TECHNOLOGICAL ADAPTATION TO COMBAT CLIMATE CHANGE IN AGRICULTURAL SECTOR-A STATISTICAL APPROACH

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Abstract: Climate change is projected to have significant impacts on agricultural conditions, food supply, and food security. The challenge is to integrate huge number of parameters interacting in and among social, economic, and cultural sub-systems, which are not included holistically in most of the cases. Integrated approach should be encouraged to aim at adopting a bottom up approach for sustainable development in third world countries to develop mitigation and adaptation strategies, programmes and projects and subsequently after the fruitful research results, to undertake pilot mitigation and adaptation projects in various agro-climatic regions. A multi stage random sampling technique was adopted for the collection of primary data. Principal Component Analysis method is used to reduce the number of variables and identify different factors of variables with similar characteristics together. The respondents were asked to indicate their degree of agreeness with the statements.(X_1 toX_6) using six point Likert scale. Stagnation in agriculture, increasing production and marketing risks, institutional vacuum and lack of alternative livelihood opportunities are the root cause of agricultural distress. So technological adaptation in modern farming require literacy, skill, innovation, credit worthiness of farmers etc, which is a challenge to farmers to combat climate change in agricultural sector. The present study is an attempt to capture the factors affecting to the farmers, who prefer to follow a new method of farming. Two factors were identified such as (i)Financially Viable Factor, (ii)Societal Advantage Factor to adopt new technology to combat climate change in agriculture.

Keywords: Climate Change, Agricultural distress, Technology, Financially Viable Factor,Societal Advantage Factor.

Introduction: Climate change, natural capital and economies impact on each other. Economic activity drives climate change but both affect natural capital stock. Agriculture has always been highly dependent on climate patterns and its variations. Adaptation , mitigation, finance, technology transfer, capacity building and transparency are the basic six elements of any model for aversion of climate change. Promoting economic growth, protecting the environment and improving public health are goals that go hand in hand[1].In particular, the socio-economic and technological characteristics of different development paths will strongly affect emissions, the rate and magnitude of climate change, climate change impacts, the capability to adapt, and the capacity to mitigate[2] .Sustainability of agriculture is a matter of question due to increased agricultural uncertainty. Farmers are facing a lot of challenges in cultivation. New generation desires decent return from agriculture. Food security poses a challenge to the world. The future of food security is highly dependent on two important and inter-related factors, first the ability to succeed and absorb the technology for raising agricultural productivity, and the second, effecting measures to successfully adapt to climate change. Moreover, Diversity results from mixing species and varieties of crops and from systematically integrating crops, trees and livestock [3]. The farmers may be categorized on the basis of relative emphasis they place on economy, comfort, performance, convenience and dignity. There is need for an increased, stable, low cost environmentally sustainable food production accompanying with an arduous task of adoption of end-to-end holistic approach covering production, protection, post harvest management and marketing to ensure appropriate returns to growers and producers [4]. A more sustainable agriculture will not, however, happen without some external help and money. There are always transaction costs associated with shifting from one way of doing things to another - the costs of learning new knowledge, the costs of developing new or adapting old technologies, the costs of learning to work together, the costs of institutions having to break free from existing paradigms of thought and practice. It will also cost time and money to rebuild depleted natural and social capital[5]. With this backdrop, there are various types of farmers having different opinions regarding technological adaptation to combat climate change in agriculture.

The objectives of the study are as follows:

i) To make a correlation analysis of the farmers rating to new system of cultivation.
ii) To determine the underlying benefits farmers seek from a new system of cultivation by classifying them according to their relative importance they put in their views by the method of Principal Component Analysis.

Me**thodology:** A multi stage random sampling technique was adopted for the collection of primary data. In the first stage a random sample of three

district comprising of one tribal, one irrigated and one non-irrigated districts were selected out of ten districts of western Odisha by the method of random sampling. Then one block from the corresponding district and one village from the corresponding block were selected by the method of simple random sampling. These three villages were selected to represent irrigated, non-irrigated and tribal villages from the corresponding blocks. In the next stage the sample households were selected on stratified random basis to represent different land classes such as Marginal, Small, Medium and Large farmers' category. A structured questionnaire was developed and applied on three hundred households. Principal Component Analysis was used to identify different factors

The respondents were asked to indicate their degree of agreeness with the following statements.(X_1 toX_6) using six point Likert scale (Strongly disagree=1,Strongly agree=6

- X_1: New method of farming is more productive than traditional methods
- X_2: New method of farming should be convenient and easy to handle by the farmers
- X_3: New method of farming should be easily available with proper credit facilities
- X_4: New method of farming should increase the income and dignity of farmers
- X_5: Price is not an important consideration for having modern agricultural implements
- X_6: New method of farming should be eco-friendly and should have better return with nutritional value.

Hypothesis: The null and alternative hypotheses taken for the study are as follows :

H_0 :ρ= 0 i.e Variables ($X_1$to X_6) are independent of one another in the population (Population correlation matrix is an identity matrix)

H_1 :$\rho \neq$ 0 i.e Variables ($X_1$to X_6) not in the population (population correlation matrix is not an identity matrix

(*where*$\rho$is the population correlation matrix, 0 is an identity).

The data collected was analysed by SPSS-16.0 software under Window XP environment which are presented as follows:

Table-1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.604
Bartlett's Test of Sphericity	Approx. Chi-Square	1043.00
	Df	15
	Sig.	.000

Table -1, above represents the values of approximate chi-square by Bartletts's test of sphericity[9] with 15 degree of freedom, which is found to be 1043.00. Since this value is significant at the 0.05, so the null hypothesis is rejected which means that the population correlation matrix is not an identity matrix. It means that there exist correlations among the variables X_1, X2... X6. The value of Kaiser-Meyer-Olkin Measure of sampling Adequacy is found to be 0.593 which is more than 0.5. Therefore factor analysis is an appropriate technique to analyse the data.

The results of the Factor analysis are presented through tables 2 to 6 and figures 1 and 2 as follows.

Table -2: Correlation Matrix

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.000	.092	.862	-.106	-.869	.014
X_2	.092	1.000	-.075	.249	-.127	.502
X_3	.862	-.075	1.000	-.130	-.755	.049
X_4	-.106	.249	-.130	1.000	.030	.413
X_5	-.869	-.127	-.755	.030	1.000	-.124
X_6	.014	.502	.049	.413	-.124	1.000

Table -3. Communalities		
	Initial	Extraction
X_1	1.000	.937
X_2	1.000	.593
X_3	1.000	.862
X_4	1.000	.496
X_5	1.000	.870
X_6	1.000	.721

Table-**4: Total variance explained for Initial Eigen**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of SquaredLoadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.681	44.680	44.680	2.681	44.680	44.680	2.680	44.661	44.661
2	1.798	29.972	74.652	1.798	29.972	74.652	1.799	29.991	74.652
3	.746	12.437	87.089						
4	.481	8.012	95.101						
5	.214	3.567	98.668						
6	.080	1.332	100.000						

Table -5: Component Matrix		
	Component	
	1	2
X_1	.967	-.044
X_2	.098	.764
X_3	.921	-.118
X_4	-.108	.696
X_5	-.931	-.067
X_6	.106	.843

Table-6:Rotated component matrix		
	Component three factors	
	1	2
X_1	.968	-.009
X_2	.070	.767
X_3	.924	-.085
X_4	-.133	.692
X_5	-.928	-.100
X_6	.076	.846

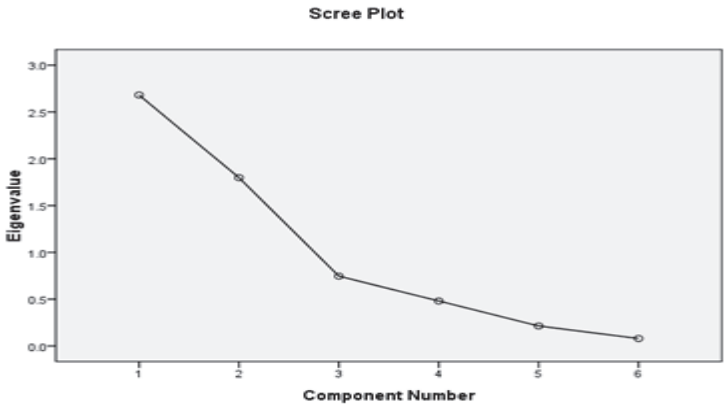

Fig.1 : Scree Plot

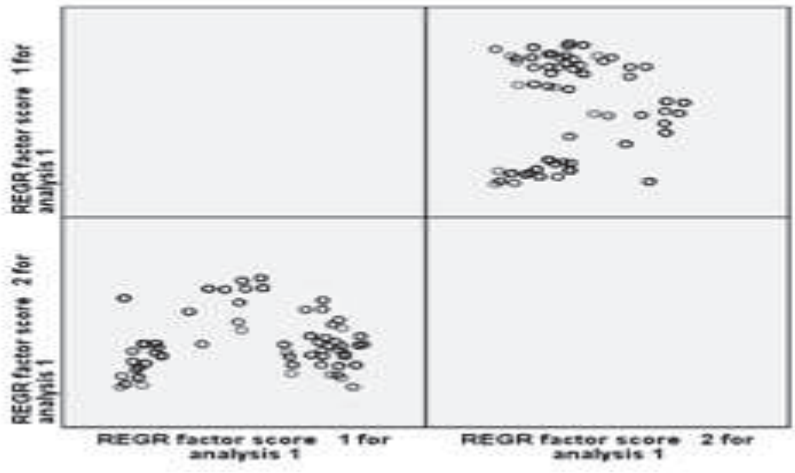

Fig.2 Plot for Regression Factor Score

Statistical Analysis and discussion: The correlation matrix([6],[7],[8],[9]) of table-2 indicates that there exist high correlation among variable X_1(New method of farming is more productive than traditional methods), X_3(New method of farming should be easily available with proper credit facilities),X_5(Price is not an important consideration for having modern agricultural implements)with the correlation coefficient r_{x1x3}=0.862,$r_{x1x5=}$ -0.869 and r_{x3x5}=-0.755 respectively. It is worth mentioning that the negative coefficient of a negative variable leads to a positive interpretation that price is an important factor. These variables to be correlated with the same set of factors, and may be expected. Similarly, there is relatively high degree of correlation among variables X_2(New method of farming should be convenient and easy to handle by the farmers), X_4(New method of farming should increase the income and dignity of farmers)and X_6(New method of farming should be eco friendly and should have better return with nutritional value)with respective correlation coefficients r_{x2x4}= 0.249,r_{x2x6}=0.502 and r_{x4x6}=0.413.Therefore ,these variables to be correlated with same set of variables may be expected. A Principal Component Analysis method([6],[7] and[8]) is employed to determine the necessary factor extraction. Table-3 (Communalities)[8] represents the application of principal component analysis to the attribute ratings of new method of farming by different respondents. "Communality" is the amount of variance a variable shares with other variables being considered. This is also the proportion of variance explained by the common factors. Under "Communalities" 'Initials' column it can be seen that communality for each variable X_1 to X_6 is 1.000 , as unities were inserted in the diagonals. Table-4 analyses the table for initial Eigen values[8]. An Eigen values represents the Total variance explained by each factor. Principal component analysis is recommended as the minimum number of factors that will account maximum variance in the data. It is evident from the above table Factor-1 accounts for variance of 2.681 which is (2.681/6)*100 i.e.44.680%. Similarly factor-2 accounts for variance of 1.798 which is (1.798/6)*100 i.e. 29.972 % and so on. Now it is to determine the number of factor to be extracted through Eigen value approach. In this approach only factor with Eigen values greater than 1.0 are retained. The Eigen values greater than 1.0 (default position) resulted two factors being extracted .This is also depicted through ScreePlot[8] (a plot of the Eigen values against the number of factors in order of extraction) in figure-1 where a distinct break occurs at three factors. Table No.5[8] represents the component matrix, which is an important output of Principal component analysis. The coefficients in the table are the factor loadings which represents the correlation between the factors and the six variables(X_1 to X_6). From the above component matrix it is found that coefficients of factor-1 have high absolute correlation with variables X_1, X_3 and X_5.i.e. 0.967, 0.921 and -0.931 respectively .Similarly, factor-2 has high absolute correlation with variable X_2 , X_4 and X_6 i.e. 0.764,0.696 and 0.843 respectively.

Although the component matrix indicates the relationship between the factors and individual variables, it seldom results in factors that can be interpreted, because the factors are correlated with many variables. So factor-2 is at least somewhat correlated with four of the six variables with absolute value of factor loading greater than or equal to 0.1. In such a complex matrix it is difficult to interpret the factor. So the rotated component matrix[8] has been computed in Table-6. By rotating the factor, each factor is to have non-zero or significant loadings for only some variables. Similarly, each variable is to have non-zero or significant loadings with only few components. Rotation does not affect the

communalities and the percentage of total variance explained.

Conclusion and policy implications: Interpretation is facilitated by identifying the variables that have large loadings in the same component. The component can then be interpreted in terms of the variables that load high on it. In rotated component matrix of Table -6, Component -1 has high coefficients for variable X_1 (**New** method of farming is more productive than traditional methods), X_3(New method of farming should be easily available with proper credit facilities) and X_5(Price is not an important consideration for having modern agricultural implements). Therefore these components or factors may be labeled as one factor. i.e."*Financially viable factor*". It is worth mentioning that the negative coefficient of a negative variable leads to positive interpretation in case of variable X_5.i.e.Price is an important consideration for purchase of modern agricultural implements for medium and small class of farmers. Thus the financially viable component affects farmers of medium and small class who seeks more productive, easy credit facility and the Prices consideration which they can afford.

Component -2 is highly correlated with variable X_2(New method of farming should be convenient and easy to handle by the farmers), X4(New method of farming should increase the income and dignity of farmers and X_6(New method of farming should be eco-friendly and should have better return with nutritional value). Therefore these variables may be grouped into one component and can be labeled as '*Societal advantage factor'*. So the '*Societal advantage factor'* affects farmers of large farmers. They intend to seek benefit from modern agricultural system that can provide them more comfort, eco-friendly features which can enhance their prestige.

Figure No.2 above depicts the regression factor scores of the variables with factor-1 and factor-2. Thus it can be inferred that the variables under studies can be segregated into two distinct groups according to their relative degrees of correlations.

With this backdrop it can be inferred that farmers adopting new method of farming because of several considerations can be attributed into two major factors which can be labeled as:

- Financially viable factor
- Societal advantage factor

Financially viable factor affects farmers who prefer to follow a new method of farming by putting more emphasis on easy availability, credit facilities, more productive. They are ready to compromise with price/cost of production. On the other hand farmers of second type are of well –to –do group who are least concerned with price. They seek benefits of convenient, easy to handle, eco friendly, better return with nutritional value, increasing income and dignity in social life. Factor affecting farmers of this class may be labeled as societal advantage factor.

At last,it may be concluded with the following policy implications:

1. Priority may be given to farmers, who, lured to financially viable factor, to make handsome investment in agricultural research and development, especially, in the state-level research institutes and agricultural universities ,to develop technologies that become instrumental in promoting desirable production pattern that economies on scarce resource use ,restore and improve soil health ,control water, soil and air pollution, enhance productivity and improve farm incomes. Further, these farm practices are knowledge-intensive and the adoption of these farm practices would increase the demand for skilled extension workers to help farmers.
2. Emphasis may be placed on rotating crops, building up soil, diversifying crops and livestock and controlling pests naturally for farmers tempted to Societal advantage factor. Further, precision farming, organic farming, integrated crop and nutrient management system may be the alternative option for crop based agriculture. The market of traditional farm inputs like farm-yard-manure (FYM), vermin-composts, and bio-fertilizers may be developed because of labour – intensive nature in production and emerging women participation rate in agriculture.

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