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Improving Agricultural Sustainability and Livelihoods
in the Central American Hillsides

Sondeo of Resource Management Systems and Practices:

National Sampling Frame for Honduras

Karen Ann Dvorak
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Project Report

25 June 1996

Tegucigalpa, Honduras
Central America

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Contents

Introduction

In 1994, the Centro Internacional de Agricultural Tropical (CIAT) initiated the project "Improving Agricultural Sustainability and Livelihoods in Central American Hillsides" (known as CAHP). One of the primary results expected from the initial phase of the project was a synthesis of existing information on sustainable agriculture for the hillsides of Central America (CIAT 1993, p. 12). The project has experimented with the development of production system typologies for Honduras as an approach to synthesizing and interpreting secondary and primary information at different resolutions, and from a variety of sources, on agriculture and natural resource management (Barreto y Dvorak 1995).

The subject of this report is a set of system typologies, defined using agricultural census data and providing sampling strata for a national survey (*sondeo*) of agricultural resources in Honduras. The objectives in developing the typologies were: (1) to define sub-national strata based on agricultural census data for agricultural land-use, infrastructure and investment in Honduras; and (2) to define a sampling frame for a national, community-level *sondeo* of resource management systems and practices.

The objective of the *sondeo* was to provide, relatively rapidly, consistent data on agricultural production systems, including agronomic and resource management practices, socio-economic features, and information on sources of pressure on those systems, opportunities, and technological change at the community level (Dvorak y Jiménez 1996a).

The national sample consists of 70 communities. In addition, the *sondeo* was conducted in 31 communities around the three CAHP research sites in Honduras (Dvorak et al. 1996, Dvorak y Jiménez 1996b, 1996c). The national sample provides links between (1) the national census data and the *sondeo* information, and (2) between the national data and the site data. The national sample thus provides a context for interpreting the data from the local sites.

Data sources and variables

The Fourth National Agricultural Census in Honduras was conducted in 1993, covering the agricultural year 1 May 1992 to 30 April 1993. Administrative divisions in Honduras in 1993 consisted of 18 *departamentos* made up of 291 *municipios* (Figure 1). The census data made available had been summarized by *departamento*, *municipio*, and by farm-size class within *municipio* (SECPLAN 1994a and 199b). *Municipio* data were selected for the analysis because (1) *municipios* were the smallest spatial units for which the 1993 agricultural census data were available; (2) *municipios* are the common unit of reporting for many Honduras datasets; (3) there were a large number of observations; and (4) although agricultural land-use, infrastructure and investment vary greatly by farm-size class within *municipios*, the patterns of distribution of resources across farm-size classes do not vary greatly between *municipios*.

Figure 1. Departments and municipios, Honduras, 1993

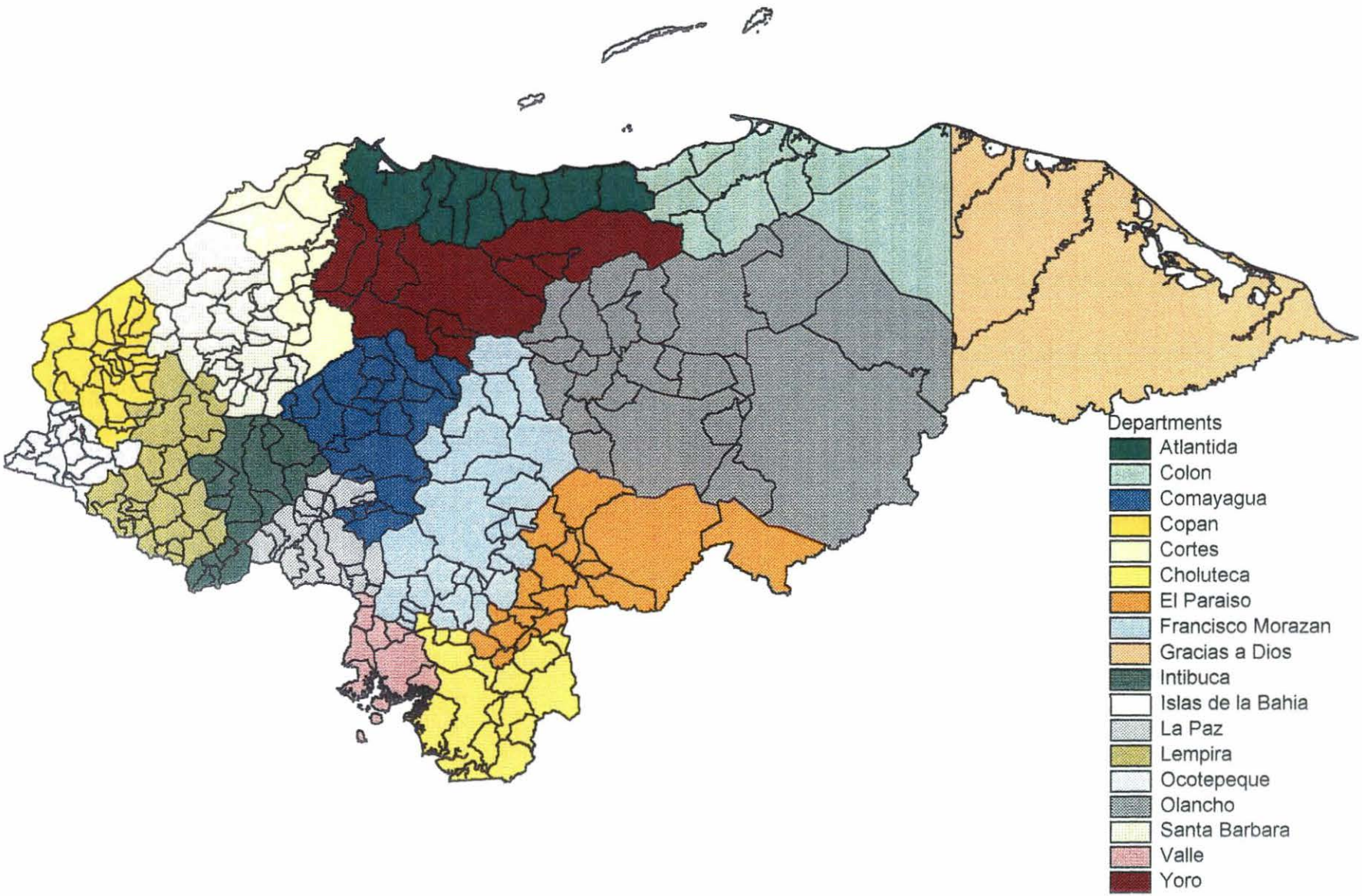
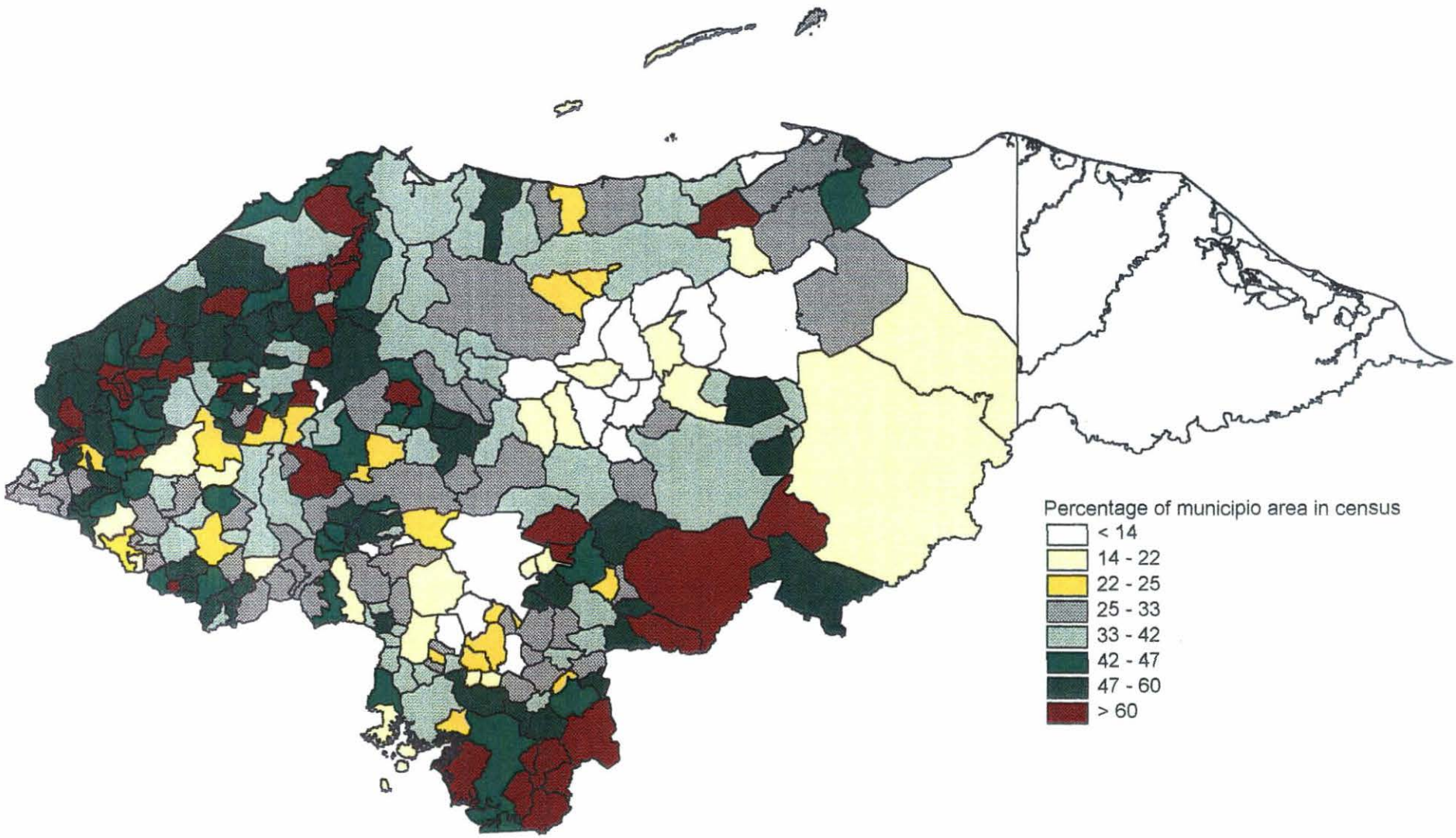


Figure 2. Percentage of total municipio area in agricultural census, Honduras, 1993



The agricultural census in Honduras was reported on the basis of area on farms;[1] i.e., it does not represent total land-use in a *municipio*. The census covered 3,337,080 out of 11,208,754 ha, or about 30% of the total area nationally. The total area of farms censused *(area censada)* was reported for each *municipio*. This variable, converted to percentage area of the *municipio*, was taken to represent the importance of agriculture relative to other land-uses within the *municipio*. Percentage area censused ranged from 2% in the northeast to 80% in some *municipios* in the *departamentos* of Santa Barbara, Cortes and Copan, along the northwest border with Guatemala (Figure 2). In some *municipios* such as Namasigue in Choluteca, percentage area censused was greater than 100%, probably due to reporting errors in the census.

Agricultural land-use within farms was reported in ten categories: annual crops, permanent crops, planted pastures, natural pastures, land in *descanso* (not cultivated during the 1991-1992 agricultural year), forest, land in *guamil* (fallow of more than one year), tanks or lagoons, other agricultural uses, and non-agricultural uses. Three of these variables were selected to represent broad patterns of agricultural land-use and production: area in annual crops, area in permanent crops, and area in planted pastures. These factors were selected after considering: (1) importance to agriculture in Honduras; (2) distinctiveness of the land-use type; (3) quality of the data; and (4) targets for agricultural research.

About 10% of the area censused was reported to be under permanent crops. Both large-scale plantations devoted to the export of permanent crops such as bananas, coffee, pineapple, sugar cane, and African oil palm, and small-holder production of bananas, coffee, and pineapple are important in Honduras, as well as sugar cane in some valleys. Improved pastures were included as an indicator of the importance of ranching. Improved pastures was used rather than unimproved pastures or both, because reporting on area under unimproved pastures is often inconsistent, as is reporting of areas in short fallows, long fallows and forest.[2] Improved pastures constituted about 22% of the area censused nationally; natural pastures, an additional 24%. Annual crops were included because of their importance to small-holders throughout Honduras, and because they were a central focus of the research project. Nevertheless, the data reported on area under annual crops appeared to be residuals of total area less other land uses.[3] Because the purpose of this analysis was to determine patterns based on relative importance of annuals, perennials and pastures across *municipios*, this did not pose problems, but the data should not be interpreted as the absolute area under annual crops within individual *municipios*.

Areas in annuals, perennials, and improved pasture were converted to percentages of area censused for each *municipio*.

Irrigation was included because it represents a high level of investment in agriculture, public or private, and because of its profound influences on the cropping environment and

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[1] SECPLAN (1994a, p. 4) defined a farm *(explotación)* as: "Toda extensión de tierra utilizada total o parcialmente en actividades agrícolas o ganaderas, manejada bajo una adminsitración única, ejercida por una persona natural or jurídica, independientement del título y tipo de tenencia."

[2] P. Jones, personnel communication, February 1996.

[3] H. Barreto, personal communication, March 1996.

choice of technology. Area irrigated was converted to a percentage of area censused for each *municipio.*

Mechanical and animal traction (and, by default, hand tillage) were included because they reflect three distinct levels of private investment in agriculture, and strongly affect choice of agricultural technology. The number of tractors and oxen teams *(yuntas de bueyes)* were calculated per 1000 hectares of area censused.

Digital data for area censused and three land-use variables; i.e., area under annual crops, area under perennial crops and area under improved pasture were provided by SECPLAN (1994a). Barreto (1995) converted the tabular data into ASCII format. The data were then read into SAS for statistical analyses. Irrigated area, number of tractors and number of oxen teams for traction were not available in digital form, so data were entered manually (SECPLAN 1994b). Area for each *municipio* was also entered manually (SECPLAN 1992). Summary statistics for selected variables are presented in Table 1.

Table 1. Mean and standard deviation of variables selected for analysis of agricultural land-use, 291 *municipios*, Honduras, 1993.

Variable	Mean	Standard deviation
Area censused as percentage of total area	40.2	18.1
Area in annual crops as percentage of area censused	17.8	9.82
Area in permanent crops as percentage of area censused	10.3	9.74
Area in improved pastures as percentage of area censused	17.0	11.7
Area irrigated as percentaged of area censused	2.02	5.59
Number of tractors per 1000 ha	0.664	0.933
Number of ox teams per 1000 ha	9.76	14.8

Source of original data: SECPLAN 1994a and 1994b; Barreto 1995

Defining strata

The first three principal components explain 70% of the variation between *municipios* (Table 2). There are three primary groups of variates. In the first principal component, the percentage of *municipio* area found on farms is relatively high and is negatively associated with annual cropping and animal traction. Irrigation and mechanized traction are strongly,

positively associated with the second component. The third component is primarily associated with the presence of improved pastures and the absence of perennials. The fourth component represents areas where agricultural was very important, and based on the production of annual crops.

Table 2. Components loadings, agricultural land-use, Honduras, 1993.

Component	1	2	3	4	5	6	7
Variation, %	30.37	24.92	14.93	10.14	7.76	6.63	5.24
Annuals	**-0.55**	+0.10	+0.12	**+0.43**	+0.02	+0.47	+0.52
Oxen	**-0.51**	+0.22	+0.14	-0.14	+0.68	-0.10	-0.42
Area censused	**+0.46**	+0.10	+0.23	**+0.74**	+0.38	-0.21	-0.03
Irrigation	+0.13	**+0.63**	+0.08	+0.09	-0.34	+0.47	-0.48
Tractors	-0.04	**+0.60**	+0.37	-0.21	-0.16	-0.52	+0.41
Improved pastures	+0.30	-0.21	**+0.71**	-0.36	+0.21	+0.41	+0.11
Perennials	+0.34	+0.36	**-0.52**	-0.25	+0.46	+0.27	+0.34

Principal components were subject to cluster analysis, with a maximum of seven clusters (Table 3). Three clusters (Cluster 1, 4 and 6) are quite small, and indicate highly specialized agricultural systems covering small areas. Clusters 1 and 4 consist of three *municipios* each, in Comayagua and Cortes Departments, respectively, with highly mechanized, irrigated agriculture (principal component 2). They both have high, but opposite means for principal components 1 and 3. That is, the Comayagua cluster has a relatively high percentage of annuals and improved pastures and a relatively low percentage of permanents. The Cortes component is high in permanents and low in annuals and improved pastures. Cluster 6 is a single *municipio* in Olancho Department with a very low agricultural census area, and high percentages of annual and permanent crops with animal traction.

The remaining four clusters represent un-mechanized, rainfed agricultural areas. Clusters are much larger, and component means are less extreme, than for clusters 1, 4 and 6. Clusters 2 and 3 are both positive in principal component 1; i.e., they have above-average *municipio* area censused, and below-average percentages of area censused in annual crops. They differ in that cluster 2 (75 *municipios*) has a greater emphasis on perennials; while cluster 3 (88 *municipios*) has a very high percentage of agricultural area in improved pastures. Clusters 5 and 7 are both negative for principal component 1; i.e. they have below-average percentages of area used for agriculture, and relatively high percentages of agricultural area in annual crops. Cluster 5 (34 *municipios*) has animal traction, whereas cluster 7 (87 *municipios*) has neither animal nor mechanical traction.

Table 3. Agricultural land-use clusters, number of *municipios*, and cluster means for principal components, Honduras, 1993

	Principal component							
Cluster	1	2	3	4	5	6	7	N
6	-7.8	+2.3	+0.5	-0.6	+5.3	+0.4	-1.8	1
1	-1.6	+6.3	+2.5	+0.1	-1.8	+0.3	-0.1	3
4	+3.5	+6.5	-1.5	+0.1	-0.5	+1.8	-1.2	3
2	+0.8	+0.3	-0.9	-0.2	+0.3	-0.1	+0.2	75
3	+0.9	-0.6	+0.9	-0.02	+0.04	+0.06	-0.1	88
5	-1.7	+1.2	+0.5	-0.4	+0.4	-0.4	+0.1	34
7	-1.0	-0.54	-0.3	+0.3	-0.4	+0.2	-0.02	87

Discriminant analysis was employed to refine cluster membership, based on the original variables' values. Twenty-one *municipios* were reclassified (Table 4).

Table 4. Resubstitution summary, discriminant analysis, agricultural land-use clusters, Honduras, 1993.

	into Cluster							
from Cluster	1	2	3	4	5	6	7	total
1	3	0	0	0	0	0	0	3
2	0	65	2	1	3	0	4	75
3	0	2	83	0	0	0	3	88
4	0	0	0	3	0	0	0	3
5	0	0	0	0	33	0	1	34
6	0	0	0	0	0	1	0	1
7	0	2	1	0	2	0	82	87
total	3	69	86	4	38	1	90	291

The analysis was not able to isolate the "agricultural frontier" in northeastern Honduras, so an eighth cluster was added by splitting cluster 7 into two groups (Figure 3).

The new cluster (cluster 8) was assigned the six northeastern *municipios* from cluster 7 in Gracias a Díos (Puerto Lempira and Brus Luguna), Colon (Iriona) and Olancho (Dulce Nombre de Culmi, Esquipulas del Norte and La Union). Out of 90 *municipios* in the original cluster 7, these six had the first, second, third, fourth, fifth and ninth lowest percentages of area censused. The sixth through eighth lowest-ranked *municipios* were located in Ocotopeque and Lempira Departments, in western Honduras, and do not belong to the area associated with the agricultural frontier in Honduras.

Variable means for the final clusters are presented in Table 5, and a map of the clusters, on the basis of *municipios*, appears in Figure 4.

Table 5. Variable means and standard deviations (in italics), by cluster, Honduras, 1993.

	Cluster								
Variable	1	2	3	4	5	6	7	8	Total
Number of municipios	3	69	86	4	38	1	84	6	291
Area censused, %	36	44	51	62	29	8.2	33	8.5	40
	10.9	*14.4*	*19.5*	*24.0*	*13.6*	*na*	*10.5*	*6.48*	*18.1*
Annuals, %	36	12	13	7.2	25	53	24	12	18
	6.13	*4.64*	*5.48*	*3.45*	*9.40*	*na*	*10.0*	*2.53*	*9.82*
Perennials, %	6.3	21	6.8	47	8.0	9.3	4.3	7.3	10
	7.01	*7.87*	*4.57*	*10.9*	*6.67*	*na*	*3.48*	*3.11*	*9.74*
Improved pastures, %	13	13	29	9.1	12	2.8	10	16	17
	8.13	*8.0*	*10.7*	*7.05*	*8.34*	*na*	*5.90*	*8.14*	*11.7*
Area irrigated, %	29	1.3	1.4	32	2.4	0.0	0.84	0.15	2.0
	7.72	*3.28*	*2.82*	*17.9*	*3.19*	*na*	*1.92*	*0.257*	*5.59*
Tractors/ 1000 ha	5.1	0.50	0.53	2.3	1.8	0.84	0.24	0.06	0.66
	0.457	*0.516*	*0.586*	*0.667*	*1.21*	*na*	*0.389*	*0.067*	*0.933*
Oxen teams/ 1000 ha	30	4.3	3.9	0.47	32	142	8.7	3.5	9.8
	9.70	*5.10*	*4.68*	*0.391*	*17.0*	*na*	*7.79*	*7.97*	*14.8*

Figure 3. Clusters based on agricultural land-use and infrastructure, Honduras, 1993

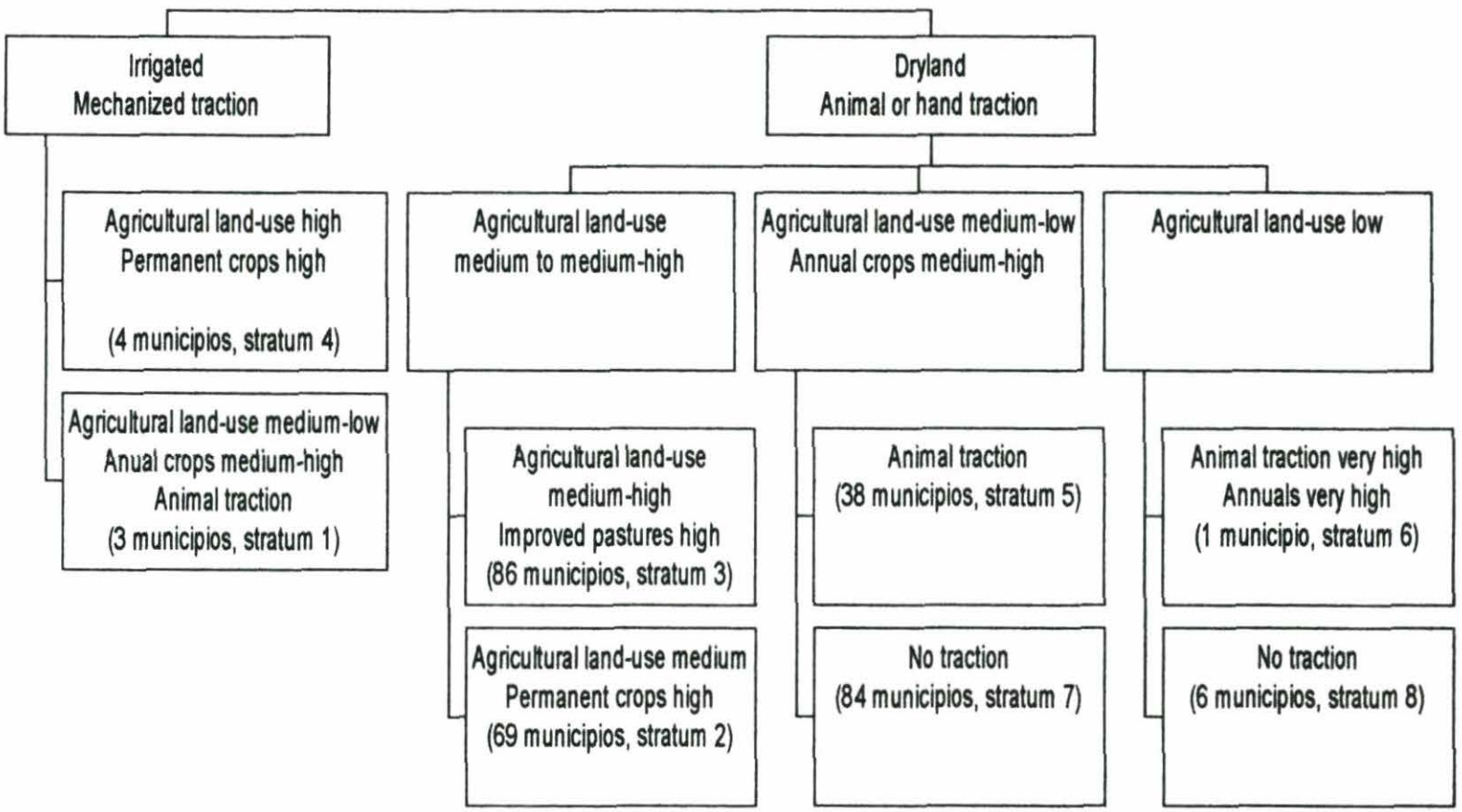
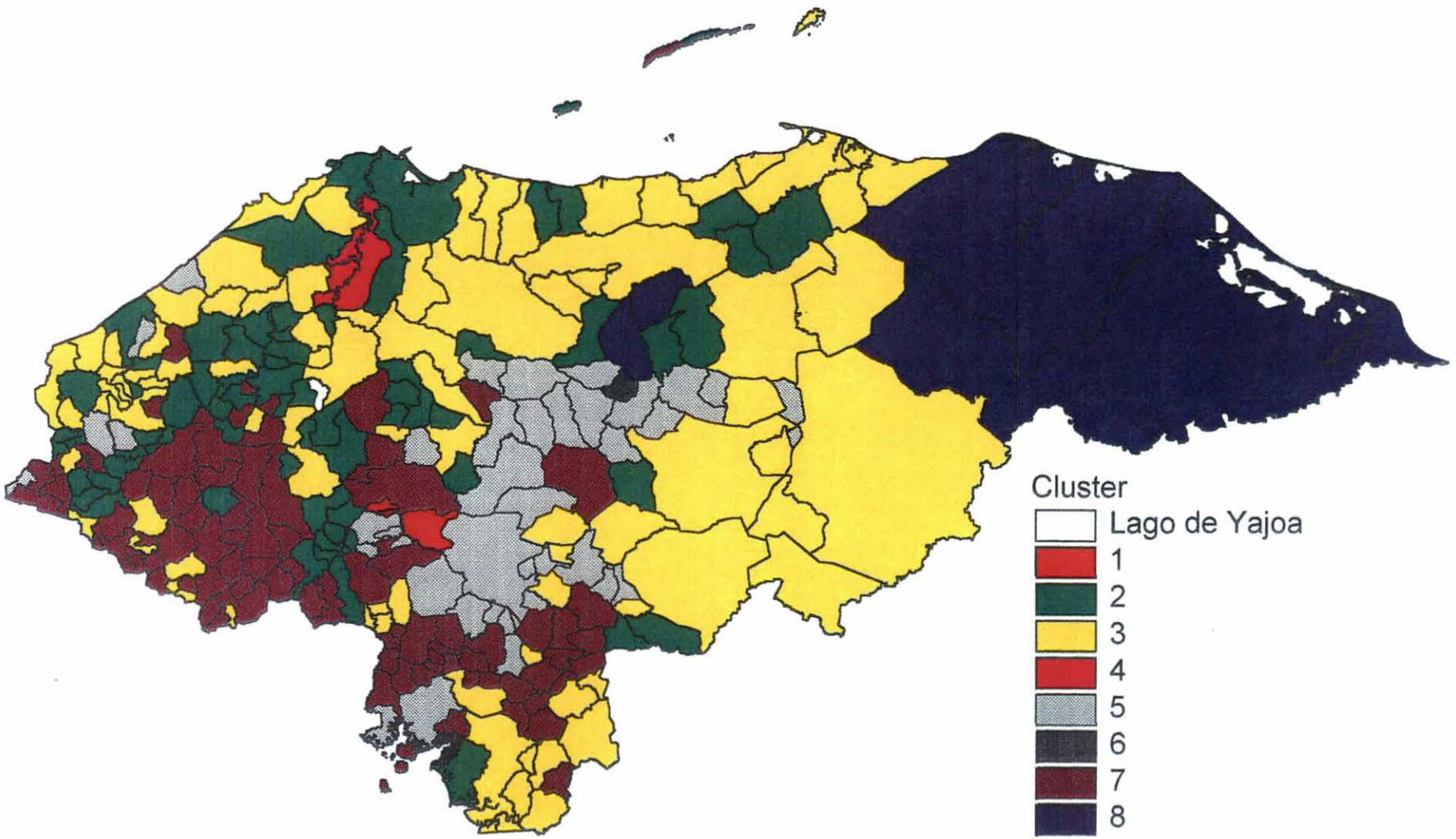


Figure 4. Municipio clusters based on agricultural land-use and infrastructure, Honduras, 1993



Selecting communities

For population enumeration purposes, population centers in Honduras are divided into the municipal seats *(cabeceras municipales)*, *aldeas*, and *caserios*. *Aldeas* have a minimum of basic, public services. They are sometimes coterminous with *caserios*, or sometimes divided into three or four *caserios*. *Caserios* often are not mapped. *Aldeas* were selected as the unit of sampling. There were 3,285 *aldeas* in Honduras (Dirección de Estadisticas y Censos 1995, and it was planned to conduct the sondeo in about 60 communities *(aldeas)*, or about 2% of the total.

Discrimant groups formed the strata for selection of communities for interviews. Using a database of *aldeas* in Honduras taken from the 1988 Census of Population and Households, and divided by *departamento* and *municipio* (Dirección de Estadisticas y Censos, 1995), *aldeas* were assigned to strata, and the total number of *aldeas* in each stratum was determined. Each *aldea* was assigned a random number between 1 and the total number of *aldeas* in the stratum.

Sampling was weighted by the area censused in strata 2, 3, 4, 5, 7 and 8 (Table 6), The area in stratum 4 (48,722 ha) was equal to one sampling unit. Strata 1 and 6 had very small areas, and 1 *aldea* was selected for each (Figure 5). A total of 70 *aldeas* were selected, or one *aldea* for somewhat less than 50,000 ha censused.

Each selected *aldea* was located on 1:50,000 topographic map sheets, and transferred to a road map of Honduras. Routes were planned for surveys of one to two weeks duration.

Discussion

To increase sampling efficiency, and to obtain coverage of the major agricultural systems in Honduras, a stratified sampling procedure was used. The procedure adopted was to use *municipio*-level data from the 1993 agricultural census in Honduras, to identify broad classes of *municipios* based on agricultural land-use patterns and agricultural infraestructure. Within these strata, communities were randomly selected. The number of communities selected was weighted by agricultural area within each strata.

An unstratified, random sample of *aldeas*; i.e., a population-based sample, would have resulted in a bias toward high-population-density, good market-access systems, and a geographic bias toward western Honduras. An area-based sample would have resulted in a bias toward the northeastern frontier area, i.e., away from the important agricultural areas in Honduras. Instead, the sample was weighted, across strata, by agricultural area within each strata and sampling within each strata was based on lists of *aldeas*. The approach used; i.e., a combination of agricultural area-based and population-based sampling, was devised to capture greater variability in the types and degrees of pressure the communities are experiencing than would have appeared with only one or the other method of sampling. Some implicit bias to more highly-populated areas probably remained, because *aldeas* are probably more densely clustered in higher-density areas. Nevertheless, data are available to re-weight survey results according to total area, agricultural area, number of population centers or population (Table 6), if desired.

Table 6. Area, area censused, number of aldeas, population and number of aldeas selected, by strata, Honduras, 1993.

Strata	Area[a]		Area censused[b]		Aldeas[c]		Population[d]		Aldeas selected
	ha	%	ha	%	Number	%		%	
1	43,690	< 1	12,273	< 1	7	< 1	21,678	< 1	1
2	1,596,870	14	646,245	19	894	27	1,141,506	26	13
3	4,455,774	40	1,762,806	53	1,126	34	1,443,923	32	36
4	86,380	< 1	48,722	1.5	77	2.3	177,569	4	1
5	1,047,490	9.3	269,381	8.1	328	10	938,777	21	6
6	14,490	< 1	1,187	< 1	9	< 1	2,976	<< 1	1
7	1,466,780	13	468,947	14	732	22	650,963	15	10
8	2,497,280	22	127,523	3.8	112	3	66,326	1.5	3
Total	11,208,754	100	3,337,082	100	3,285	100	4,443,721	100	70

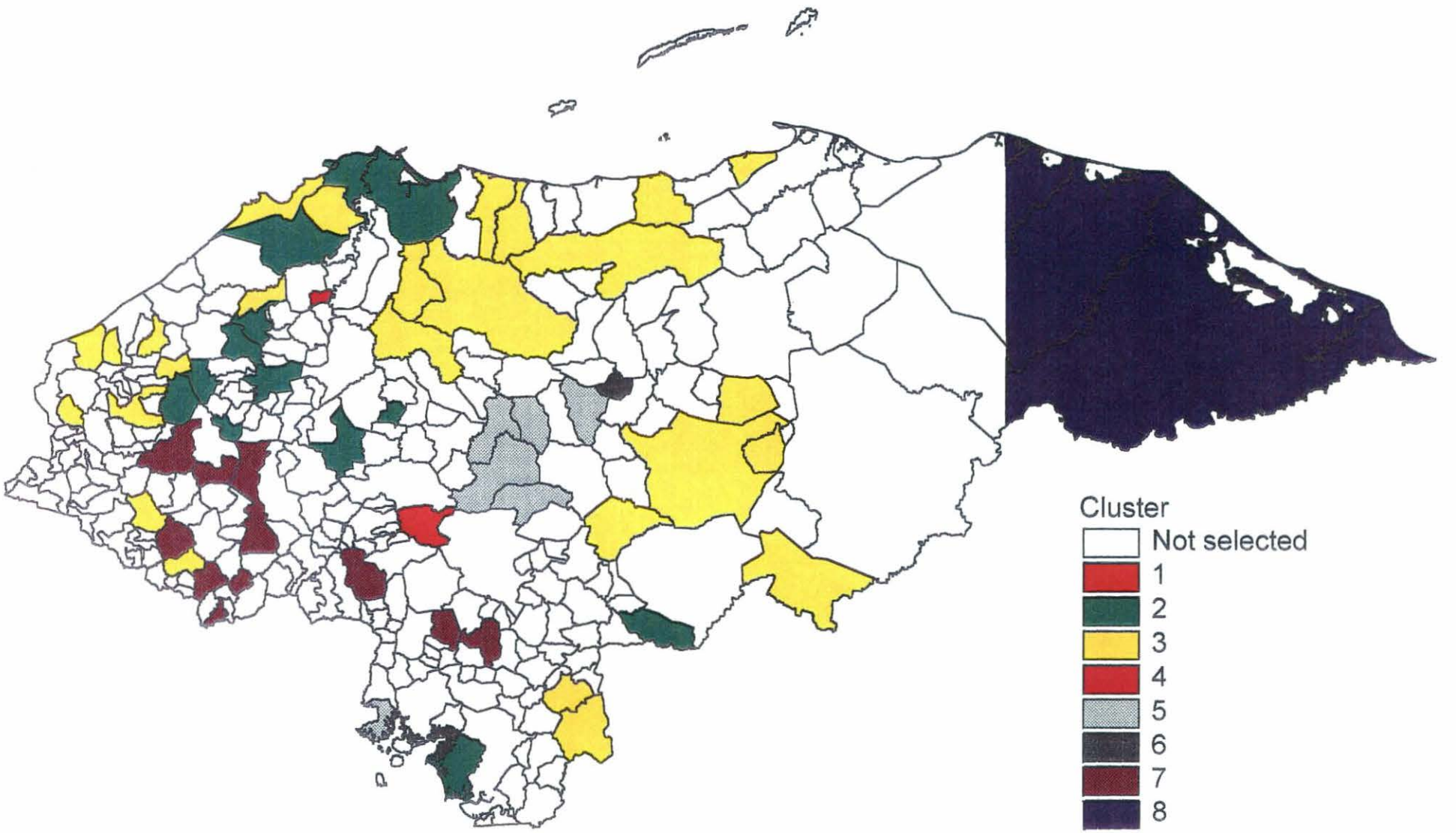
[a]SECPLAN 1992

[b]SECPLAN 1994

[c]Dirección de Estadisticas y Censos 1995

[d]SECPLAN 1989

Figure 5. Municipios from land-use and instrastructure clusters with aldeas selected for sondeo, Honduras, 1996



The use of *municipios* as the unit of analysis for cluster analysis, rather than agricultural area, did not distort the results. The cluster means, weighted by agricultural area, did not differ greatly when weighted by agricultural area (Table 7). The "interpretation" of the clusters remained unchanged.

Table 7. Variable means and standard deviations (in italics), by cluster, Honduras, 1993, weighted by *municipio* area (% area censused) or area censused (all other variables) per *municipio*.

	Cluster								
Variable	1	2	3	4	5	6	7	8	Total
Number of *municipios*	3	69	86	4	38	1	84	6	291
Area censused %	28	40	40	56	26	8.2	32	5.1	30
	1138	*2239*	*4425*	*2902*	*2205*	*na*	*1290*	*3717*	*4001*
Annuals %	35	12	12	8.2	24	53	22	11	14
	237	*397*	*656*	*408*	*748*	*na*	*675*	*338*	*791*
Perennials %	5.5	21	6.7	46	8.0	9.3	5.0	6.6	10
	377	*668*	*612*	*1121*	*542*	*na*	*305*	*466*	*959*
Improved pastures %	12	16	29	10	14	2.8	9.6	15	22
	352	*745*	*1355*	*777*	*652*	*na*	*406*	*1400*	*1258*
Area irrigated %	26	2.4	1.6	29	2.2	0.0	1.5	0.17	2.2
	280	*436*	*393*	*1886*	*212*	*na*	*226*	*39.3*	*541*
Tractors/ 1000 ha	5.4	0.67	0.70	2.0	2.0	0.84	0.37	0.06	0.77
	30.0	*52.0*	*81.4*	*46.2*	*91.1*	*na*	*37.1*	*7.62*	*85.0*
Oxen teams/ 1000 ha	26	3.6	3.6	0.47	27	142	9.8	1.2	6.3
	367	*436*	*512*	*37.1*	*1323*	*na*	*568*	*673*	*1012*

With the exception of failing to isolate the "agricultural frontier," clusters produced were consistent with agricultural regions in Honduras. The small, intensive-agricultural areas around Cortes and Comayagua were readily isolated from surrounding areas and from each other. The remaining agricultural regions are much larger and distinguished on more subtle gradations of importance of agriculture, the relative importance of improved pastures and

permanent crops, and the presence or absence of animal traction. This provided a suitable and manageable sampling frame for the *sondeo*.

The CAHP project is working with a variety of methods to develop other farm typologies appropriate to other research issues. Analyses are being conducted that combine the agricultural census data with climatic, topographic and soils databases. In addition, geographic coverages are being developed for major crops in Honduras, particularly for patterns of productions of basic grains. Regional and local studies will complement national studies such as this one.

In addition, agricultural land-use, infrastructure and investment vary greatly by farm-size class in Honduras. Because the pattern of distribution of resources across farm-size classes within a *municipio* does not vary widely across *municipios*, variables that reflect distribution of resources were not included in this analysis. Nevertheless, any agricultural typology designed to identify target groups of farmers, or technologies suitable for groups of producers, would need to take into account the unequal distribution of resources across farm-size classes.

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