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An application of principal component analysis on factors associated with milk production in Tamil Nadu

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ABSTRACT : A study was conducted to analyse the factors associated with the milk production in Tamil Nadu using principal component analysis. The results of the principal component analysis in milk production of the state of Tamil Nadu revealed that milk production was having positive relationship with the indigenous cattle population, she-buffalo population, number of veterinary institutions, gross cropped area, area under paddy, area under groundnut, native purebred cattle population, graded and indigenous buffalo population, agricultural labour population, crossbred cattle population, no. of financial institutions and graded buffalo population. The results indicated that growth in milk production potential would be technology driven which was seen from the positive association of milk production with the crossbred cattle population in dimension three and graded buffaloes population. This suggested that effecting a shift in herd structure in favour of crossbred cows and graded buffaleos can augment the milk production potential.

KEY WORDS : Milk production, Determinant factors, Principal component analysis

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INTRODUCTION

Dairy farming as visualized by the farmers in Tamil Nadu state is it is part of an integrated agricultural system where dairy and agriculture complement each other. Dairy farming can act as an instrument to enhance the income and livelihood of small and marginal land holders and it can act as an important subsidiary source of income. Through improved breeding, feeding and operation flood programmes, there has been marked improvement in the country's milk production and productivity of milch animals. Tamil Nadu, the southernmost state of India is one of the top ten milk producing states in the country with an annual milk production of 6.83 million tonnes (Statistical Handbook of Tamil Nadu, 2012). Effective planning and policy making for the development of dairy sector in a state could be brought about by studying the factors associated with milk production at macro level. These factors are often interdependent of each other. Hence regular procedures of regression tools would not be effective in studying the factors associated with milk production in the state. Keeping all these factors in mind an attempt was made to analyse the factors associated with milk production in the state of Tamil Nadu using principal component analysis, a multivariate analytical approach.

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MATERIAL AND METHODS

Principal component analysis:

The multivariate analytical tool, principal component analysis was used to reduce the dimensionality of multivariate data. In this technique correlations and interactions among the variables are summarized in terms of a small number of underlying factors. The method rapidly identifies key variables or groups of variables that control the system under study. Principal component analysis of a set of 'm' original variables generate 'm' principal components, PC_1, PC_2, ... PC_m, with each principal component being a linear combination of Ss' scores on the original variable, *i.e.*

$$PC_1 = b_{1\,1} X_1 + b_{1\,2} X_2 + \ldots + b_{1\,m} X_m = Xb_1 ;$$
$$PC_2 = b_{2\,1} X_1 + b_{2\,2} X_2 + \ldots + b_{2\,m} X_m = Xb_2 ;.$$

$PC_m = b_{m1} X_1 + b_{m2} X_2 + \ldots + b_{mm} X_m = Xb_m$

where,

b_i refer to the coefficients, i = 1 to m

x_i refer to the variables, i = 1 to m

The coefficients for PC_1 are chosen so as to make its variance as large as possible. The coefficients for PC_2 are chosen so to make the variance of this combined variable as large as possible, subject to the restriction that scores on PC_1 and PC_2 (whose variance has already been maximized) be uncorrelated. In general, the coefficients for PC_1 are chosen so as to make its variance as large as possible, subject to the restriction that it be uncorrelated with scores on PC_1 through PC_{i-1}.

If b_{ij} is the coefficient of linear transformation where j refers to the component and i to the original variable, then,

$$\sum_{i=1}^{n} b_{ij}^2 = 1$$

where,

n = number of variables

Thus, b^2_{ij} gives the variation of variable i in the j^{th} component.

It is then possible to ascertain the variation attributable to each component for the selected variable. (Karamathullah *et al*.,2002).

The principal component analysis was employed to study the factors which together impinge on the milk production in various districts of Tamilnadu. Selvakumar (1996) employed multivariate techniques such as principal component analysis and factor analysis to identify the factors influencing milk production. In the present study the 17 dairy related variables were considered district-wise. The variables refer to the 17 numbers of dairy related variables. (X_1 – Milk production …… X_{17} – Average annual rainfall).

List of variables taken for analysis

Sr. No.	Variables
1.	Milk production per 100 sq.km of the district (in '000 tonnes)
2.	Indigenous cattle population per 100 sq.km (in numbers)
3.	Cross bred and Exotic cattle population per 100 sq.km (in numbers)
4.	Native purebred cattle population per 100 sq.km (in numbers)
5.	Indigenous buffalo population per 100 sq.km (in numbers)
6.	Graded buffalo population per 100 sq.km (in numbers)
7.	She-buffalo population per 100 sq.km (in numbers)
8.	Veterinary institution per 100 sq.km (in numbers)
9.	Financial institution per 100 sq.km (in numbers)
10.	Agricultural labour population per 100 sq.km (in numbers)
11.	Area under permanent pasture per 100 sq.km (in ha)
12.	Area under paddy per 100 sq.km (in ha)
13.	Area under maize per 100 sq.km (in ha)
14.	Area under groundnut per 100 sq.km (in ha)
15.	Area under other cereals per 100 sq.km (in ha)
16.	Gross cropped area per 100 sq.km (in ha)
17.	Average annual rainfall (in mm)

RESULTS AND DISCUSSION

The results of the principal component analysis in milk production of the state are given in Table 1. and 2. Table 1 shows the component loadings and Eigen values for each component. The eigen values of the first five components are more than one and these components were able to explain about 85.8 per cent of the variation. Table 2 gives the details of extracted components, which are extracted by using the components having the highest zero order correlation for milk production.

In Table 2 milk production was considered as the dependant variable. In the first component of the extracted component matrix, milk production was having positive relationship with the indigenous cattle population, she-buffalo population, no. of veterinary institutions, gross cropped area, area under paddy, area under groundnut, native purebred cattle population, graded and indigenous buffalo population and agricultural labour population. In the third component, the variables, crossbred cattle population, no. of financial institutions and graded buffalo population have positive relationship with milk production.

The results of principal component analysis thus suggested that growth in milk production potential would be technology driven which was seen from the positive association of milk production with the crossbred cattle population in dimension three and graded buffaloes population in dimension one. This suggests that effecting a shift in herd structure in favour of crossbred cows and graded buffaleos can augment the milk production potential. Birthal *et al.* (1999) observed similar findings.

The positive association between milk production and the number of veterinary institutions and the number of financial institutions was on expected lines. This has proved the fact that development of animal health services in the country had significantly reduced the incidence of animal diseases and avoided yield loss (Singh *et al.*, 1998). Animal health services also influence milk production through dissemination of yield increasing technology and breeding services. Similarly, the financial institutions have also played a crucial role in enhancing the investment made on dairy farming through various schemes and livestock loans.

Summary:

The results of the principal component analysis in milk production of the state of Tamil Nadu revealed that milk production was having positive relationship with the indigenous cattle population, she-buffalo population, number of veterinary institutions, gross cropped area, area under paddy, area under groundnut, native purebred cattle population, graded and indigenous buffalo population, agricultural labour population, crossbred cattle population, no. of financial institutions and graded buffalo population. The results

Table 1 : Principal component Analysis for milk production in Tamil Nadu

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Milk production	0.800	-0.038	0.459	0.021	-0.115	0.005	-0.110	-0.079	0.243	-0.156	-0.181	-0.004	0.013	-0.021	-0.003	0.012	0.005
Cross Bred population	0.222	0.510	0.546	0.421	-0.210	-0.094	0.310	0.168	-0.106	-0.116	0.023	0.098	0.048	-0.025	-0.026	-0.012	-0.005
Indigenous population	0.721	0.093	-0.646	0.029	0.029	-0.040	0.163	0.080	0.104	-0.001	0.045	0.003	0.024	0.032	-0.036	-0.023	0.028
She buffalo population	0.762	-0.504	0.236	-0.219	0.106	0.007	0.007	-0.146	-0.086	-0.060	0.025	0.083	0.004	0.090	-0.042	0.018	-0.009
Veterinary Institution	0.578	0.653	0.270	-0.127	0.101	0.035	0.156	-0.074	-0.008	0.303	-0.108	0.044	-0.054	-0.014	-0.025	-0.002	-0.001
Financial Institution	0.210	0.706	0.550	-0.033	-0.094	0.134	0.202	-0.187	0.122	0.011	0.168	-0.075	0.018	0.030	0.039	0.010	0.003
Permanent pasture	0.146	-0.575	-0.020	-0.453	-0.293	0.470	0.328	0.151	-0.033	-0.025	0.004	-0.031	-0.027	-0.034	-0.011	0.016	0.002
Gross cropped area	0.861	0.235	-0.020	0.248	0.048	0.180	-0.255	0.057	0.011	-0.079	0.098	-0.048	-0.138	-0.017	-0.026	-0.016	-0.009
Area under maize	-0.376	-0.068	0.398	0.059	0.721	0.319	-0.034	0.226	0.114	0.010	0.020	0.053	0.034	0.005	0.000	0.001	0.001
Area under paddy	0.588	0.505	-0.528	-0.210	0.114	0.061	-0.100	-0.086	-0.046	-0.067	0.056	0.167	0.002	-0.048	0.037	0.024	0.005
Area under other cereals	0.099	-0.401	-0.188	0.701	-0.266	0.410	-0.154	-0.135	0.001	0.127	0.004	0.040	0.058	0.002	-0.003	0.008	0.001
Area under groundnut	0.567	-0.649	0.221	0.295	-0.067	-0.205	0.104	0.211	0.007	0.071	-0.001	0.046	-0.082	0.029	0.066	0.013	0.007
Rainfall	0.269	0.691	0.066	-0.286	-0.343	0.142	-0.359	0.293	-0.049	0.038	-0.040	-0.003	0.049	0.051	0.017	-0.004	-0.001
Native pure bred population	0.752	-0.059	-0.570	0.043	0.041	-0.165	0.127	0.144	0.158	0.071	0.036	-0.046	0.065	-0.011	-0.004	0.017	-0.026
Graded buffalo population	0.544	-0.456	0.563	-0.145	0.011	-0.220	-0.267	0.047	-0.065	0.099	0.116	-0.046	0.056	-0.055	-0.027	0.015	0.012
Indigenous buffalo population	0.781	-0.536	0.147	-0.228	0.053	0.079	0.011	-0.105	-0.029	0.015	-0.001	0.022	0.050	-0.017	0.043	-0.059	-0.008
Agri.labour population	0.797	0.250	-0.138	0.226	0.354	0.089	0.096	-0.014	-0.235	-0.060	-0.092	-0.142	0.035	0.003	0.020	0.014	0.005
Eigen values	5.927	3.717	2.565	1.344	1.033	0.709	0.643	0.370	0.207	0.186	0.114	0.087	0.051	0.022	0.016	0.007	0.002
Percentage variation	34.867	21.863	15.089	7.905	6.079	4.168	3.784	2.177	1.219	1.094	0.671	0.510	0.300	0.130	0.092	0.040	0.012

Table 2 : Extracted components for milk production

Variables	1	2	3	4	5
Milk production	0.800	-0.038	0.459	0.021	-0.115
Cross Bred population	0.222	0.510	0.546	0.421	-0.210
Indigenous population	0.721	0.093	-0.646	0.029	0.029
She buffalo population	0.762	-0.504	0.236	-0.219	0.106
Veterinary Institution	0.578	0.653	0.270	-0.127	0.101
Financial Institution	0.210	0.706	0.550	-0.033	-0.094
Permanent pasture	0.146	-0.575	-0.020	-0.453	-0.293
Gross cropped area	0.861	0.235	-0.020	0.248	0.048
Area under maize	-0.376	-0.068	0.398	0.059	0.721
Area under paddy	0.588	0.505	-0.528	-0.210	0.114
Area under other cereals	0.099	-0.401	-0.188	0.701	-0.266
Area under groundnut	0.567	-0.649	0.221	0.295	-0.067
Rainfall	0.269	0.691	0.066	-0.286	-0.343
Native pure bred population	0.752	-0.059	-0.570	0.043	0.041
Graded buffalo population	0.544	-0.456	0.563	-0.145	0.011
Indigenous buffalo population	0.781	-0.536	0.147	-0.228	0.053
Agri.labour population	0.797	0.250	-0.138	0.226	0.354

indicated that growth in milk production potential would be technology driven which was seen from the positive association of milk production with the crossbred cattle population in dimension three and graded buffaloes population. This suggested that effecting a shift in herd structure in favour of crossbred cows and graded buffaleos can augment the milk production potential.

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