Prompt Corrective Action Parameters Identification Using PCA Analysis for Sustainable Development in a Gandhian State, Odisha

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Abstract: Nature expects all creature to love it and be loved by nature for long-term sustainability. Mahatma Gandhi ji has practiced the path of simple living and high thinking for long-term sustainability. All Indian villagers' life style is akin to this Gandhian concept. Live with less and lesser need and still less use of natural resources to keep it rejuvenated for eternality. Present cropping calendar with technology and narrow mind-sets of the human have polluted the environment and global warming is about to destroy the total earth through increasing in temperature. Sustainability involves society, environment and economy parameters. The crops produces in India are different based on agro climatic zone. Considering the major crop grown for food security and minor crops as social requirement. Twenty-six crops grown in Odisha [1] naturally matches with the agro-climatic zones. All crops grown requires soil nutrient for best production. The chemical fertiliser use along with more area under commercial crops has made the soil sick over vast area. The inputs like farm mechanization, seed, finance and fertiliser are some of the prime requirement for best crop production. The sustainability of crop production achieved with lesser interventions. It is important to know from the redundant data recorded and reported by Directorate of Agriculture and Food production and Survey of India, use it for prompt corrective planning. Principal component analysis carried out to know correlated inputs for a stable soil health and crop production. Prompt corrective activity suggested for sustainability and soil health, nutritional security, food security jointly addressed in this research work. Continuous development required at school and college level to achieve this target as per Gandhi's dream. Average data for last 10 years have been taken for five parameters like water, loan, seed, fertiliser and farm machinery use in all 30 districts of Odisha for PCA analysis. The correlation table, eigenvalue computation, followed by outlier plot, scree plot, score plot, loading and biplot made for analysis. From PCA analysis it seen that new set of variable (loan, seed, fertiliser and machinery) combine to form principal component 1 (PC1). Once one of them changes, all these parameter also change. The contribution percentage is around 0.5 but contributes 56.4% towards the result. Irrigation alone contributes to 20.8% towards output. Loan and seed jointly contributes 7.2% of the production,

farm machinery alone contributes to 7.7 % towards the output. Seed and fertiliser jointly contributes towards 3.4% of the production. Prompt corrective actions must be initiated on PC1, PC2, PC3 so that about 88.9% target can be achieved. The financial allocation for annual plan to be matched with PC1, PC2, PC3 parameters proportionately to enhance output of the implementation of annual plan. This is not practiced until date. They are the lower hanging fruits and addressing these parameters proportionately can increase implementation efficiency.

Key Words: PCA, Security, Sustainability, Climate change, Inputs

INTRODUCTION

Odisha has 30 districts and 13 agro-climatic zones demanding separate planning for crop production in Kharif and Rabi season. There are many controllable and non-controllable inputs for production. There are 26 predominate crops grown to meet the staple food and ceremonial food requirements. The cropping patters followed makes it sustainable over long time and the correlations among the pattern and parameters are dismal. Data from DA&FP has been collected for last 10 years [1] and filtered, average data generated for few important parameters for analysis. The input parameters identified are water, finance, seed, fertiliser and farm machinery for analysis. Ten-year average data for all 30 districts used in present PCA analysis [3]. Sustainability in true Gandhian spirit addresses peace, people, planet, peace, prosperity and partnership. Innovation, job creation, less resource use, diversity, less waste generation and cleaner environment are essentials of Gandhian planning for sustainability [2].

Sustainable development goal defined by UN are technology based or parallel to Gandhian vision for development. In present research work, planning made to find least interventions required to increase production with minimum input parameters. Parameters responsible for production listed as land, climate, soil, technology, labour, extension, water, finance, seed, fertiliser and machinery. The input stakeholders must be reduced to less numbers to make production strategy efficiently implemented. These inputs are not correlated and data collected have hive redundancy. Picking up the right data and finding meaningful output is essential [3]. A group of data those work in synergy identified through Eigenvector vector analysis. Similar data in orthogonal planes computed and repeated for third time. These three components known as principal components. The groups of stakeholder responsible in these three PCAs are determined. Generally, correlation above 0.5 taken for considering the significant stakeholders. The regression line for each principal components written for computation of projected contributions.

The outlier plot, scree plot, score plot, loading plot and biplots are prepared. The plots interpreted for the contribution of the components and their directions. Knowing all parameters, it is possible select a few parameters and enforce implementation of selected stakeholders for positive change sustainable production. PCA analysis can also be made for the selection of crop so that the soil health maintained. Use of selected stakeholders like water, loan, seed, fertiliser and farm machinery considered to find the combination work for sustainable production. The farthest point on the plots shows that they are the contributors. The points near to the centre are districts on which less stress given so that the visible change is more.

Identification of districts for implementation and the combination of the components to form principal components are main objectives of PCA [4]. Identification of PC1, PC2 and PC3 and its joint contribution to be noted for knowing the efficiency of implementation.

MATERIALS AND METHOD

The agricultural production and input parameters data recorded meticulously by state and central Government every year. These data are redundant type and isolation of suitable parameter for fruitful use done using PCA analysis. Controllable parameters identification and data for 10 years are required for the computing the PC1, PC2 and PC3 stakeholders [5]. Computation of Eigenvalues and ranking are done know the set of stakeholders resulting in better change through synergy. Change of one parameter in on PCA also changes (positively / negatively) other parameters. The high correlation coefficients value shows the importance of that stakeholder. The PC 2 perpendicular to PC 1 are non-correlated data in PC1 plane. Similarly, data correlated with each other in orthogonal plane computed. The contribution of PC 2 also guides the amount of time, money, work force; implementer can plan for efficient implementation of program. The analysis will open a learning for the management and executers. This learning process over time make the implementer more effective. It is observed that although Agriculture department spends huge money in production enhancement program; the efficiency and outcome is never marked remarkably.

Machine learning adopts similar process to make the machine more powerful to decide the process of execution. The planners and the execution team must learn from such analysis and improve the implementation. The regression coefficient under the PCs also prompts to know the allocation of amount of money for effective output.

Gandhiji has thought of using high-tech computation and interpretation for sustainable development. Such simple analysis and it's in depth interpretation can help at present juncture to combat against the climate change by using less and lesser resource for higher production through identification of principal component and the synergy among the stakeholders.

Computation of eigenvalues, ranking them and tabulating it produces a plot of eminent importance and visual interpretation. The normalization of data, which are not in one plane, is much required for best interpretation.

$$Normal\ data(x) = (xi - mean(xi))/SD(xi)$$

The redundancy of data checked before all analysis. The eigenvalue calculation ranking, done for determining the stakeholders under each principal components (n-1) numbers, where n is the numbers of variable. Synergy of stakeholders and its joint contribution out of 100% are also determined. This is essential for making financial provision to targeted areas.

USE OF MINITAB SOFTWARE

Statistical calculations performed using R, SPSS, SAS, Microstat, Minitab etc. to find the desired output. In this research, Minitab 18 used for computation of PCA and plotting the graphs. All graphs plotted using Minitab used for finding conclusion as envisaged. The colour coding and labelling used to emphasize the parameters.

RESULTS AND DISCUSSIONS

Ten years average data of inputs like water, loan, seed, fertilizer and farm machinery used in each district for paddy production taken in this research problem. The 30 districts data entered for analysis using Minitab-18.

Name of District	Production ('000 t)	Net Area Sown ('000ha.)	Rain fall (mm.)	Loan (Crore)	Seed ('000 Kg)	Fertilizer ('000 Kg)	Machinery ('000) Rs.	Productivity (t/ha)
Jharsuguda	102.45	107.61	1653.60	23.15	1653.00	9408.00	64418.00	0.95
Deogarh	58.21	108.08	1346.60	12.07	1080.30	3321.00	18693.00	0.54
Boudh	93.16	139.13	1525.30	24.64	3307.80	7152.00	17124.00	0.67
Gajapati	43.61	141.61	1279.30	17.67	4986.00	5187.00	22805.00	0.31
Jagatsingpur	179.12	186.36	1688.50	53.03	6980.00	11710.00	77414.00	0.96
Phulbani	73.97	190.25	1686.20	24.64	1262.00	1425.00	8384.00	0.39
Sonepur	246.74	198.40	1488.70	37.87	9642.00	9342.00	112225.00	1.24
Malkangiri	112.35	221.29	1349.80	20.42	6533.00	6417.00	25424.00	0.51
Nayagarh	133.22	222.75	1497.60	94.98	2081.00	7334.00	33198.00	0.60
Khordha	163.11	232.65	1447.40	196.97	5752.00	13917.00	60238.00	0.70
Bhadrak	344.45	237.96	1285.30	124.84	6844.00	34584.00	43973.00	1.45
Rayagada	98.82	251.56	1285.70	42.19	7862.00	8513.00	45445.00	0.39
Dhenkanal	185.35	262.79	1428.70	131.45	5921.00	8122.00	35245.00	0.71
Kendrapara	200.87	268.45	1658.90	75.45	5302.00	9217.00	94971.00	0.75
Nawapara	150.77	268.89	1312.40	42.82	9832.00	10931.00	32319.00	0.56
Jajpur	212.26	272.72	1469.20	81.11	7127.00	32609.00	50631.00	0.78

Sambalpur	337.13	281.59	1879.00	80.28	12320.00	30595.00	121203.00	1.20
Nabarangpur	195.69	286.10	1838.20	60.47	13210.00	27875.00	17910.00	0.68
Puri	206.10	286.70	1419.50	80.21	11013.00	18808.00	72288.00	0.72
Cuttack	189.22	309.39	1853.00	201.76	8457.00	23012.00	81525.00	0.61
Angul	134.08	321.34	1422.20	78.24	5055.00	8833.00	23120.00	0.42
Balasore	351.58	332.61	1701.00	227.00	16273.00	43045.00	105723.00	1.06
Sundargarh	300.56	377.67	1496.20	101.39	9658.00	12764.00	87298.00	0.80
Koraput	212.66	394.29	1647.80	77.32	16886.00	14066.00	39248.00	0.54
Keonjhar	278.00	439.95	1298.80	75.51	11133.00	11098.00	58566.00	0.63
Bargarh	633.71	447.36	1279.10	211.11	29464.00	47760.00	111950.00	1.42
Bolangir	311.67	472.05	1641.00	57.36	19666.00	19710.00	54649.00	0.66
Mayurbhanj	542.59	518.84	1763.00	132.86	10777.00	21844.00	100605.00	1.05
Kalahandi	349.96	606.14	1885.40	72.39	24630.00	36134.00	132726.00	0.58
Ganjam	474.55	686.09	1161.90	140.92	24871.00	40136.00	94349.00	0.69

Above table shows the data used in this analysis. Ten years data from 2005-2014 used for computation. The output are paddy production and paddy productivity. The input parameters like water, loan, seed, fertilizer and farm machinery used in this computation to know the importance of all these stakeholders jointly and combined in different planes (n-1).

The Eigen analysis shows that PC1, PC2, PC3, PC4, PC5 contributes 56.4%, 20.8%, 11.6%, 7.7% and 3.4% out of 100 % goal to achieve. Table [2]. Irrigation alone contributes to 20.8% of the target (PC2). Farm mechanization development contributes 7.7 % of the target (PC4). Other principal components contributes combined Table [3]. Further, it has been observed from the Eigenvectors that, seed (PC1, PC3, PC5) and farm machinery (PC1, PC4) have more positive importance to achieve the goal. During execution of plan, more emphasis has to be given on managing funds and facilities for seed and machinery. Loan and fertiliser show

contribution to achieve goal, but it has positive and negative values. They must be timely implemented to achieve the goals. Some stakeholders are time specific and others are others quantity available for use. Executors must consider these aspects while implementing.

Table 1 Eigen Analysis

Eigen analysis of the Correlation Matrix					
Eigenvalue	2.8203	1.0401	0.5823	0.3861	0.1712
Proportion	0.564	0.208	0.116	0.077	0.034
Cumulative	0.564	0.772	0.889	0.966	1.000

Table 2 Eigen vectors

Eigenvectors					
Variable	PC1	PC2	PC3	PC4	PC5
Rain fall	0.157	0.921	-0.095	-0.326	0.110
Loan	0.445	-0.189	-0.814	0.026	0.320
Seed	0.499	-0.198	0.540	-0.277	0.587
Fertilizer	0.541	-0.143	0.032	-0.398	-0.726
Machinery	0.485	0.238	0.188	0.811	-0.122

The interpretation of the plots as per PCA frame work shown below. The outlier plot (Figure [1]) shows that all the data lies within 3.62 of the normalized value as per Mahalanobis theory. The other plots uses data, which are within this system. The districts like Kalahandi, Bolangir and Ganjam have better paddy production compared to Boudh, Jharsuguda and Deogarh. The staff placement, financial planning and input deployment to be accordingly. Kenderapara, Dhenkanal produces paddy with low productivity special planning for these districts are required.

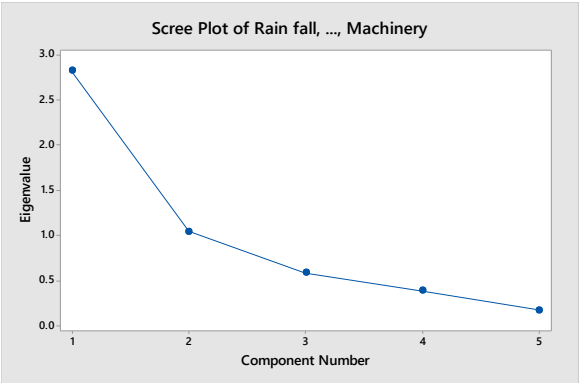

Figure 1 Outlier Plot

Screen plot shows all the principal components. It has been clearly seen that three principal components contributes 88.6% to achieve the goal. All five stakeholders contribute towards achieving the goal. PC1 contributes to 56.4 % taking loan, seed, fertiliser and machinery in to consideration. Input in one brings changes with others. While planning as priority number one all these four components are to be planned with same weightage. The synergy strength of these four stakeholders are recorded through this analysis. The factor PC4, PC5 has been not emphasized in this result.

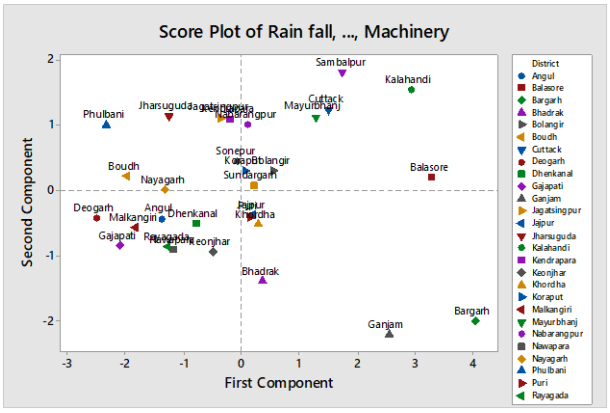

Figure 2 Screen Plot

Score Plot generated from this PCA analysis to find the district with positive impact and negative impact. The ++ quadrant has 8 districts, -+ quadrant has 7 districts, -- quadrant has 9 districts and +- quadrant has 6 districts. This shows that the paddy cultivation has less productivity in 9 districts and 8 districts has good paddy production record. 6 districts has scope to improvise and 7 district require the motivation. The planning must be done according and staff with expertise to be deployed to these districts to achieve higher efficiency in implementing production policy. The relationship of PC1 and PC2 are very important for the planners to act for achieving better efficiency.

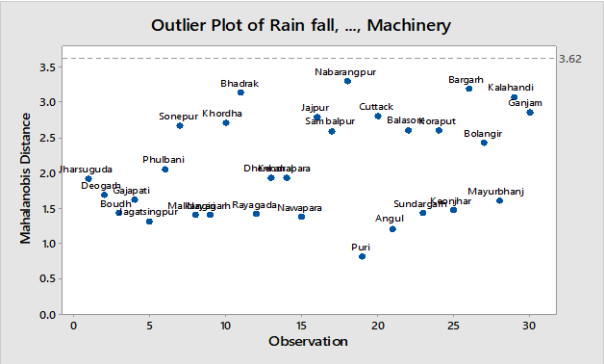

Figure 3. Score Plot

Loading plot clearly shows that Water and machinery has higher effect on paddy production in totality. Similarly large value of fertiliser, loan, and seed with a negative slope shows that the effect has negative effect at some point of time and loan has the least effect. Fertiliser use is less, as the farmers of Odisha are not investing more on chemical fertiliser like Punjab farmers. Paddy has good correlation with water. High rainfall and supplementary irrigation can boos the paddy production. Machinery is developing slowly and has a positive trend. More money to be spend for such development.

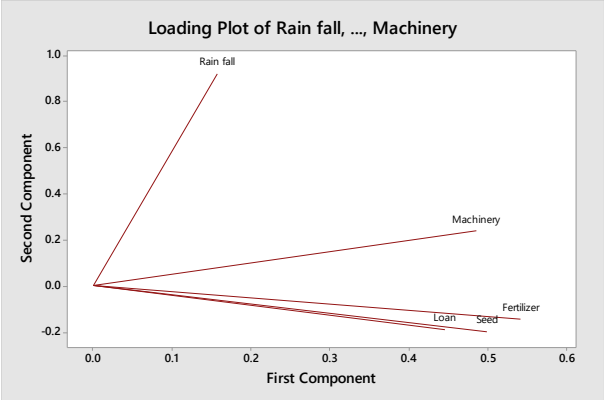

Figure 4 Loading Plot

Biplot reveals that the implementation of input management program in all thirteen districts of Odisha has positive trend. The trend of all above 5 stake holder has positive of +- trend. The inputs provided has maintained the positive trend for production of paddy crop. This trend in the districts where the effect is noticed more are to be verified and future programmes to be made.

Similar analysis to be performed for different crops and joint planning will help the farmers to have a good cropping patter and sustainable Development as per the dream of Gandhi Ji..

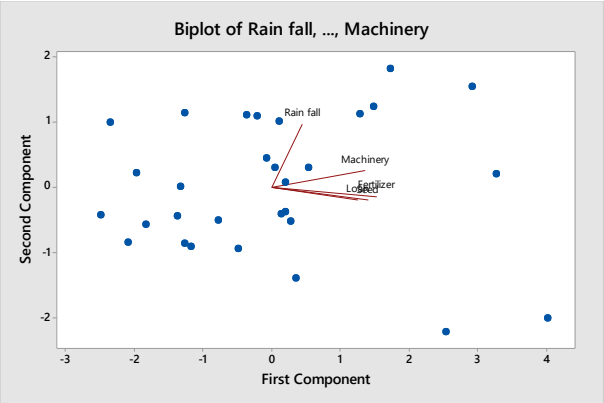

Figure 5 Biplot

CONCLUSIONS

Prompt corrective action on PCA findings will show case the increase in productivity in agriculture sector. Planners must have more and more scientific approach to attain the goals und SDG. Synergy is vital in agricultural planning, as controlling environment is impossible one. Agro-climatic zone wise PCA planning will bring more clarity and synergy. Until now, no work done in this area to give Gandhi Ji's dreams a true implementation touch. This will full all human need but not one's greed.

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