each region. Above results should therefore not be interpreted as NCR having higher percentage of households belonging to the third level (77.3%) as compared to Regions IV (74.7%) and VIII (69.0%). This is because households in each region were separately analyzed. These results are useful at the regional level, that is, in targeting food insecure households in the region or in identifying which among the households in the region, say NCR, should be given priority for assistance.

Valid comparison was achieved by combining all the sampled households in the three regions and performing similar statistical procedures discussed. Table 5 shows comparison of households in the three regions classified into three levels of food security. Comparing all the households in the three regions, highest percentage of food insecure households (Level 3) was found in Region VIII, followed by Region IV, and lowest percentage was found in NCR.

Looking at the mean total household income and 95% Confidence Interval (C.I.) for the means for the three regions (Table 6), it can be inferred that for NCR, households in the first level is within the 95% C.I. of second level food secure households in Region VIII, which means that lower income is required for households in Region VIII to be more food secure than households in NCR. This is possibly because of: a) higher food cost in NCR; b) more exposure of households to various non-food items in NCR, and thus priority on spending was not channeled to purchase of food; c) there is more opportunity for Region VIII households to raise vegetables, fruits, and rootcrops than NCR households (due to space limitation in NCR); d) Region VIII households have more opportunity to produce their own staple food such as rice and corn, and likewise they also have more opportunity to raise animals for food.

Table 5. Distribution of Households by Level of Food Security

LEVEL OF FOOD SECURITY	NCR		REGION IV		REGION VIII	
	FREQ.	%	FREQ.	%	FREQ.	%
First Level	18	4.7	11	2.1	1	0.4
Second Level	116	30.3	95	18.2	34	11.8
Third Level	249	65.0	416	79.7	252	87.8

Table 6. Means and 95% C.I for means of Total Household Income, NCR, Region IV, and Region VIII

Level of Food Security	NCR	Region IV	Region VIII
	95% Confidence Interval		
First Level	P 399,374	238,703	153,217
	354,121 – 444,628	216,631 – 260,775	137,586 – 168,849
Second Level	155,235	103,499	58,774
	146,996 – 163,474	98,642 – 108,356	54,496 – 63,051
Third Level	53,310	30,944	17,587
	50,611 – 56,010	29,214 – 32,674	16,184 – 18,990

4. SUMMARY

Several studies have been conducted to identify indicators of household food security. The importance of knowing these indicators for planning, policymaking, and targeting priority groups that need assistance, leads to continued effort and researches.

Different studies present various methods that provide various results and sets of indicators, found specific to the area of study. Present condition affecting directly or indirectly food security, as well as availability of data or information are considered some important factors that should be looked into when developing strategy for selecting food security indicators.

This study provides an alternative method for determining food security indicators at the household level. Different statistical techniques such as factor analysis, cluster and discriminant analyses were used in the process. Analysis of variance and Chi-square tests were likewise employed.

Factor analysis was the first statistical technique employed. Using the original set of 77 variables, factor analysis enabled the identification of four factors found to have

relationships with household food security. These were – household energy and nutrient intake adequacies, food-buying capacity of the household, factors for increasing food availability, and calamities experienced by the household. Using these four factors as clustering variables, the 1,200 households in the three regions under study (NCR, Regions IV and VIII) were grouped into three clusters, namely food secure, vulnerable, and food insecure. This was made possible through cluster analysis. Results revealed that approximately 4.7% of households in NCR are first level food secure, 2.1% in Region IV, and 0.4% in Region VIII. Second level food secure households were found to have prevalence rate of 30.3%, 18.2%, and 47.7% for NCR, Region IV, and Region VIII, respectively. Food insecure households or those belonging to the lowest level food secure households consisted 65.0% in NCR, 79.7% in Region IV, and 87.8% in Region VIII. These results indicated the presence of serious food security problem in the three regions. This led to conclusion that regardless of economic condition of a region, the issue of food security should be given priority and attention.

Results of discriminant analysis provided different sets of discriminating variables for the three regions that can be used in classifying households by level of food surety. For NCR, total household income, household size, use of refrigerator for food storage, raising of rootcrops and banana in homeyard/farm were found to have discriminating power and were considered important indicators of household food security.

For Region IV, six (6) variables were found to discriminate the households. These were total household income, household per capita adequacy for Retinol, use of refrigerator for food storage, frequency of serving mango, and frequencies of buying food from the market and supermarket/ grocery. For Region VIII, discriminant analysis selected three (3) variables. These were total household income, frequency of serving pork , frequency of serving processed fish.

Differences in the sets of discriminating variables for the three regions indicated that the manners of identifying food secure households also vary. While this study considered economic condition of the three regions as the main possible reason for such differences, other characteristics inherent to each region, in one way or another, contributed to these results.

The derived statistical models can classify households according to level of food security. The models derived for the three regions when applied to the same set of households revealed high percentages of correct classification. For NCR, 99.2% of the households were correctly classified, 99.2% also for Region IV, and 97.2% for Region VIII.

Focusing on the households belonging to the lowest level of food security, the study showed that total household income ranges from P50,611 – P56,010 in NCR, in Region IV income ranges from P29,214 – P 32,674, and P16,184 – P18,990 in Region VIII.

The prevalence of households belonging to the lowest level of food security was found to be highest in Region VIII, with 252 out 287 households or 87.8 %. In Region IV, there were 416 out of 522 households or 79.7 %, while in NCR, 246 out of 383 or 65.0 % were classified as third level food secure households.

With the method presented in this study, determination of food security condition in other regions could easily be undertaken. Households belonging to the lowest level of food security in the regions would be identified and thus, targeting of areas that should be given attention and priority for support would become possible.

5. CONCLUSIONS AND RECOMMENDATIONS

The following are some conclusions and recommendations derived from this study:

1) Identified factors related to household food security provided insights on areas that should be looked into for improving household food security condition.

2) Aside from total household income, other inherent regional differences emerged to have contributed to the differences in the developed food security indicators. It is therefore recommended that a similar study be conducted for other regions in the country.

3) The technique presented herein is an appropriate way for developing tools necessary for quick identification of households that need priority for assistance.

4) To identify the least secure households, conduct of similar study is recommended, focusing on the households belonging to the third level.

5) High percentages of correctly classified households (as reflected from the discriminant analysis results) indicated that FNRI NNS data and various multivariate statistical techniques are very good combinations for developing food security indicators.

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