Website : www.ssdatmeerut.in
Progressive Research : An International Journal
Vol 16 (2) : 130-134 (July-2021), Print ISSN : 0973-6417, Online ISSN : 2454-6003
Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) India

A Study of Hunger Situation in India Through Formulation of India State Hunger Index Using PCA

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Abstract

World is facing, one of the many terrible problems which is threatening the existence of human being, a cruel hunger. Hunger is directly correlated with food production and supply. Calculation of weights, standardization of the component data and formulation of four different versions of the hunger index for 35 states of India was carried out. Mean squared error criterion and effect size analysis were adopted for ascertaining the efficiency of the indices. The percentage of children who are stunted in India is the most important component of India state hunger index. On the basis of results of mean squared error, standard error and the effect size analysis of the index versions, the approach of formulating the India state hunger index by assigning weights using principal component analysis to the non-standardized data of the components showed feasible results. According to ISHI, Kerala has the lowest value of 13.81 and Jharkhand has the largest value of the index (30.62). 16 states are categorized as moderate, 18 states are placed in serious category and the value of index for India is 26.05 and categorized in serious category.

Key words : *India state hunger index, PCA, stunting, wasting.*

Introduction

World is facing, one of the many terrible problems which is threatening the existence of human being, a cruel hunger. There are many faces of hunger such as loss of energy, lack of interest, increased vulnerability to disease, shortfalls in nutritional status and premature death. The development agenda has a factor of brawling with under-nutrition and hunger. Poverty reduction, food security and nutrition played a vital role to achieve the targets of millennium development goals till 2015, the people suffering from hunger will be nearly 580 million according to the recent predictions.

The same rate of child malnutrition in two countries can have very different consequences in terms of malnutrition-related deaths among children, depending on the overall rate of child mortality. Death data contains more causes of death than malnutrition, and the real contribution to malnutrition in children at death is not easy to trace because the immediate cause of death is usually an infectious disease. Malnourished adults such as children are less productive physically and mentally, receive less education and earn a living and are affected by higher rates of chronic illness and disability. The proportion of young children and older women who are shorter and underweight indicates that the prevalence of malnutrition is higher than recommended by the FAO .

Global Hunger Index (GHI) : It is a tool that measures wîrld hunger, regionally and nationally. GHI wàs developed in 2006 and first published by the International Food Policy Research Institute (IFDRI) (Source: https://www.globalhungerindex.org/pdf/en/2020.pdf). GHI is used to calculate hunger indices for different countries and ranks countries according to GHI scores. On a global scale, hunger and malnutrition have declined since 2000; in some parts of the world, however, hunger and molnutrition persist or even worsen in many countries. Sinñe 2010, 16 ñîuntries have not seen any change or increase in their GHI standards.

The present study aims to formulate State Hunger Index using percentage of undernourished population (PUN), percentage of stunted children (CST), percentage of wasted children (CWA) and percent child mortality (CM) as its components. The percentage of people who are food and energy deficient (undernourished population) includes population from all age groups whereas, the other three components only consider the children up to five years of age. However, instead of per thousand child mortality values percent values are used for child mortality. The index reflects scoring by states on a 100-point scale where 0 is the best score (no hunger) and 100 the worst. A score >=50 is defined as 'extremely alarming'; 35-50 as 'alarming'; 20-35 as 'serious'; 10-20 as 'moderate' and <10 as 'low'.

The state-wise data (2011-12) required for calculation of percentage of undernourished population was used from , following FAO methodology for 19 states and for remaining states the national average of 17.9 for

Received : June-2021 Revised : June-2021 Accepted : July-2021

Table-1 : Maximum and threshold value values of the components.

S.N.	Component	State	Year	Observed maximum value (%)	Threshold value set (%)
1.	Stunted	Bihar	1992-93	60.90	65
2.	Wasted	Madhya Pradesh	2005-06	39.50	45
3.	child mortality	Madhya Pradesh	1998-99	13.76	20
4.	Undernourishment	Tamil Nadu	2011-12	48.74	55

(NFHS Reports of respective years)

Table-2 : Factor scores and derived weights of components.

Factor statistics	**Eigenvalue**	**Percent of variance**	**Cumulated percentage**
Factor 1	2.35	58.71	58.71
Final statistics	**Communality**	**Factor score**	**Derived weight**
Stunted	0.757	0.371	0.29
Wasted	0.466	0.291	0.22
Mortality	0.546	0.315	0.24
Undernourished population	0.579	0.324	0.25

Only one factor was finally extracted by principal component analysis. (Criterion : eigen value >1).

the year 2011-12 was considered . The data pertaining to the remaining three components was taken from the 4th round of National Family Health Survey 2015-16.

Materials and Methods

It includes computation of weights to the components using principal component analysis, standardization of the components and formulation of the hunger index for Indian states.

All the components were standardized with the threshold values (Table-1). These threshold values were fixed somewhat greater than the existing maximum value of the respective component, obtained in the previous years till 2015. Greater threshold values were set to overcome the chance of increase in the existing maximum values of the components in future.

Below given formulae were used for standardization of the data of the components.

$$\text{Standardized PUN} = \frac{\text{PUN}}{\text{Threshold value (55)}} \quad 100$$

$$\text{Standardized CWA} = \frac{\text{CWA}}{\text{Threshold value (45)}} \quad 100$$

$$\text{Standardized CST} = \frac{\text{CST}}{\text{Threshold value (65)}} \quad 100$$

$$\text{Standardized CM} = \frac{\text{CM}}{\text{Threshold value (20)}} \quad 100$$

Where, PUN, CWA, CST and CM are the existing values of the respective components for the year 2015. The data of all the four components was standardized and the results are presented in the table-3.

The four hunger indices for Indian states (ISHI) were formulated considering the combinations of principal component analysis (PCA) weights and non-standardized components, PCA weights and standardized components, weights assigned by IFPRI (1/3,1/6,1/6,1/3 for PUN, CST, CWA and CM, respectively.) and non-standardized components, weights assigned by IFPRI and standardized components. Below given formulae were used for the formulation of four different versions of India State Hunger Index as per above combinations.

$ISHI_{(1)}$ = (PCA weight)*PUN+(PCA weight)*CWA+(PCA weight)*CST+(PCA weight)*CM

$ISHI_{(2)}$ = (PCA weight)*Std.(PUN)+(PCA weight)* Std.(CWA)+(PCA weight)* Std.(CST)+(PCA weight) * Std. (CM)

$ISHI_{(3)}$ = (IFPRI weight)* PUN+(IFPRI weight)* CST+(IFPRI weight)*CWA+(IFPRI weight)*CM

$ISHI_{(4)}$ = (IFPRI weight)*Std.(PUN)+(IFPRI weight)* Std.(CWA)+(IFPRI weight)* Std.(CST)+(IFPRI weight)* Std.(CM)

Mean squared error criterion and effect size analysis were adopted for ascertaining the efficiency of the indices.

Results and Discussion

Principal component analysis (PCA) : Weights for all the components were calculated using principal component analysis which resulted in 0.25, 0.29, 0.22, and 0.24 for undernourishment, stunted, wasted and child mortality, respectively, with 0.67 sampling adequacy.

Formulation of India State Hunger Index (ISHI) :

1. The India state hunger index (ISHI(1)) is formulated by assigning weights calculated based on PCA to the non-standardized data of the components. Numerically it can be expressed as;

Table-3 : Components of ISHI and its standardized values.

States / UTs	(PUN)	Std (PUN)	CST)	Std (CST)	CWA)	Std (CWA)	(CM)	Std (CM)
A and N Islands	17.90	32.55	23.3	35.85	18.9	42.00	1.30	6.50
Andhra Pradesh	28.13	51.15	31.4	48.31	17.2	38.22	4.08	20.40
Arunachal Pradesh	17.90	32.55	29.4	45.23	17.3	38.44	3.28	16.40
Assam	40.78	74.15	36.4	56.00	17.0	37.78	5.66	28.30
Bihar	31.09	56.52	48.3	74.31	20.8	46.22	5.81	29.05
Chhattisgarh	38.21	69.48	37.6	57.85	23.1	51.33	6.42	32.10
Daman and Diu	17.90	32.55	23.4	36.00	24.1	53.56	3.40	17.00
D and N Haveli	17.90	32.55	41.7	64.15	27.6	61.33	4.20	21.00
Delhi NCT	17.90	32.55	32.3	49.69	17.1	38.00	4.20	21.00
Goa	17.90	32.55	20.1	30.92	21.9	48.67	1.29	6.45
Gujarat	44.22	80.40	38.5	59.23	26.4	58.67	4.35	21.75
Haryana	28.09	51.07	34.0	52.31	21.2	47.11	4.11	20.55
Himachal Pradesh	16.31	29.65	26.3	40.46	13.7	30.44	3.76	18.80
Jammu and Kashmir	22.84	41.53	27.4	42.15	12.1	26.89	3.76	18.80
Jharkhand	39.19	71.25	45.3	69.69	29.0	64.44	5.45	27.25
Karnataka	43.69	79.44	36.2	55.69	26.1	58.00	3.22	16.10
Kerala	17.90	32.55	19.7	30.31	15.7	34.89	0.71	3.55
Lakshadweep	17.90	32.55	27.0	41.54	13.8	30.67	3.00	15.00
Madhya Pradesh	38.15	69.37	42.0	64.62	25.8	57.33	6.49	32.45
Maharashtra	36.97	67.21	34.4	52.92	25.6	56.89	2.91	14.55
Manipur	17.90	32.55	28.9	44.46	6.8	15.11	2.59	12.95
Meghalaya	17.90	32.55	43.8	67.38	15.3	34.00	3.97	19.85
Mizoram	17.90	32.55	28.0	43.08	6.1	13.56	4.59	22.95
Nagaland	17.90	32.55	28.6	44.00	11.2	24.89	3.73	18.65
Odisha	34.96	63.56	34.1	52.46	20.4	45.33	4.86	24.30
Punjab	28.41	51.65	25.7	39.54	15.6	34.67	3.32	16.60
Puducherry	17.90	32.55	23.7	36.46	23.6	52.44	3.22	16.10
Rajasthan	29.53	53.69	39.1	60.15	23.0	51.11	5.07	25.35
Sikkim	17.90	32.55	29.6	45.54	14.2	31.56	3.22	16.10
Tamil Nadu	48.74	88.62	27.1	41.69	19.7	43.78	2.69	13.45
Telangana	17.90	32.55	28.1	43.23	18	40.00	3.36	16.80
Tripura	17.90	32.55	24.3	37.38	16.8	37.33	3.26	16.30
Uttarakhand	18.34	33.35	33.5	51.54	19.5	43.33	7.81	39.05
Uttar Pradesh	34.45	62.63	46.3	71.23	17.9	39.78	4.67	23.35
West Bengal	38.38	69.77	32.5	50.00	20.3	45.11	3.18	15.90
India	36.38	66.15	38.4	59.08	21.0	46.67	5.00	25.00

$$ISHI_{(1)} = 0.25*PUN + 0.22*CWA + 0.29*CST + 0.24*CM$$

$ISHI_{(1)}$ coins the value of 13.81 for Kerala (Table-4), which is least amongst all, followed by 16 states in moderate category. Apart from this, other 18 states are placed in serious category with the largest value of the index (30.62) for Jharkhand. The value of index for India is 26.05 and categorized in serious category.

2. The India state hunger index (ISHI(2)) is formulated by assigning weights calculated based on PCA to the standardized data of the components. Numerically it can be expressed as;

$$ISHI_{(2)} = 0.25*Std.(PUN) + 0.22* Std.(CWA) + 0.29* Std.(CST) + 0.24 * Std.(CM)$$

$ISHI_{(2)}$ represents that Kerala is leading with index value 25.45, whereas, Jharkhand, Madhya Pradesh, Gujrat, Chhattisgarh and Karnataka lies in the bottom section with index values 58.74, 56.48, 55.40, 53.14, 52.82, respectively and are placed in the extremely alarming category (Table-4). The upper section of the index list belongs to the serious category and middle section lies in the alarming category. The index value for India is 49.94, which falls in alarming category.

3. The India state hunger index (ISHI(3)) is formulated by assigning weights as suggested by IFPRI to the non-standardized data of the components. Numerically it can be expressed as;

$$ISHI_{(3)} = 1/3* PUN + 1/6*CST + 1/6*CWA + 1/3*CM$$

Comparatively lesser index values were obtained for

Table-4 : India State Hunger Index (ISHI).

S.N.	States / UTs	$ISHI_{(1)}$	$ISHI_{(2)}$	$ISHI_{(3)}$	$ISHI_{(4)}$
1.	Kerala	13.81	25.45	11.20	21.26
2.	Manipur	14.97	27.46	11.88	23.46
3.	Mizoram	15.04	29.12	12.28	26.30
4.	Goa	15.43	29.36	12.50	24.63
5.	Himachal Pradesh	15.62	30.36	13.36	27.97
6.	A and N Islands	15.70	29.33	12.53	24.35
7.	Tripura	16.00	31.10	13.00	27.10
8.	Lakshadweep	16.06	30.53	12.87	26.25
9.	Nagaland	16.13	30.85	12.94	26.91
10.	Sikkim	16.96	32.15	13.44	27.43
11.	Jammu and Kashmir	17.22	33.03	15.45	31.62
12.	Puducherry	17.31	34.11	14.02	29.40
13.	Daman and Diu	17.38	34.44	14.12	29.80
14.	Telangana	17.39	33.51	13.87	28.68
15.	Arunachal Pradesh	17.59	33.65	13.94	28.62
16.	Delhi NCT	18.61	35.95	14.70	30.83
17.	Punjab	18.78	35.99	17.46	35.12
18.	Uttarakhand	20.47	42.19	17.55	39.95
19.	Andhra Pradesh	20.90	40.10	18.84	38.27
20.	Meghalaya	21.50	39.92	16.24	32.73
21.	Haryana	22.53	43.23	19.93	40.44
22.	D and N Haveli	23.65	45.27	18.02	37.13
23.	West Bengal	24.25	45.68	22.65	44.41
24.	Odisha	24.28	46.91	22.36	45.59
25.	Rajasthan	25.00	48.20	21.88	44.89
26.	Tamil Nadu	25.02	47.11	24.94	48.27
27.	Maharashtra	25.55	48.16	23.29	45.56
28.	Assam	25.85	49.88	24.38	49.78
29.	Chhattisgarh	27.08	53.14	24.99	52.06
30.	Uttar Pradesh	27.10	50.65	23.74	47.16
31.	Bihar	27.75	52.82	23.82	48.61
32.	Karnataka	27.94	52.63	26.02	50.79
33.	Madhya Pradesh	28.95	56.48	26.18	54.26
34.	Gujarat	29.07	55.40	27.01	53.70
35.	Jharkhand	30.62	58.74	27.26	55.19
	India	26.05	49.94	23.69	48.01

all the states in this version (Table-4). It follows the same pattern as that of first two versions of the index. Kerala is at the top in the list with index value 11.20 followed by Manipur (11.88), Mizoram (12.28) and Goa (12.50) under moderate category. Jharkhand (27.26) is at the bottom of the list. The first 16 states of the list are in the moderate category and the remaining states are in serious category.

4. The India state hunger index (ISHI(4)) is formulated by assigning weights as suggested by IFPRI to the standardized data of the components and numerically it is expressed as;

$$ISHI_{(4)} = 1/3*Std.(PUN) + 1/6* Std.(CWA) + 1/6* Std.(CST) + 1/3* Std.(CM)$$

The index value for India is 48.01 belonging to alarming category. Being the lowest value (21.26), Kerala is on the top with serious category, followed by Manipur, Andaman and Nicobar Islands, and Goa. The highest value is 55.19 for Jharkhand which is in the extremely alarming category of the list (Table-4).

Efficiency of the model : Mean squared error (MSE) and standard error (SE) estimate were calculated for all the four index versions using regression analysis (Table-5).

The minimum mean squared value was obtained for $ISHI_{(3)}$ followed by $ISHI_{(1)}$, $ISHI_{(2)}$ and $ISHI_{(4)}$. On the contrary the standard error estimate (SE) indicated lowest value for $ISHI_{(1)}$. The mean squared values for $ISHI_{(1)}$ and $ISHI_{(3)}$ are in close proximity and to find the superior one the effect size for $ISHI_{(1)}$ and $ISHI_{(3)}$ was calculated. The effect size is calculated by squaring the Pearson's correlation coefficient r.

Table-5 : Mean squared error (MSE) and standard error (SE) estimate.

	$ISHI_{(1)}$	$ISHI_{(2)}$	$ISHI_{(3)}$	$ISHI_{(4)}$
MSE	218.39	805.31	210.753	840.211
SE	0.00246	0.00275	0.00274	0.00254

Table-6 : Effect size of $ISHI_{(1)}$ and $ISHI_{(3)}$.

Indices	Effect size				Combined effect size
	Stunted	Wasted	Mortality	Undernourished population	
$ISHI_{(1)}$	0.692	0.477	0.338	0.750	2.257
$ISHI_{(3)}$	0.549	0.437	0.284	0.876	2.146

$ISHI_{(1)}$ is having greater effect size for all the components as compared to $ISHI_{(3)}$, excluding undernourished population. The combined effect size is also greater for $ISHI_{(1)}$, hence, on the basis of mean squared error and the effect size of the indices, it can be concluded that the $ISHI_{(1)}$ is the most appropriate method of calculating the state level hunger index in India.

Principal component analysis revealed that the percentage of children who are stunted in India is the most important component of state hunger index. The approach of formulating the India State Hunger Index with PCA weights and non-standardized components (ISHI(1)) showed feasible results. This method of calculation is simple, the weights computed using PCA are based on the actual data of the components of hunger index and does not include the tedious procedure of standardization. This combination of components and weights gives reasonable values of the index as compared to other versions.

Nearly similar ranks are obtained for all the states from all the four versions of the index. However, as per the ranks obtained from ISHI(1) the states like Jharkhand, Gujarat, Madhya Pradesh, Chhattisgarh, Karnataka, Bihar and Uttar Pradesh, laying at the bottom section of the rankings needs to be concentrated and requires immediate attention to reduce the hunger problem.

The problem of child stunting, wasting and mortality below five years can be prevented by ensuring that the healthy, appropriate and nutritious food is available at an affordable price to every child for consumption to achieve his or her full potential. Pregnant women and infants should be closely monitored up to 1000 days and nutritious ample food should be provided for pregnant and lactating women to ensure the good health of the baby and the mother. Awareness regarding rapid and exclusive breast feeding to new born baby, availability of trained and experienced staff with antenatal, birth and postnatal care skills at remote and rural areas. Awareness and knowledge about the harmful symptoms affecting infant and child health to remote and rural population. Similarly, access to clean drinking water, sanitation and timely vaccination can prevent most of the diseases that cause death of the infants and children. All these efforts will definitely help to reduce the hunger problem of the Indian states.

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