AGRICULTURE MODERNIZATION AND THE TECHNOLOGY RANKING OF COUNTIES IN THE STATE OF MARANHÃO

Reginaldo Farias de Souza[1]
Ahmad Saeed Khan[2]

ABSTRACT

This work analyses the level of agricultural modernization and creating a ranking of 136 counties in the state of Maranhão. The data were obtained from the Brazilian Institute of Geography and Statistics (IBGE). The study uses factor analysis technique to describe current technologies and to generate the ranking. The results demonstrate variations in agricultural technology across the states, with only a small portion of the counties employing a modern technology as defined in terms of intensity of cultivation or by rates of capital per unit of labor. On the other hand, the producers in the majority of counties employ rudimentary, even primitive, technologies. Thus, the study concludes that Maranhão shows differences in agricultural technology and which require urgent measures to reduce technology disparities in agriculture and promote overall development.

Key words: Technology, ranking, counties, Maranhão.

[1] M.S. in Agricultural Economics, Ph.D. student in agricultural economics at Federal University of Viçosa – MG.
[2] Ph.D. Professor of Department of Agricultural Economic at Federal University of Ceara. Post Box 6017, Fortaleza, Ceará. Email: saeed@ufc.br

1 Introduction

The modernization of agriculture in Brazil, began with the industrialization of the country after the second world war. The increased demand by secondary sector accelerated urbanization and industrialization in the country. Hoffmann (1996) describes the modernization of the Brazilian agriculture, as the consolidation of a number of transformations occurred in agriculture or there is a deepening inter sector relationships with the increasing use of modern inputs such as, tractors, chemical fertilizers, insecticides, fungicides and herbicides, produced in the country.

According to Kageyama (1996), a modernization of agriculture in Brazil incorporates following three basic changes: first, the modernization is not only based on the increasing use of modern inputs, but also a change in labor use. A second change is represented by mechanization in the productive process, beginning with the preparation of soil to harvesting the crop, therefore, substituting the labor as well as the worker's manual ability and consequently, resulting in a qualitative jump in agricultural production. The third change is marked by the installation of basic industries (steel plant, petro-chemical, rubber and plastic industries) in the country, during the decades of 50 and 60, to produce agricultural machines and equipments.

During these decades, a package of modern techniques, based on agronomic sciences, was generated, mainly, in the United States and Japan and later on, was spread all over the world, particularly, in the developing countries which were looking for modernization of their traditional agriculture.

The diffusion technology model was assuming that substantial difference in agricultural productivity, among countries, could be reduced by the use of modern technologies in developing countries (Hayami and Ruttan, 1988).

The modernization of Brazilian agriculture, initially, was based

on the American model, which was embodying the increase in labor productivity. This process had the decisive participation of government which implemented various agricultural policy instruments, such as, extension and technical assistance, mechanization and agricultural financing etc, which have contributed to the increase in agricultural productivity and production (Monteiro, 1985). He agreed with Muller (1982) and Saint (1988), that the policies of agricultural modernization in Brazil were already oriented to the existing agrarian structure and the adoption of new technologies will benefit the medium and large farmers who do not produce desired results such as increased productivity and production as mentioned by Silva (1981), Ribeiro (1973), Pastore and Alves (1984) and Santana (1997).

The modernization of agriculture in Brazil occurred in a heterogeneous form. In the regions of South, Southeast and in few areas of Center-West, modern technologies are employed while farmers in the North and Northeast regions are using rudimentary practices, Hoffmann (1992) and Figueiredo and Hoffmann (1998).

During the decade of 70, the policy of subsidized agricultural credit to buy fertilizer, agricultural machines and equipments contributed substantially to the modernization of agriculture in the country. It is observed that policy benefited export crops produced in the Center-South region of the country. Northeast responsible for 22% of the agricultural production, during the decade of the 70s, received only 12% of the total agricultural credit. On the other hand, the three states of Center-South, producing wheat and soybean, received almost four times more credit than Northeast and are responsible for about 38% of the value of agricultural production (Goldin and Rezende, 1993).

Presently, in spite of the existence of several institutions responsible for promoting agricultural development in the Northeast, it is observed that low level of technology used in the region, comprised various states, having condition to produce different crops, given a regular rainfall in

large part of your area, for example, the state of Maranhão.

During the year 1995, service, industry and agriculture sectors contributed 65%, 18,9% and 16,1%, respectively, to state gross domestic product. It is important to know that 53,5% of the total labor force is employed in the agriculture sector. The main crops produced in the state are: sugarcane, rice, bean, cassava, corn, soybean and banana (IBGE, 1998).

Agriculture is responsible for providing employment opportunities to a large part of the population, but still traditional agricultural technology is used in the state of Maranhão.

It is important to note that agriculture in the state presents a great contrast. A small number of large farmers are employing modern technologies, on the other hand, a large number of small farmers are using traditional technologies, used in Brazil more than half century ago.

It is true that the implementation of policies promoting an increase in agricultural productivity by the use of modern technologies should not be compatible with satisfaction of present human needs, but also, should preserve the scarce resources for future generation (KHAN, 1997). Due to this, all the strategies for modernization of agriculture should consider the types of technology used in each region. It justifies the realization of research that provides information about relative level of agricultural development in the counties of Maranhão.

2 Methodology

2.1 Data Source

The data related to variables representing modernization of agriculture for each county of Maranhão were obtained from State Agriculture Census, for the year 1995/96, published by IBGE.

2.2 Factor Analysis

In a given region where the type of technologies used in agriculture can not be measured directly, but may be reflected by means of the association of a large number of indicators related to the package of technology employed in agriculture, it is important to use the statistical techniques capable to correlate the different indicators of technology to small number of artificial variables which permits to drive simple conclusions related to phenomenon under study.

Factor analysis technique allows interdependence among variables and transforms a large number of variables to a few variables called as factors. This technique explains the variation of a group of variables from different orthogonal factors, independent to each other (Hoffmann, 1992).

Factor analysis technique is of great importance, when a large number of variables have to be reduced by grouping those variable which have high correlation among themselves.

According to Norusis (1994), the basic factor analysis model may be written in the form:

$$Z_i = A_{i1} F_1 + A_{i2}F_2 +...+ A_{iK}F_K + d_iU_i \qquad (1 \leq K \leq N)$$

In this expression A_{iK} is value of standardized multiple-regression coefficient of variable K of factor K (factor loading); F_K is value of common factor K; U_i represents unique factor; d_i is the value of standardized regression coefficient of unique factor i.

In factor analysis, each factor is constituted by a linear combination of original variables included in the study. A linkage between factors and variables is given by saturation coefficients (factor loadings), which can have positive or negative values, but never more than unity. These factor loadings have the same interpretations as the regression coefficients (Simplicio, 1985).

The square of saturation coefficient (A^2_{iK}) is the contribution of factor K to the variance of Z_i. The sum of the squares of common-factor coefficients (saturation coefficients) is called the communality of variable Z_i and represents proportion of total variation of each variable explained by a set of factors considered in the study. The sum of the squares of common-factor coefficients for each factor is called "eigenvalue". The "eigenvalue" divided by the number of variables included in the research, represents the portion explained by a given factor to the investigated problem.

It is important to know that the communality in factor analysis has the same importance as coefficient of determination (R^2) in application of regression analysis.

For application of factor analysis, the variables representing Figueiredo and Hoffmann (1998), were used.

The included variables in the study were calculated as per unit of explored area (EA), measured in hectares (ha), as per unit of labor use, measured in man-day (EH); as portion of total number of farms (TE).

The explored area is defined as the sum of the areas occupied with permanent and temporary crops, cultivated and natural pasture and forest area. The term may-day means an adult working 8 hours/ day during one year.

In factor analysis, the selection of appropriate variables related to phenomenon under investigation is of vital importance. Once these variables are selected, they have significant influence on the results obtained by applying factor analysis technique.

To verify the appropriateness of the data for factor analysis, Kaiser-Mayer-Olkin (KMO) index was calculated which may vary from 0 to 1.

Bartlett statistic was used to test the null hypothesis that the correlation matrix is an identity.

After selecting the indicators of modernization of agriculture,

simple correlation matrix was calculated. From this matrix, using the Principal Component Method, factors were calculated. First factor has more weight in relation to the second factor which is more important than the third and so on (Hoffmann (1994); Mayorga (1997)).

To simplify the readings of results, factor rotation by varimax method was made. This way, the factors remained directly related to the specific group of variables, altering the contribution of each factor in explaining the variance of indicators of modernization, however, without changing the proportion of the total variance explained by these indicators.

After factor rotation, factor coefficient matrix was obtained by multiplying the transposed matrix of factor loadings with inverse of simple correlation matrix of variables considered in the study.

The matrix of factor scores is a product of the factor coefficient matrix and the transport matrix of standardized variables.

2.3 Definition of Variables

The variables considered to determine relevant factors related to the level of modernization in the counties of the state of Maranhão are following:

X_1 = number of mechanical plows per unit explored area;
X_2 = number of animal plows per unit explored area;
X_3 = number of tractors per unit explored area;
X_4 = number of tractors per unit labor;
X_5 = proportion of farms using insecticides;
X_6 = proportion of farms using organic and / or inorganic fertilizer;
X_7 = proportion of farms applying animal power;
X_8 = proportion of farms using mechanical power;
X_9 = proportion of farms having electricity;
X_{10} = proportion of irrigated area;
X_{11} = consumption of fuel per unit explored area;

X_{12} = labor per unit of explored area;
X_{13} = proportion of farms receiving technical assistance;
X_{14} = credit per unit of explored area;
X_{15} = investment per unit of explored area;
X_{16} = credit per unit of labor;
X_{17} = investment per unit of labor;
X_{18} = proportion of cooperative farms;
X_{19} = production value per unit explored area;
X_{20} = production value per unit of labor;
X_{21} = fertilizer, corrective and seed expenditures per unit explored area;
X_{22} = total expenditures per unit of explored area;
X_{23} = total expenditures per unit of labor.

3 Results and Discussion

3.1 Agricultural Technology used in the Counties of State of Maranhão

The calculated value of Kaiser-Mayer-Olkin Index (0,757) indicated that the original data is appropriate for factor analysis. The Bartlett test (662,12) rejects the hypothesis of identity of correlation matrix and suggests the use of factor analysis technique.

The application of factor analysis by using principal component method, based on simple correlation matrix, three characteristic roots with decreasing value of 8,41; 4,17 and 1,85 were obtained. These jointly, explained 62,75% of total variation of 23 indicators of modernization of agriculture used in the study.

After factor rotation, the obtained factor loadings are presented in Table 1. These factor loadings correspond to the correlation coefficient between each factor and each of these variables considered in the research.

The communality value, obtained as the sum of square of factor loadings, for each variable, is given in Table 1. It represents the proportion of variance of each variable explained jointly, by three factors. The percentage of total variance of all variables explained by each factor is also shown in Table 1. This percentage is calculated from the ratio between the sum of square of loadings of each factor and a number of variables included in the model.

It is observed from Table 1 that the factor 1 (F_1) is positively related to intensive use of land (X_1, X_3, X_5, X_6, X_{10}, X_{15}, X_{21}), energy use per unit of explored area (X_9, X_{11}) and production value and total expenditure per unit of explored area (X_{19}, X_{22}). The variables related to F_1 indicate that factor represents the intensive use of land.

Analyzing the loadings related to factor 2 (F_2), one may conclude that this factor is strongly related to variables, such as, X_4, X_{16}, X_{17}, X_{20} and X_{23}.

This factor represents the capital use per unit of labor in agriculture in the state of Maranhão.

Factor 3 (F_3) shows a strong positive association with variables X_2 and X_7, indicating the use of traditional agricultural technology in the State.

Table 1. Factor loadings (after varimax rotation) of three factors and communality of 23 indicators of agriculture modernization in "counties" of the State of Maranhão.

Variables	F_1	F_2	F_3	*Communality*
X_1	0,8120	0,1420	0,2080	0,7228
X_2	-0,0210	-0,0730	0,6340	0,4077
X_3	0,5920	0,0129	0,4590	0,5613
X_4	-0,0044	0,8930	-0,0440	0,7994
X_5	0,7310	-0,1290	-0,0032	0,5510
X_6	0,7450	0,2200	-0,1220	0,6183
X_7	-0,0740	0,0130	0,7390	0,5518
X_8	0,0425	0,5750	-0,1740	0,3627
X_9	0,7090	0,1780	-0,2230	0,5841
X_{10}	0,5800	0,0124	0,0468	0,3387
X_{11}	0,5720	0,2050	0,1850	0,4034
X_{12}	0,5550	-0,2530	0,4180	0,5468
X_{13}	0,4980	0,3410	-0,1370	0,3831
X_{14}	0,1860	0,1860	0,5750	0,3998
X_{15}	0,8750	0,0741	0,2060	0,8136
X_{16}	-0,0600	0,8620	0,1620	0,7729
X_{17}	-0,0330	0,8950	0,1020	0,8125
X_{18}	0,6060	0,3540	-0,0055	0,4926
X_{19}	0,9410	-0,0520	0,0540	0,8911
X_{20}	0,4100	0,8020	0,0097	0,8114
X_{21}	0,9280	0,0636	-0,0120	0,8654
X_{22}	0,9440	0,0139	0,0659	0,8957
X_{23}	0,2430	0,8810	0,1010	0,8454
% of Explained Variance	34,20	20,04	8,51	-

Source: Research results

3.2 Ranking of Counties in the State of Maranhão

After achieving information about the nature of each factor (F_1 – land use intensity, F_2 – capital-labor ratio, F_3 – use of traditional technology), it becomes easier to interpret the scores obtained through factor analysis.

It is important to know that factor scores (F_1, F_2, F_3) are normally distributed with zero mean and unity variance. The factor scores with value close to zero, means an average level of modernization of agriculture in relation to this factor. A larger factor score value, in relation to zero, represents an advanced use of technology in agriculture in the counties and low score value means that a traditional agriculture practiced in the counties of Maranhão. The high value of factor score of F_1 above zero suggests an intensive use of land. Similar interpretation for F_2 and F_3 can be made.

Based on joint factor score, the ranking of counties were made by considering the relative level of technology used by each of them.

Index score and relative index (based on 100) for each county is shown in Table 2. The ranking of counties in relation to use of agricultural technology (Table 2) reveals that Tasso Fragoso, São Luis and São José de Ribamar represented better level of agricultural technology, followed by the counties of Guimaraes, Barreirinhas, Imperatriz, Bacuri, Paco do Lumiar, Açailandia and Benedito Leite.

The county Tasso Fragoso is located in the "cerrado" region of Maranhão where rice and soybean are the main crops. The variables such as total investment per labor unit, production value per unit of labor, total expenditure per unit of labor have contributed to put the county in first place.

Table 2. Ranking of counties in decreasing order in relation to use of agricultural technology in the State of Maranhão.

"Counties"	Index score	Index based on 100	Ranking
Tasso Fragoso	9,66	100,00	1
São Luís	8,82	92,22	2
São José de Ribamar	7,00	75,36	3
Guimarães	6,92	74,64	4
Barreirinhas	4,38	51,11	5
Imperatriz	3,64	44,22	6
Bacuri	3,52	43,09	7
Paço do Lumiar	2,51	33,75	8
Açailândia	2,17	30,62	9
Benedito Leite	2,17	30,60	10
Balsas	1,98	28,88	11
Palmeirândia	1,94	28,44	12
São Raimundo das Mangabeiras	1,81	27,23	13
Cururupu	1,52	24,63	14
Porto Franco	1,49	24,27	15
Mirinzal	1,15	21,16	16
Alto Parnaíba	1,00	19,78	17
Alcântara	0,98	19,56	18
Rosário	0,97	19,50	19
Miranda do Norte	0,96	19,44	20
Peri Mirim	0,90	18,83	21
Estreito	0,43	14,47	22
Sambaíba	0,36	13,87	23
Esperantinópolis	0,27	13,05	24
Bequimão	0,23	12,60	25
São Mateus do Maranhão	0,22	12,58	26
Coelho Neto	0,22	12,51	27
São Domingos do Maranhão	0,20	12,33	28

Table 2. Ranking of counties in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continuation)

"Counties"	Index score	Index based on 100	Ranking
Fortaleza dos Nogueiras	0,18	12,14	29
Icatu	0,09	11,30	30
Olho d'água da Cunhãs	0,05	10,93	31
Bacabal	0,00	10,53	32
Pindaré Mirim	0,00	10,51	33
Vitorino Freire	-0,01	10,38	34
São Luís Gonzaga do Ma	-0,04	10,11	35
Riachão	-0,06	9,94	36
Presidente Dutra	-0,11	9,51	37
Tuntum	-0,13	9,29	38
Matinha	-0,14	9,19	39
Cedral	-0,16	8,99	40
Vitória do Mearim	-0,17	8,93	41
Penalva	-0,18	8,88	42
Barra do Corda	-0,19	8,74	43
Timon	-0,20	8,67	44
Magalhães de Almeida	-0,20	8,63	45
Montes Altos	-0,24	8,32	46
Carolina	-0,25	8,19	47
Santa Rita	-0,26	8,12	48
Arari	-0,28	7,89	49
Pinheiro	-0,31	7,67	50
Cajapió	-0,31	7,62	51
Lago Verde	-0,34	7,31	52
João Lisboa	-0,35	7,23	53
Zé Doca	-0,36	7,16	54
Santa Inês	-0,38	7,02	55
Luís Domingues	-0,38	6,95	56
São Vicente de Ferrer	-0,43	6,48	57

Table 2. Ranking of counties in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continuation)

"Counties"	Index score	Index based on 100	Ranking
Monção	-0,44	6,42	58
São Bento	-0,46	6,27	59
Pedreira	-0,46	6,24	60
Lima Campos	-0,47	6,10	61
Araioses	-0,48	6,10	62
Itapecuru Mirim	-0,49	5,93	63
Cantanhede	-0,54	5,52	64
Brejo	-0,54	5,47	65
Nova Iorque	-0,54	5,46	66
Buriti Bravo	-0,55	5,40	67
Colinas	-0,56	5,34	68
Governador Archer	-0,56	5,31	69
São João Batista	-0,57	5,20	70
Anajatuba	-0,58	5,13	71
Amarante do Ma	-0,59	5,04	72
Dom Pedro	-0,60	4,99	73
Santa Luzia do Paruá	-0,61	4,87	74
Sítio Novo	-0,61	4,86	75
Grajaú	-0,62	4,74	76
Caxias	-0,62	4,74	77
Anapurus	-0,64	4,62	78
Santo Antônio dos Lopes	-0,65	4,49	79
Santa Helena	-0,65	4,46	80
Barão de Grajaú	-0,65	4,44	81
Godofredo Viana	-0,66	4,42	82
Loreto	-0,67	4,30	83
Tutóia	-0,69	4,10	84
Pio XII	-0,69	4,06	85
Codó	-0,71	3,88	86
São João dos Patos	-0,72	3,88	87

Table 2. Ranking of counties in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continuation)

"Counties"	Index score	Index based on 100	Ranking
Santa Luzia	-0,73	3,71	88
Fortuna	-0,73	3,70	89
Pastos Bons	-0,74	3,65	90
Santa Quitéria do Ma	-0,75	3,53	91
Parnarama	-0,75	3,52	92
Igarapé Grande	-0,77	3,41	93
Altamira do Maranhão.	-0,82	2,92	94
Matões	-0,82	2,89	95
Gonçalves Dias	-0,83	2,77	96
Carutapera	-0,84	2,71	97
Viana	-0,84	2,68	98
Humberto de Campos	-0,85	2,59	99
Urbano Santos	-0,86	2,55	100
São Bernardo	-0,87	2,49	101
Axixá	-0,87	2,48	102
Mirador	-0,87	2,45	103
Cândido Mendes	-0,87	2,45	104
Vargem Grande	-0,87	2,42	105
Paraibano	-0,88	2,33	106
Bom Jardim	-0,89	2,25	107
Lago do Junco	-0,89	2,23	108
Poção de Pedras	-0,90	2,19	109
Aldeias Altas	-0,90	2,18	110
Coroatá	-0,91	2,11	111
Turiaçu	-0,91	2,10	112
Duque Bacelar	-0,91	2,09	113
Graça Aranha	-0,91	2,08	114
Nina Rodrigues	-0,91	2,04	115
Joselândia	-0,92	1,99	116
Lago da Pedra	-0,92	1,99	117
Paulo Ramos	-0,92	1,94	118

Table 2. Ranking of counties in decreasing order in relation to use of agricultural technology in the State of Maranhão.(continuation)

"Counties"	Index score	Index based on 100	Ranking
Pirapemas	-0,93	1,92	119
Arame	-0,93	1,85	120
Governador Eugênio Barros	-0,95	1,73	121
Sucupira do norte	-0,96	1,63	122
São Benedito do Rio Preto	-0,96	1,58	123
Buriti	-0,97	1,48	124
São Francisco do Maranhão	-0,98	1,45	125
Mata Roma	-0,98	1,43	126
Afonso Cunha	-0,99	1,38	127
Chapadinha	-1,01	1,10	128
Cajari	-1,02	1,07	129
Presidente Vargas	-1,02	1,05	130
Passagem Franca	-1,03	0,99	131
Primeira Cruz	-1,06	0,69	132
Timbiras	-1,06	0,68	133
Presidente Juscelino	-1,07	0,55	134
São Félix de Balsas	-1,10	0,29	135
Morros	-1,13	0,00	136

Source: Research results

The sugarcane and tomato are the principal crops produced in the county of São Luis. The variables such as, intensive use of land, due to scarcity caused by the urbanization, the variables such as, high use of fuel per unit explored area, total expenditure per unit area, high investment per unit explored area and high production value per unit explored area have placed the county second in ranking.

São José de Ribamar, third placed in ranking, has more diversified agriculture among these three counties. The crops produced are: cassava, tomato, lemon, passionflower and papaya. Variables such as,

high expenditure per acre with modern inputs, intensive use of land, high production value and total expenditure per unit area and also per unit labor have contributed to this high ranking of the county.

To the lower end of ranking, it is observed that the county of Morros has lowest level of agricultural technology in the state of Maranhão, followed by São Félix the Balsas, Presidente Juscelino, Timbiras, Santa Cruz, Passagem França, Presidente Vargas, Cajari, Chapadinha and Afonso Cunha.

The main crops produced in these counties are rice, corn, cassava and sugar cane, which are not decisive in relation to ranking received by them. The form in which these activities are planned as well as the factors of production are used might have contributed to their low ranking.

In general, the counties using low level of agricultural technology show a shortage in the following factors of production: number of tractors per unit area and also per unit labor and proportion of irrigated area. It is sure that these factors with combination to others have contributed to lower ranking of these counties.

The contrast observed, among counties of Maranhão, in relation to level of agricultural technology used requires that the government should create new development programs to reduce disparity among counties.

Some of the action already taken by the government, such as, implantation of irrigation projects, distribution of irrigation kits, technical assistance are good examples and should be given priority to the low ranking counties, in exception to the ones with no agricultural potentialities.

4 Conclusions and Suggestions

The results of the study showed that 131 out of 136 counties of the State of Maranhão represented less than 50% of level of technology observed in the first ranked county.

Five counties using more advanced level of technology are Tasso Fragoso, São Luis, São José de Ribamar, Guimaraes e Barreirinhas. On the other hand, five low ranked counties are listed as: Morros, São Felix de Bolsas, Presidente Juscelino, Timbiras and Primeira Cruz.

The government support in the form of constructing infrastructure of highways and electricity net work in the rural area, technical assistance of good quality is of fundamental importance for rural development of these counties. In addition, the government should also encourage agricultural technical teaching in rural area, formation of association and cooperative societies of farmers and increase credit facilities by reducing bureaucracy existing in public and private financing institutions.

The government should take concrete and effective action to reduce the existing contrast in technology used in the state of Maranhão. In order to obtain full potential of each region, it is necessary to use an adequate package of thecnology which is competitive with environment preservation. The modernization of agriculture that contributes to increase economic returns does not necessarily means the use of large amount of modern inputs, but the rational use of natural resources by using appropriate techniques of production.

5 References

HAYAMI Yujiro e RUTTAN, Vernon W. Desenvolvimento agrícola: teoria e experiências internacionais. Brasília: EMBRAPA, 1988. 583p.

HOFFMANN, Rodolfo. A dinâmica da modernização da agricultura em 157 microrregiões homogêneas do Brasil. Revista de Economia e Sociologia Rural, Brasília, v.30, n.4, 1992. p.271-290.

_____. Componentes principais e análise fatorial. 3 ed. Piracicaba ESALQ/USP, 1994. (Série didática n. 90)

_____. Distribuição da renda e pobreza na agricultura brasileira. IN: DELGADO, G. C., CASQUES, J. G., VILLA VERDE, C. M. Agricultura e Políticas Públicas. 2 ed. Brasília: IPEA, 1996. p. 3-111.

IBGE. Censo agropecuário de 1995-1996. Rio de Janeiro, n.7, 1998. (Estado do Maranhão).

KAGEYAMA, Angela, BUAINAIN, Antônio Márcio, REYDON, Bastiaan P., GRAZIANO DA SILVA, José, SILVEIRA, José Maria J., FONSECA, Maria da Graça D., RAMOS, Pedro, FONSECA, Rinaldo B., BELIK, Walter. O novo padrão agrícola brasileiro: do complexo rural aos complexos agroindustriais. IN: DELGADO, G. C., CASQUES, J. G., VILLA VERDE, C. M. Agricultura e Políticas Públicas. 2 ed. Brasília: IPEA, 1996. p. 113-223.

KHAN, Ahmad Saeed. Conservação do solo e produtividade agrícola: um estudo de caso. IN: CAMPOS, Robério Telmo (organizador), KHAN, Ahmad Saeed, Biserra, José Valdeci e Sales, Patrícia Verônica. Mudança tecnológica na agricultura. Fortaleza: Edições UFC, 1997. p.53-96.

MAYORGA, Ruben Dario. Níveis de qualidade de vida nos municípios com maiores índices de degradação ambiental no semi-árido cearense. Fortaleza: UFC, 1997. 58p. (Tese do concurso de professor titular).

MEYER, Leandro Frederico Ferraz e SILVA, José Maria Alves da. A Dinâmica do progresso técnico na agricultura mineira: resultados e contradições da política de modernização da década de setenta. Revista de Economia e Sociologia Rural. Brasília: SOBER, v.36, n.4, 1998. p. 39-70.

MONTEIRO, José de Anchieta. A Geração de tecnologia e a ação de grupos de interesse. São Paulo: IPE/USP, 1985. 170p. (Tese de doutorado).

MÜLLER, Geraldo. Estado e classes sociais na agricultura. IN: Estudos econômicos. São Paulo: IPE/USP, v.12, n.2, ago. 1982. p. 81-94.

NORUSIS, M. J. SPSS Guide. 1994.

PASTORE, José e ALVES, Eliseu Roberto de Andrade. Reforming the brazilian agricultural research system. IN: YEGANIANTZ, Levon. Brazilian agriculture and agricultural research. Brasília: EMBRAPA, 1984. p. 117-149.

RIBEIRO, Sílvio Wanick. Desempenho do setor agrícola: década de 1960/ 70. Brasília: IPEA, 1973. 176p. (série estudos para o planejamento).

SANTANA, A.C. Modelos alternativos de desenvolvimento. IN: SANTANA, A. C., D'ÁVILA, J. L., ALENCAR, M. I. R.. de, MATTAR, P. N., SOUZA, R. F., COSTA, R. M. Q. da. Reestruturação Produtiva e Desenvolvimento na Amazônia: condicionantes e perspectivas. Belém: BASA; FCAP, 1997. p.60-94.

SANTOS, Robério Ferreira dos. O Crédito rural na modernização da agricultura brasileira. Revista de Economia e Sociologia Rural. Brasília, v.26, n. 4, out./dez. 1988. p. 393-404.

SILVA, José Graziano da. A Modernização dolorosa: estrutura agrária, fronteira agrícola e trabalhos no Brasil. Rio de Janeiro: Zahar, 1981. 191p.

SIMPLÍCIO, Thelma Alves. Caracterização socioeconômica do desenvolvimento do setor rural do Nordeste brasileiro. Fortaleza: UFC, 1985. 99p. (Dissertação de Mestrado).