TYPOLOGY OF AGRICULTURAL LAND USE IN THE STATE OF PARÁ, BRAZIL: AN APPLICATION OF MULTIVARIATE ANALYSIS

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Abstract

The present work introduces a typology of agricultural land use in the state of Pará, Brazil. We employ techniques of factorial and cluster analysis to obtain factors that reflect the main types of agricultural land use in the state's 128 counties[1] and to form groups of counties with factor similarities. The counties in the groups do not necessarily share borders. The groups of counties identified in this work constitute preliminary information for localized application of public policies in the agricultural sector and investment planning by private enterprises.

Key words: agricultural development, multivariate analysis, Pará.

1. Introduction

Planning for the rational use of agricultural land demands information about the main stipulators affecting the production process. According to Hyami and Ruttan (1988) the efficiency of development policies is directly associated with an understanding of the environmental and socioeconomic characteristics in the targeted areas or regions.

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[1] Today the state Pará has 143 counties.

The Brazilian government maintains various zonal subdivision programs for use as instruments to increase the efficacy of elaboration and implementation of policies adapted to local conditions. A climatic zones subdivision is developed for specific types of cultivation and identifies favorable and unfavorable planting periods. Zoning techniques are also applied to define the areas destined to specific activities in specific regions. Ecological and economic zoning is a pre-requisite to gain access to some resources and incentives associated with certain types of development programs.

Unfortunately, the complexity and cost of Ecologic and Economic Zoning (EEZ) has limited its nationwide application and made it unavailable for most of the Amazonian region. In the state of Pará, municipal administrations have become involved in political disputes over EEZ priority – which municipality will get zoned first. As long as the information generated by these sophisticated studies is unavailable to local planning agencies, disorderly settlement of the Amazon territory will continue, increasing both economic and environmental risk in the region.

Limited in purpose to agricultural activities, this work presents a typology of agricultural land use in the state Pará in the eastern Amazonian region of Brazil. This typology defines forms of agricultural land use and then identifies the form of agricultural land use found in the state's counties. We first select variables (71) to identify and describe the characteristics of the main types of agricultural use of land. We then use these main types to group the state counties according to similarities in forms of land usage. The result is a collection of maps that describe the relative importance of each type of land use in both the individual counties and in areas having similar combinations of these main types of land use.

At least in relation to agricultural activities, this typology provides useful information for the establishment of rational settlement directives when EEZ results or well-studied agricultural and ecological zoning plans are unavailable.

2. Statistical Model

This study's statistical model employs techniques of multivariable

analysis—factorial analysis followed by cluster analysis—to extract factors that reflect the main types of agricultural land use. By means of group analysis, the analysis units (counties/municipalities in Pará) are then grouped to according to their degree of similarity with the factors.

2.1- Factorial Analysis

Factorial analysis can be applied to confirm the hypothesis that there exist specific underlying causal factors that determine relations between observed variables. In the present case, the structure of the relations between the variables defining distinctive agricultural land use types is not known a priori. Our analysis is of an exploratory nature, leaving the standard of association between variables and factors in need of interpretation.[2]

The steps of the factorial analysis we employed can be summarized as follows: (1) determination of a correlation matrix between all variables[3]; (2) Extraction of factors necessary for representation of the data; (3) Transformation (rotation) of factors in order to ease their interpretation; and (4) Determination of factorial scores[4].

Step one provides information to verify the adequacy of a sample to the statistical procedure. Variables with little relation to the other variables will tend to present a low proportion of the variance "explained" by common factors and must be removed from the analysis. In our study, the size of the correlation matrix hampers the selection of variables in this manner. To compensate, we utilized a variation of the Kaiser-Meyer-Olkin (KMO) measure as our gauge of sampling adequacy (MAS).

The second stage involves the determination of the number of factors needed to represent a set of data. The main component method was used to extract the factors from the data, while the technique

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[2] For a discussion of factorial analysis in an exploratory or confirmatory character PLS see chapter II of Stevens (1996).

[3] A factorial analysis can also be applied from a variance or (covariance) matrix.

[4] More detailed explanations about factorial analysis can be found in Kim and Mueller (1978) or Manly (1986) (Chpt. 8) other applications related to agricultural economy in Kageyama e Leone (1990), Hoffmann (1992) and Sales (1994).

employed to determine the number of factors will be discussed later.

The third step, main axis rotation, intends to find a simple structure of association between the factors and the variables. In the present case, we used an orthogonal rotation method (Varimax) that tries to minimize the number of variables strongly related to each factor, allowing us to obtain more easily interpreted factors.

Finally, for each observation, the factorial score is obtained by multiplying the value of variable I by the corresponding factorial score coefficient. The general expression to estimate the j-TH factor, Fj is given by:

$$F_j = \sum_{i=1}^{p} W_{ji} X_i = W_{j1} X_1 + W_{j2} X_2 + \ldots + W_{jp} X_p$$, in which W_{ji} is the coefficient of factorial scores and P is the number of variables.

2.2- Cluster Analysis

Cluster analysis is a statistical technique used in the classification of observations or variables in homogenous groups when there is more than one dimension to be considered simultaneously. Detailed descriptions can be found in Duran and Odell (1974), Everitt (1977), Kleinbaum and Kuper (1978), Manly (1986), or Bussab et.al. (1990).

To understand this procedure, it is necessary to insert the concept of distance between the classification objects. There are various methods to measure distance. The most used are the Euclidean measure and its derivations. In this context, distance is used in our analysis to reflect the degree of similarity between the state's counties according to factorial scores.

Groups were formed to present the greatest possible internal uniformity, that is, the lowest total sum of distances between components and the maximum dissimilarity between groups. Objects [areas] were grouped using Ward's method, an agglomerative hierarchic approach to grouping that employs the square of the Euclidian distance to measure similarity between observations. Since there is no single established criterion that defines the number of groups to be created, this determination

was made by the researcher.

2.3- Variables and data source

Indicators employed to determine the main types of agricultural land use categories were selected to reflect two basic dimensions: "intensity of land use" and the "capital/work relation". The variables include technical progress, which takes in infrastructure indicators and the use of mechanical and chemical resources, production relations, level of capitalization of establishments, and type of agricultural activity.

In order to represent the dimensions "land use intensity" and "relation capital/work" the variables representing technology appear as the ratio of used area and the ratio of used personnel, respectively. Used area (AE) is defined as sum of areas occupied by permanent and temporary cultivation, natural or cultivated pasture, and natural or cultivated woods and forests, as in Hoffmann (1992). Used personnel (PO) is defined by the sum of people classified as responsible and unpaid family members, permanent workers, temporary workers, and partners, which includes women and children under the age of 14[5]. Other variables are created using a ratio represented by the specific item (machinery, electricity, plows, etc.) divided by either the total number of establishments or the total area of the establishments.

All in all, 195 variables were created; though, 125 of these were removed from the analysis for not showing a high enough degree of correlation with any others variable.[6] Data are from the census of agriculture and cattle breeding in the state of Pará (IBGE, 1996).

[5] According to Bialoskorski (1995) ratios by used personnel correspond to ratios by man - equivalent, for use in factorial analysis.

[6] Details about used criteria in this step, and sense of this reduction of number of variables can be found in Meyer and Braga (1999).

3. Results and Discussion

3.1- Determination of number of factors

One criterion often used to stipulate the number of factors to be employed is to select only those that have values larger than a unit, but this is not mandatory and is often left to the researchers discretion. In this analysis, 11 main components present a characteristic root larger than a unit and "explain" about 85% of the total variance, but components 10 and 11 have no descriptive value and components 5 and 8 do not reflect agricultural land use. Therefore, we will only consider components 1, 2, 3, 4, 6, 7 and 9, which together, after rotation, explain nearly 67% of total variance (Table 1, last column).

Table 1 - Factors extracted by the "main components" method

Component	Initial Solution			Solution after rotation (VARIMAX)		
	Eigenvalue	Explained variance (%)	Accumulated Variance (%	Eigenvalue	Explained variance (%)	Accumulated Variance (%
1	19.71	28.15	28.15	13.59	19.42	19.42
2	15.53	22.19	50.34	7.65	10.93	30.34
3	5.94	8.49	58.83	7.62	10.89	41.23
4	4.37	6.24	65.07	7.23	10.33	51.56
5	4.07	5.81	70.88	6.80	9.72	61.28
6	2.55	3.64	74.53	4.07	5.81	67.09
7	1.95	2.79	77.32	3.89	5.55	72.64
8	1.88	2.69	80.01	2.86	4.09	76.73
9	1.58	2.25	82.26	2.71	3.88	80.61
10	1.28	1.83	84.09	2.27	3.24	83.85
11	1.08	1.55	85.64	1.25	1.79	85.64

Bartlett Esfericity Test = 18753,95 ($p < 0,0000$), *KMO* = 0,76675

The following section defines each ordinary factor used in our study. In most cases, we only consider variables with correlation coefficients over 0.5.[7] But, to better explain the meaning of some factors, specially the last ones, we made use of variables with weaker correlations. The matrix of factorial changes and the complete list of variables were

[7] When we use the main components method, followed by orthogonal rotation of Axis (Varimax) the factorial loadings correspond to the correlation coefficients between the factor and the variable.

omitted from this paper due to space limitation. The description of the variables considered to characterize the main types of agricultural land use in Pará follows.

3.2- Distinctive types of agriculture land use in Pará.

Factor 1 - Commercial agriculture (intensive).

Factor 1 consists of a group of variables that identify modern land use, at least relative to the norm in Pará in 1995. This type of land use requires the intense application of technological and capital inputs per unit of exploited area

This factor is strongly and positively related to the value of total receipts by unit of exploited area (VR-02). In the structure of these revenues, the value of vegetal production (VP 05), especially horticultural (GAT 02), vegetal products (VV 02), and dung sales (VVII), stood out, as did revenues from services provided to third parties (VV20), probably related to machinery rental.

The most important positive correlations between total area exploited and expenditures were found in the following variables: purchase of seeds and seedlings (VD 17), fertilizers (VD 14), toxins (VD 20), product transportation (VD 44), bags and other packing materials (VD 53), fuels and lubricants (VD 56), wages paid in cash and products (VD 05), and electric power bills (VD 59).

The use of modern technology per unit of area appears associated with the following variables: number of tractors of between 10 and 50 horsepower (TR_05), number of mechanical traction plows (AR_05), number of machines for planting and harvesting (MQ_02), and number of vehicles with mechanical traction (MT02). In addition, the variables number of grain storage units (PD 02) and other products (DP 05) per total exploited area are positively related to modern technology and are also representative of the infrastructure found in some municipalities.

The variables that are related to the value of sales, cost of product packaging, and transportation indicate that this type of agricultural production is market oriented, while wage expenses (VD 05) incurred to

employ mainly permanent workers (PO 04) show that this type of agricultural enterprise is capital intensive.

Factor 2 - Breeding of small animals (commercial poultry husbandry).

Factor 2 identifies land used for animal production (VP 02 & VP 03) and represents the intensive breeding of small animals, especially commercial poultry husbandry. Animal product sales revenue is strongly related to total occupied personnel (VV 15) and total exploited area (VV 14), but total enterprise revenue is more affected by the total number of workers (VR 03). Small animal husbandry expenses are strongly affected by the cost of fertilized eggs (VD 36), one-day old chicks (VD 35), industrial food ration (VD 30), medicines (VD 23), electrical power (VD 60), and machine and equipment rental (VD 39).

Factor 3 – Extensive, absentee owned (patronal), cattle breeding.

Factor 3 land use is representative of cattle breeding establishments of between 1,000 and 10,000 ha (EA 07 & EA 08) worked by permanent employees (PO 05). This type of enterprise is normally owned by outside investors, as shown by its negative association with variable (PO 02)—establishments operated by the owner and other unpaid family members.

An above average proportion of cattle breeding businesses in the total number of enterprises in a particular county is reflected in variable (GAT 04). The application of capital is only related to the number of employees, tractors larger than 50HP (TR 09), mechanical traction plows (AR 06), and mechanical traction vehicles (MT 03). The most important expenses are for animal medicine (VD 24) and machine fuels and lubricants (VD 57); but these expenses have a stronger relation to Factor 6.

Factor 4 – Slash and burn "wandering" agriculture

Factor 4 is representative of the cut and burn agriculture typically practiced by small farmers in Brazil's North region. Variables (UT 03 and UT 04) show changes in temporary farming (UT 03) of the "white" farm crops (rice, corn, cassava, caupi beans) and fallow periods (UT 04). This kind of farming is more common on farms of from 10 to 100 ha, as shown by variable (AE 04), and the work force is made up of family members (PO 01 and PO 19) and other farm residents (PO 16). The variable representing the value of rural products sales (VV 17) shows the importance of cassava flour to these small farms. Regional customs dictated that cassava is used to complement the family diet; though, cassava production has now become the main source of income for a majority of Pará's rural poor. The negative relation between Factor 4 and variable (UT 01) [% of farm area under cultivation] and the positive relation between Factor 4 and variable (UT 09) [% of productive areas not in use] shows that this type of farming is inefficient, apparently due to work force limitations.

Factor 6 - Semi-intensive (patronal) cattle breeding.

Cattle breeding reappears in Factor 6 as indicated by the factor's positive relation with variables (GAT 04) (percentage of farms with cattle breeding as main activity), (VP 03) (value of animal production), and (VV 15) (value of animal products sales). As opposed to Factor 3, there is no strong relation between Factor 6 and large establishments and a relatively greater dependence on investment (VI 03 and VI 02), purchases of seed and seedlings (VD 18), medicine for animals (VD 24), fuel and lubricants (VD 57), and machines and equipment rental (VD 39) relative to the total number of employees. Therefore, this is a more capital-intensive type of cattle breeding than that represent by Factor 3. Factor 6 also has a patronal character, relating positively with variables (PO 05) [permanent employees] and (VD 42) [employment of free-lance workers] and a negative relation with variables (PO 02) [family-member labor] and (EA 01) [participation of establishments < 10 ha).

Factor 7 - Rural "mosaic" (diversified breeding and planting).

The variables with the strongest relation to Factor 7 suggest a subsidiary type of animal production, as shown by variables (VP 02) [value of animal production] and (VV 14) [animal products sales value]. However, those variables are more strongly related to Factor 2 [small animal breeding], in which one finds a higher level of capitalization, as indicated by the strong association between expenses and total revenue value (VR 03). In Factor 7 land usage, the values of vegetal and animal product sales are not strongly related to operating costs. Despite that, variables PO 04 [permanent workers] and VD 05 [wages] show that some capital is applied to employ outside workers.

The values for variables VD 30 (expenses for industrial food ration), VD 23 (expenses for animal medicines), VV 11 (dung sales), VD 60 and VD 59 (expenses for electric power), and VD 35 (expenses for purchase of fertilized eggs and one day old chicks) indicate that poultry husbandry is practiced on Factor 7 land. If we allow weaker relations, we also find an association with variables GAT 08 (production of vegetable charcoal) and GAT 02 (horticulture), indicating that Factor 7 land use reflects diversified agricultural activities.

Factor 7 land use is practiced on small properties (negative relation with EA 08 - large establishments) that divide their production between goods for the market and goods for family use. Factor 7 represents a kind of rural "mosaic," combining diversified subsistence agriculture and commercial production (horticulture, poultry raising).

Factor 9 "Rural resident" and vegetal harvest

The phrase "rural resident" has been informally used to describe farmers that can no longer survive solely on agriculture. They live in rural areas, work part-time on the farm, and earn additional income working in the cities as employees or as owners of small businesses.

Variables PO 01 and PO 19, also appearing in Factor 4 (wandering agriculture), show that most workers on Factor 9 land are unpaid family members. The direct association with variables EA 01 and EA 02 shows

that a majority of the enterprises are less than 10 ha, and the inverse association between Factor 9 and variable EA 03 [% of enterprises from 10 to 100 ha] reinforces this interpretation.

Factor 9 has no strong relation with any variable relating to production activity; so, when a Factor 9 pattern is present in counties close to cities, one can interpret land use for rural residences. Though, when Factor 9 appears in areas where there is a predominant riverside population, one could assume small-scale fishing – not really a land use – and when appearing in or very near to coastal cities, Factor 9 may also include tourism areas.

3.4- Determination of group size

The first finding derived from our grouping analysis is that there is great heterogeneity in the ways land is used in Pará, confirmed by the dimensions of distance coefficients between single or group observations. This implies major difficulties in forming groups with a significant degree of internal uniformity.

Just as in the case of our determination of the number of factors, the determination of number of groups to be considered depends on the researcher's perception. In our study, it was necessary to work with a large number of isolated counties (groups with only one element). We decided to work with 21 clusters of districts and 14 isolated districts, which were defined at the level of 5.52% of the total variation in the distance measurements (Stage 93 of the grouping scheme). [ed.: Generally, the districts were also state counties and the counties are named for largest metropolitan in the county.]

Figure 1 shows the pattern of spatial distribution of agricultural land use types in Pará in accord with the types of land use defined in the prior section (Figures 2 and 3 help to interpret the distinctive characteristics of each group). The value zero on the vertical scale represents the state's factorial score average, and the values indicated in the diagram ordinates represent deviations from this average.

3.5- Spatial distribution of land use types: summary of main types

We observe that commercial agriculture (Factor 1) is concentrated almost entirely in the municipality of Ananindeua, with the municipality of Santo Antônio do Tauá a distant second. Both municipalities are located within 100km of Belém, Pará's largest city and capital, and both remained isolated (a group of one) when the groups were formed. This indicates that the more technologically developed agriculture in Pará is located close to Belém; though, to a much lesser degree this type of agriculture is found in the counties of Curuçá, Castanhal, Breu Branco, and in counties of Group 27.

Factor 2, small animal breeding (especially, commercial poultry raising), follows the same pattern. This activity is concentrated in Benevides and Santa Isabel, two areas that were isolated when groups were formed and both near Belém. Factor 2 land use is also found to a lesser extent in Curuçá, Igarapé-Açu, São Francisco of Pará (Group 26), Castanhal, and Curionópolis. This last town is located in the region of Parauapebas in the eastern portion of the state.

Factors 1 and 2 are the only agricultural and animal-breeding activities that employ entrepreneurial managerial techniques. This type of land use is found almost exclusively near the state's largest metropolitan area and is not typical.

Extensive cattle breeding (Factor 3) activities are generally concentrated in counties that also remained isolated when the groups were formed: Ulianópolis and Dom Eliseu in the state's southeastern Paragominas region. To a lesser extent, Factor 3 land use is also found on Marajó Island in Soure county (Group 30) and near the Group 19 municipalities of Cachoeira do Arari, Ponta de Pedras and Santa Cruz do Pará, in Parauapebas county (Group 30), in the Group 28 counties of Jacareacanga and Novo Progresso, and in Group 3 (Rondon do Pará and Abel Figueiredo).

It should be noted that in Group 3, Factor 3 land use is often combined with similar but more intensive Factor 6 land use. Also, Factor 9 land use is more prevalent on Group 28 land in the state's southwestern Itaituba region, reflecting mineral extraction (gold, calcareous rocks, tin

ore) and the harvest of wood, Brazil nuts, açaí, and natural rubber.

Slash and burn "wandering" agriculture, Factor 4, seems to be widespread in the state's northeast. Factor 4 agriculture is practically the only kind of main type land use practiced in Bujaru, near Belém, and in Groups 29 (Magalhães Barata and Maracanã), 16 (Bonito, Bragança, Traquateva, Salinópolis, São Domingos do Campo, São João das Pirabas and São Miguel do Guamá), 12 (Aurora do Pará, Concórdia do Pará, Garrafão do Norte, Moju, Nova Esperança do Piriá and Santa Luzia do Pará), and in Colares. Colares distinguishes itself by also being an area of Factor 9 land use (rural residence), which in this case better reflects vegetable harvesting and fishing.

The Factor 4 also stands out on Group 2 areas (Augusto Corrêa, Primavera and Guatipuru), where it also combines with Factor 9, Factor 7 (rural mosaic), and some Factor 6 (semi-intensive cattle breeding). In Group 26 (Igarapé-Açu and São Francisco to Pará), Factor 4 land use appears in association with Factor 2 (small breeding and with commercial poultry raising) and Factor 7 (various activities). In São Francisco do Pará, there is also some important modern commercial agriculture (Factor 1) combined with Factor 4.

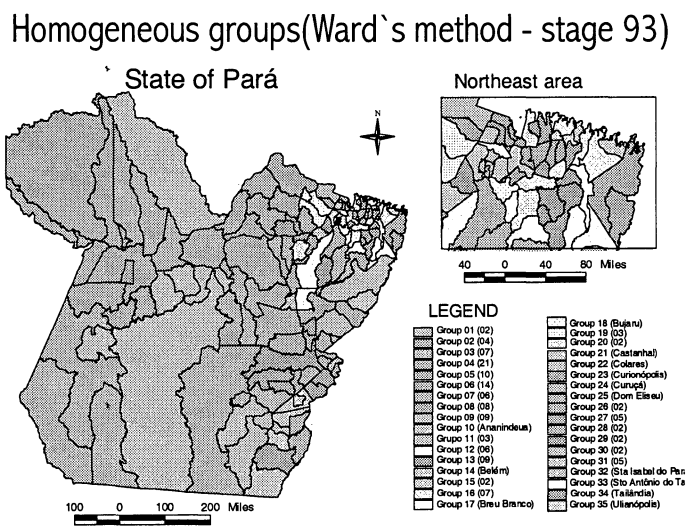


Fig. 1 - Map of land use in the state of Pará.

Obs.: The map used for this display presents 143 counties. The agricultural and animal breeding census of 1996 only shows 128 counties. The 15 new ones received the same color code as their counties of origin

Finally, Group 13 is made up of areas that practice Factor 4 agriculture; though, this group is not uniform. In some Group 13 counties (Curralinho, Irituia, Mocajuba), slash and burn agriculture is the only noticeable agricultural activity, while in other Group 13 counties (Barcarena, Terra Alta and Vigia), Factor 4 combines with commercial agricultural production destined for markets in Belém and other nearby cities or combines or with small animal husbandry and diversified planting (Capanema and Capitão Poço).

Fig. 2 - Character of Groups formed in stage 93 (Ward's method)

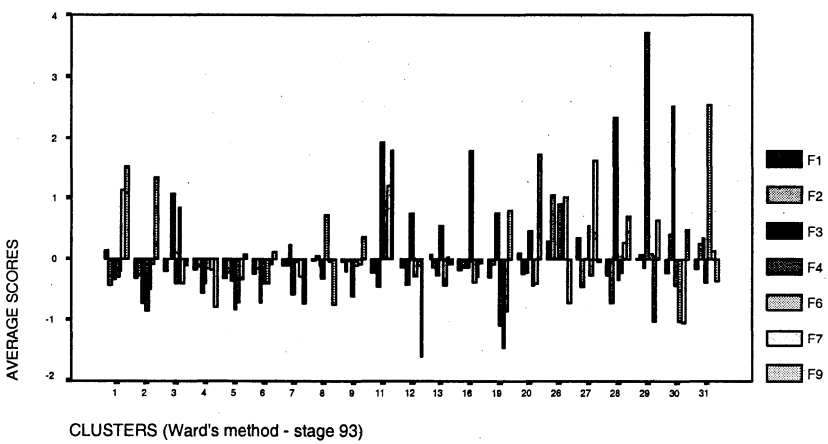
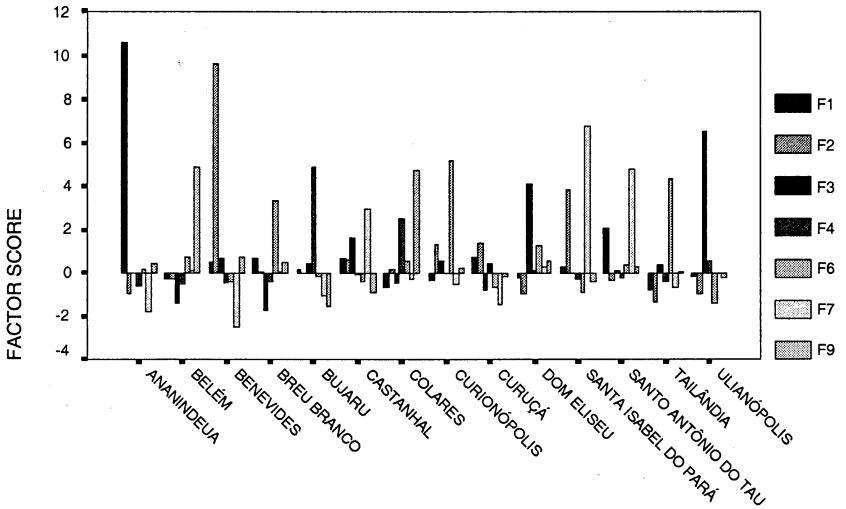


Fig. 3 - Character of isolated counties in stage 93 (Ward's method).



The largest concentrations of capital-intensive cattle breeding areas (Factor 6) are found in Curinópolis (southeast), Tailândia (northeast) and Breu Branco (southeast). Although less important relative to state average, Factor 6 land use is the agricultural standard in the southeastern counties of Group 31 (Redenção, Rio Maria, Santana do Araguaia and Xinguara) and Group 8 (Marabá, Parauapebas, Santa Maria das Barreiras and São Geraldo do Araguaia). In Group 3 (Abel Figueiredo, B. G. do Araguaia, Cumaru do Norte, Ouril do Norte, Pau Darco and Rondon do Pará), Factor 6 land use combines with extensive animal breeding (Factor 3) and intensive small-animal husbandry (Factor 2).

Factor 7 (rural mosaic) represents diversified agricultural activities, mainly small-animal husbandry and a mix of subsistence and commercial agriculture. The main expression of this characteristic is again location differentiation and isolation in the state's northeast near Belém. Factor 7 appears as the main land use type in the isolated districts of Santa Isabel Pará, Santo Antonio do Tauá and Castanhal and less expressively in Group 27 (Inhangapi, Nova Timboteua, Santa Maria do Pará, São C. das Odivelas. These diversified agricultural activities are

also relatively important in Groups 1 (Abaetetuba and Santarém Novo), 11 (Augusto Corrêa, Primavera and Quatipuru) and 26 (Igarapé-Açu and São Francisco do Pará). Factor 7 land use divides space with Factor 4 land use in Groups 11 and 26 and with Factor 9 land use (rural resident) in Groups 1 and 11.

The major concentrations of Factor 9 (rural resident) are in Belém and Colares counties. In Belém, this occurs because of population size and relative wealth makes a rural, second residence possible. In Colares and in Groups 1, 2 (Anajás, Limoeiro do Aturu, Salvaterra and São Sebastião da Boa Vista), 11, 20 (Cametá and Marapamim), and Marajó (except Limoeiro do Araju, close to Cametá) the presence of Factor 9 reflects vegetal extraction (wood, hearts of palm, açaí and natural rubber), fishing, and tourist facilities.

4. Summary and Conclusions

The results of factorial analysis suggest that capital intensive, profit maximizing agriculture is not the main type of land use in the state of Pará. This differs from results arrived at by Gontijo and Aguirre (1988) working with the totality of uniform regions in Brazil. In the state of Pará, the types of land use that better approach their configuration are modern agriculture and commercial poultry husbandry (Factors 1 and 2).

The use of data limited to Pará did help to identify land use configurations that are typical to this region: slash and burn "wandering" agricultural land use (Factor 4), rural "mosaic" agricultural land use (Factor 7), and "rural residence" agricultural land use (Factor 9). When we work with data from all of Brazil, the variables forming these particular configurations fail to express themselves as main components of Brazilian land use. Even the relation between variables and factors in the remaining land use configurations found in Pará are distinct.

One flaw in our study has been its inability to properly reveal forestry and permanent, year round, farming activities. Although they were present in the initial variables, they where removed from the analysis for having too little relation to the remaining agricultural land-use variables. This may serve as evidence that forestry in Pará is based on extraction,

large informal and/or illegal activities, or is unimportant. However, this omission implies an under-estimation of some types of mechanized, permanent agriculture, as may be the case in the northeastern regions of Guama Bragantina and Tomé-Açú, where coconut, "Dendê", black pepper, and fruit are grown.

The concentration of more intense agriculture and animal breeding in areas surrounding Belém validates theoretical models of agricultural development that emphasize the influence of cities and industrial districts. This influence, however, is very limited in Pará; and the districts where modern agriculture is practiced are so distinct that they cannot be grouped with the other districts.

Slash and burn "wandering" agriculture (Factor 4) combined with small-animal husbandry (Factor 2) and other diversified farming activities (Factor 7) are the typical types of agricultural land use in Pará. These types agriculture involve little of the capital investment or modern technology occasionally employed in the state's northeast. Extensive cattle breeding (Factor 3) and semi-intensive cattle breeding (Factor 6) activities are generally to found in the state's southeast. Because of insignificant agricultural activity, most of the counties in Groups 4, 5, 6, 7 and 9, a vast area of the state, are not mentioned in the spatial distribution land use study; though, there is semi-intensive animal breeding (Factor 6) in the counties of Água Azul Do Norte (Group 7) and Almerim (Group 9) and an indication of modern commercial agriculture (Factor 1) in Santa Barbara do Pará (also, Group 9).

New roads helping to expand agriculture into virgin areas and small regional consumer markets have delayed the technological modernization of Para's existing agriculture sector activities. Socioeconomic and environmental conditions also hinder the modernization of agricultural practices in the Pará and other Amazon states, making the development of sustainable agricultural activities without government encouragement extremely difficult.

The recent introduction of soy and cotton in Pará's southern and southeastern "cerrado" (open pastures) lands enhances the possibilities of large-scale economic activity and the substitution of large property holdings for small farms. In order to accommodate this shift in land use,

the ideal policies should provide improved storage and transportation infrastructure in these areas. In the coastal areas of Salgado and Bragantina and also on the island of Marajó, agricultural land use could be considered a subsidiary to the development of tourism facilities.

Government policies for the Amazonian region in general and Pará in particular should provide incentives to promote the use of technologies better adapted to the region's land, climatic, and social conditions by focusing on agricultural development based on small family businesses. Local agricultural product producers should be encouraged seek out larger markets and take advantage of the regions' proximity to markets in North America and Europe. They should also be urged to rationally produce agricultural products using environmentally friendly technologies, thereby better exploiting product differentiation based on origin.

These types of policies would allow the region's small producers to increase their income through sustainable agriculture rather than through industrial employment and illegal, counter-productive wood harvesting activities while helping to reduce conflicts over land ownership in Pará's south and southeast.

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