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Composite index for cash crop production

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ABSTRACT

Cash crops are those crops that are grown for sale rather than consumption by the farmers.These crops provide income to the farmer immediately after harvest of the crop, thus it fulfill the economic need of the farmer instantly. Different cash crops are grown in different region of the India. Cotton, Jute, Mesta, Sugarcane and Tobacco are the major cash crop in India.Cotton, Jute, Mesta are fiber crop but it provide income to the farmers immediately after harvest, thus these crops are included in the study. In the present study, ranking of the states has been done on the basis of Cash Crop Index (CCI). The CCI has been constructed using Principal Component Analysis (PCA) for several states of the country. The state wise secondary data on production of Cotton, Jute, Sugarcane and Mesta for the year 2013-14 were taken from Directorate of Economics and Statistics, Gov. of India. The PCA methodology has been used for construction of index and the ranking of the states was performed based on the developed CCI. It was found that West Bengal ranked first in CCI followed by Bihar and Andhra Pradesh. It was also investigated that the CCI was highly sensitive to Jute production followed by Mesta and Cotton production.

***Keywords* :** Cash crop index, composite index, indicator, principal component analysis

1. Introduction

Cash crops are those crops which are produced for the purpose of marketing. Cash crop farming is also called commercial farming or cash cropping. Different cash crops are grown in different states of the India. Cotton, sugarcane, oilseeds, vegetables and fruits are the major cash crops of Haryana whereas in Kerala, tea, ginger, coconut, coffee, and cashew are the main cash crops. Many cash crops like sugarcane, cotton, oilseeds, rubber, coffee, tea and chillies are grown in Tamil Nadu. In West Bengal, jute is the important cash crop. The aromatic and medicinal plants are considered as cash crops in the state of Jharkhand. Among several cash crops, fiber crops are of great importance. Cotton, jute, mesta, sugarcane and tobacco are the major cash crop in India. In the present study, to compare the scenario of production of cash crops in different states of the India, Cash Crop Index has been constructed and ranking of the states have been done on the basis of constructed index.

An indicator is a quantitative or a qualitative measure that can assign relative positions in a particular area. Indicators are useful for determining trends and making conclusions about particular issues in policy analysis. A composite indicator is formed when many indicators are compiled into a single index using a specific methodology. The composite indicator can measure multi-dimensional concepts, which cannot be explained using a single indicator.

Composite Index has been constructed by mainly authors using different methodology and technique. Among them, Analytic Hierarchy Process (AHP) is an important technique that is being used extensively in many areas. AHP is based on expert judgment and the experts of related field give their opinion/priorities to many alternatives to analyze and support decisions. It is subjective in nature because it is based on expert's judgment. Environmental problem index was developed using AHP considering public opinion as a weighting technique (Parker, 1991). AHP was also used in landfill siting using GIS (Siddique *et al.*, 1996). A methodology for construction of composite index was proposed and used in construction of development index (Narain *et al.*, 1991). The methodology involves the problem of multicollinearity. A potential agro forestry area was identified using Objective Analytic Hierarchy Process (OAHP) (Ahmad *et al.*, 2003). Socio-economic development of different districts of Kerala was also estimated (Narain *et al.*, 2005). The techniques used above to construct composite index is either subjective in nature or involves the problem of multicollinearity. In case of multicollinearity present in the dataset, the weight of one variable is added up to the weight of correlated variables, thus yields poorly constructed composite index. A new methodology was proposed by Kumar *et al.*, (2013) and in this, Principal Component Analysis (PCA) was used in construction of composite index to overcome the problem of multicollinearity. Kumar *et al.* (2013) constructed Agriculture Development Index of Bihar state, India using the proposed methodology. Also, Flower Production Index (FPI) was constructed using PCA for 18 districts of West Bengal state, India (Kumar *et al.*, 2015). Thus, the methodology developedby Kumar *et al.*, 2013 has been used for construction of Cash Crop Index. Secondary data on production of cotton, jute, sugarcane and mesta for the year 2013-14 have been used for constructing the CCI.

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MATERIALS AND METHODS

In the present paper, composite index namely Cash Crop Index has been constructed using secondary data taken from Directorate of Economics and Statistics, Govt. of India. The state level data on production of cotton, jute, sugarcane and mesta for the year 2013-14 have been used in the construction of composite index. The methodology developed by Kumar *et al.*, 2013 as given below has been used for constructing the Cash Crop Index. The statistical analysis was performed using SAS-9.3.

Maximum Likelihood Estimate (MLE) of variance-covariance matrix (Σ) of the given data set was estimated using equation-1

$$\hat{\Sigma} = \frac{1}{n}\sum_{i=1}^{n}\left(\underline{X}_i - \underline{\bar{X}}\right)\left(\underline{X}_i - \underline{\bar{X}}\right)' \qquad (1)$$

Where, $\underline{X} = \begin{bmatrix} X_1 \\ X_2 \\ . \\ . \\ . \\ X_q \end{bmatrix}$

where, q is the number of indictors / variables.

$$\underline{\bar{X}} = \frac{1}{n}\sum_{i=1}^{n}\underline{X_i}$$

and n is total number of states.

Then Correlation Matrix (**CM**) was obtained using above variance-covariance matrix as

$$CM = \left(\sqrt{V}\right)^{-1}\hat{\Sigma}\left(\sqrt{V}\right)^{-1} \qquad (2)$$

where

V = Diagonal matrix obtained from variance-covariance matrix and

$\hat{\Sigma}$ = M. L.E. of variance-covariance matrix.

Next step was to obtain principal components using eigen vectors of the estimated correlation matrix and standardized values of variables. The principal components were obtained by using the formula given below.

$$P_1 = a_{11}Z_1 + a_{12}Z_2 + ... + a_{1q}Z_q$$
$$P_2 = a_{21}Z_1 + a_{22}Z_2 + ... + a_{2q}Z_q$$
.
.
.
$$P_q = a_{q1}Z_1 + a_{q2}Z_2 + ... + a_{qq}Z_q$$

where

P_qs : q[th] principal components

Z_qs : standardized values of q[th] variable

a_{kq}: element belonging to k[th] eigenvector and for q[th] variable, k=1,2, …,q; q=1,2, …,q.

The composite index was constructed using the obtained eigenvalues and principal components given in equation-3:

$$CI_i = \frac{\lambda_1 P_1 + \lambda_2 P_2 + ... + \lambda_q P_q}{\sum_{j=1}^{q}\lambda_j} \qquad (3)$$

Where,

CI_i= composite index for i[th] state,

λ_js are eigen values,

P_q's are q[th] principal components,

i =1,2, …, n; j=1,2, …, q.

Further, the composite index of each state was normalized to convert the composite index values between 0 and 1 using the equation-4:

$$CI_{ni} = \frac{CI_i - \min(CI)}{\max(CI) - \min(CI)} \qquad (4)$$

where,

CI_{ni}= normalized value of composite index of i[th] state,

min (CI) = minimum value of composite index among all,

max (CI) = maximum value of composite index among all.

RESULTS AND DISCUSSION

The statistical analysis was performed using SAS 9.3 package (SAS Institute India Private Limited, Mumbai, India) available at BCKV, Mohanpur, Nadia, West Bengal, India. The PRINCOMP procedure was used to analyze the data.

The correlation matrix for different cash crop was evaluated. The correlation matrix is presented in table1. Only, the correlation between jute and mesta production was found significant at p value 0.05. High positive correlation was recorded between jute and mesta production. The correlation between remaining crops was not significant at p value 0.05.

The obtained eigenvalue of the four principal components is given in table 2. It was clear from table 2 that among four principal components, first principal component explained maximum 36.16 per cent variation in the dataset. Out of the four principal components, the

Table 1 : Correlation Matrix for Cash Crop

	Cotton	Jute	Sugarcane	Mesta
Cotton	1	-0.24	0.51	0.06
Jute		1	-0.05	**0.85***
Sugarcane			1	0.06
Mesta				1

Note: The value indicated by '' is significant at p=0.05*

Table 2 : Eigenvalue of Principal Components (PCs)

PCs	Eigenvalue	Varaince explained %	Cumulative variance
1	1.44626	36.16	36.16
2	1.13251	28.31	64.47
3	0.85916	21.48	**85.95**
4	0.56207	14.05	1
		100	

Table 3 : Eigenvectors

	Eigenvectors			
	1	2	3	4
Cotton	-0.309	0.694	-0.513	0.398
Jute	0.675	0.131	0.286	0.666
Sugarcane	-0.381	0.452	0.804	-0.048
Mesta	0.549	0.544	-0.083	-0.628

Table 4 : Cash Crop Index of India

State	CCI	Rank
West Bengal	1.000	1
Bihar	0.820	2
Andhra Pradesh	0.376	3
Uttar Pradesh	0.338	4
Maharashtra	0.235	5
Orissa	0.198	6
Assam	0.133	7
Karnataka	0.091	8
Tamilnadu	0.090	9
Uttarakhand	0.025	10
Chhattisgarh	0.015	11
Haryana	0.015	12
Punjab	0.014	13
Jharkhand	0.009	14
Kerala	0.008	15
Himachal Pradesh	0.008	16
Jammu & Kashmir	0.008	17
Madhya Pradesh	0.007	18
Rajasthan	0.003	19
Gujarat	0.000	20

first three principal components together, explained more than 85 per cent variation in the dataset.

The evaluated eigenvectors are given in table 3. As the eigenvalue of first and second principal components were greater than one and there were highest component for Jute production followed by Mesta in first eigenvector. Clearly, in second eigenvector, there is highest component for cotton production. Thus, it was concluded that the constructed composite index (Cash Crop Index) were highly sensitive to jute production followed by mesta and cotton production. This indicates that jute production influences maximum in ranking of the states.

The constructed Cash crop Index for each state with their rank is given in table 4. It was investigated that on the basis of constructed Cash Crop Index, West Bengal ranked first followed by Bihar and Andhra Pradesh. Gujarat and Rajasthan ranked last and second last respectively on the basis of constructed index. The ranking of the states may help in making equity among states regarding production of cotton, jute, sugarcane and mesta.

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