

Original Research Article

Identifying and understanding factors influencing the knowledge level of farmers in watershed development programme using Principal Components Analysis

ABSTRACT

Watershed Development Programme based on participatory approach and bottom-up planning. Good understanding about the guideline will help in effective implementation of the programme to achieve the end results. Considerable gaps were observed on various aspects of implementation of the programme such as institutional arrangement, community organization, objectives, programme formulation and implementation, funding pattern, monitoring and evaluation. Further exposures are essentially required of the watershed people to the guideline for clear understanding of the operational procedures towards effective implementation of the programme. Principal component analysis (PCA) is a technique for reducing the dimensionality of datasets, increasing interpretability but at the same time minimizing information loss. It does so by creating new uncorrelated variables that successively maximize variance. Based on the original variables, PCA calculates a set of new variables that describes as much as possible of the variance in the data. The new 'variables' are named principal components (PCs). Our study identifies the socioeconomic factors prompting knowledge level of the watershed users groups and their level of adoption of different watershed practices. The present study was conducted with a sample size of 192 progressive farmers and watershed user groups in Nuapada and Kalahandi district of Odisha state, aiming at tracing out the major socio economic characteristics or factors governing farmers' knowledge and adoption level of different watershed activities. Data were collected by personal interview and analyzed using different statistical analysis and principal component analysis. Three different principal components could finally be extracted out of twelve relatively important variables governing knowledge and participation level of farmers in different watershed activities.

These socio-economic factors provide essential information to support efforts and policies aimed at improving adoption by recognizing heterogeneities in the targeted populations. Furthermore, we concluded that multivariate analysis provides valuable and appropriate tools for identifying the main socioeconomic variables of farmers that influenced the knowledge level and adoption of watershed practises for the long-term enhancement of agriculture and farm revenue. Out of 12 relatively essential variables influencing farmer progressiveness, three distinct components or factors could eventually be derived. These three factors were resource richness, which was associated with higher farm revenue, cosmopolitaness, which was associated with extended contact and motivation, and family type, which

was associated with manpower and farming as a primary employment. These factors can be used as crucial input to predict models or as benchmarks for developing scales or indices for measuring farmers' progressiveness and knowledge and adoption of watershed activities . Data were evaluated by multivariate statistical models. Firstly, data reduction was conducted through principal component analysis to identify three components accounting for slightly more than 58.66 % of the total variability in the data. It is evident from the results that socioeconomic factors such as Land holding , Annual Income , Type of house, Cosmo politeness and extension contact , Education , more use communication materials , Social participation and age of the farmer, can be associated with higher knowledge and adoption of watershed activities and practices. Conversely, big farmers , resource rich farm families with family labour and large farm sizes, and farmers with more extension contact and exposure were found to be better adopters of watershed practices . From the findings of the study, it was concluded that three principal components viz. **'resource rich ness'** , **'education and extension contact'** and **'farm family occupation "** were found to have exerted significantly high influence and contributed 23.44%, 20.12% and 15.1% variance in determining the extent of farmers' knowledge level about watershed activities .

Moreover, the findings imply that these socio -economic factors contribute to a larger extent towards farmers' knowledge level which leads higher adoption of water shed activities , hence should invariably be addressed while planning developmental programmes for the farmers.

Key words- Watershed development programme, Socio economic factors, Multivariate analysis Dimension reduction technique, Principal Components Analysis.

INTRODUCTION

Participatory watershed development programme was implemented in Odisha after introduction of the revised watershed guidelines of 2001 developed by the Ministry of Rural development and "JANASAHABHAGITA" guideline of the Ministry of Agriculture, Government of India. The guideline envisages clear-cut institutional arrangements, operational procedure, programme designing, programme implementation, fund utilization, monitoring and evaluation. It is purely based on the concept of bottom-up planning with single window, integrated, participatory as well as sustainable area development programme. Watershed management is the integrated use of land, vegetation, and water in a geographically discrete drainage area for the benefit of its residents, with the

objective of protecting or conserving the hydrologic services the watershed provides and reducing or avoiding negative downstream or groundwater impacts (Darghouth et al., 2008).

Dufera, et al (2020) concluded that the overall findings indicated that, the intervention of watershed management practice not only increase crop yield and livestock production but also it has high contribution to increases the perception, adoption, participation, and maintenance of implemented watershed management practices. The watershed people have to actively participate in the programme starting from planning to implementation, fund utilization and evaluation of the activities. Therefore, clear understanding of the watershed people towards operational procedure is the pre-requisite for effective implementation of the programme. With this hypothesis in view; the present study has been designed to assess the knowledge level of the watershed people towards functioning of the programme. The socio economic factors , of the farmers can be very useful in exploring adoption of watershed practices in related areas. No single uniform approach will equally improve adoption of watershed practices in a heterogeneous population. It is therefore crucial that efforts and/or policies meant to improve adoption and use of watershed technologies and practices in rain fed area agriculture should be more focused on specific groups such as these socioeconomic characters defined. Stakeholders concerned with improving watershed activities adaptation in rainfed farming areas can therefore create new structures and strategies or modify their existing ones for improving adoption of watershed practices .

Progressiveness, excellence and success of farmers are generally governed by a number of individual forces operating on it, known as factors. The factors themselves are latent dimensions of more than one contributing variables. Hence to have such a perspective of the farmers as well as other stakeholders, a quantitative research was emphasized under the present study with the aim of identifying and prioritizing the determinants of farmers' socio economic characteristics that influence progressiveness resulting in higher adoption and , higher profit and overall success of watershed activities (Rakesh Kumar et al , 2015) . Socioeconomic status (SES) is an economic and sociological combined total measure of a person's work experience and of an individual's or family's economic access to resources and social position in relation to others. When analyzing a family's SES, the household income, education and occupation are examined, as well as combined income, whereas for an individual's SES only their own attributes are assessed.

(Chikowo et al. 2014) stated household typologies based on socioeconomic characteristics that influence adoption technologies and (Bidogezza et al. 2009) who typified farm households based on socioeconomic characteristics that promote adoption of new farming technologies in general. Socio-economic status is the position an individual or a family occupies concerning the prevailing average

standards of cultural possessions, effective income, material possession, and participation in the group activity of the community. "Knowledge is defined as those behaviors and test situations which emphasized the remembering either by recognition or recall of ideas, materials or phenomena" (Bloom et al, 1956). In the present study, knowledge was operationalized as the quantum of specific information possessed by the respondents about the intervened technology. In this study, the empirical approach adopts multivariate statistical techniques that allow us to identify the socio economic variables, especially when an in-depth database is available (Bidogeza et al. 2009).

Principal component analysis (PCA) is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components (Abdi et al 2013)

Principal component analysis (PCA) simplifies the complexity in high-dimensional data while retaining trends and patterns. It does this by transforming the data into fewer dimensions, which act as summaries of features. PCA is a statistical procedure that converts a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. In simpler words, PCA is often used to simplify data, reduce noise, and find unmeasured "latent variables. PCA is used in exploratory data analysis and for making predictive models. It is commonly used for dimensionality reduction by projecting each data point onto only the first few principal components to obtain lower-dimensional data while preserving as much of the data's variation as possible. The first principal component can equivalently be defined as a direction that maximizes the variance of the projected data. The principal components are eigenvectors of the data's covariance matrix. Thus, the principal components are often computed by eigen decomposition of the data covariance matrix or singular value decomposition of the data matrix. PCA is the simplest of the true eigenvector-based multivariate analyses and is closely related to factor analysis (Chachlakis, 2019).

According to (Vyas and Kumaranayake, 2006) PCA is a multivariate statistical technique used to reduce the number of variables in a data set into a smaller number of 'dimensions'. In mathematical terms, from an initial set of 'n' correlated variables, PCA creates uncorrelated indices or components, where each component is a linear weighted combination of the initial variables. The weights for each principal component are given by the eigenvectors of the correlation matrix, or if the original data were standardized, the co-variance matrix. The variance for each principal component is given by the eigenvalue of the corresponding eigenvector. The components are ordered so that the first component (PC1) explains the largest possible amount of variation in the original data, As the sum of

the eigenvalues equals the number of variables in the initial data set, the proportion of the total variation in the original data set accounted by each principal component is given by (λ_i/n) . The second component (PC2) is completely uncorrelated with the first component, and explains additional but less variation than the first component, subject to the same constraint. Subsequent components are uncorrelated with previous components; therefore, each component captures an additional dimension in the data, while explaining smaller and smaller proportions of the variation of the original variables. The higher the degree of correlation among the original variables in the data, the fewer components required to capture common information.

OBJECTIVE

The study was undertaken with an objective to assess the knowledge and perception level of the tribal people about functioning of Watershed development programme and use of principal component analysis (PCA) for necessary data reduction to identify typical, socio economic variables. Farmers adopted improved farming practices only for economic gain. The economic gain of the farmer depends upon the farmer's age, education, size of holding socio- economic status and their progressiveness because progressive outlook motivates the farmers to adopt the new ideas or agricultural technology for their economic gains. Udiin et al (2014), in their study concluded that the socioeconomic variables like age, education, family size, farm size, family income, and involvement in cooperatives were significantly related to adaptation of Environmental Degradation and Climate Change Effects.

This study is unique as it is one of a few to focus on the dynamics of socio- economic characteristics in influencing the knowledge and adoption level of different watershed activities operating in the study area. However, there are some closely related studies that have relied on the same approach in defining socio- economic characteristics based on adoption of watershed practices and technologies adoption. Specifically, we use a combination of principal component analysis (PCA) for necessary data reduction and cluster analysis to identify typical, socio economic variables following studies by (Usai et al 2006) and (Bidogeza et al. 2009)

MATERIALS AND METHODS

The study was undertaken in tribal dominated Nuapada and Kalahandi district under Western Undulating Agro-climatic zone of Odisha. Six watersheds from two blocks of each district were selected for the purpose of investigation. Watershed president, secretary, chairman, six from user group, three each from landless and women category and one from watershed committee of each watershed were selected as the respondents with total sample size of 192. Information collected on scale point of strongly agree, agree and disagree were analyzed with score value of 2,1 and 0 respectively. The

independent variables, such as caste, education, land holding, social participation and socio-economic status, were measured by the scale of Trivedi (1963). Mean score, gap percentage, multiple regression analysis and Principal component analysis (PCA) were employed to reveal the results. PCA is a statistical procedure that converts a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. In simpler words, PCA is often used to simplify data, reduce noise, and find unmeasured “latent variables”.

Principal Component Analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. Principal component analysis, or PCA, is a dimension reduction technique and a statistical procedure that allows us to summarize the information content in large data tables by means of a smaller set of “summary indices” that can be more easily visualized and analyzed. Principal Component Analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. PCA works on a process called Eigenvalue Decomposition of a covariance matrix of a data set. Principal component analysis was used for necessary data reduction analysis and it was evident from our results that various socioeconomic factors define clusters and can be associated with knowledge level of the respondents and adoption level of watershed practices.

. In some situations the measurements are taken over a large number of variables. But it is not possible to deal with a large number of variables. Therefore instead of these large number of variables their linear combinations, which are linearly independent and ortho normal also, are used which can explain maximum possible variation in the data. These linear combinations are called as principal components. Transforming the original vector variable to the vector of principal components amounts to a rotation of coordinate axes to a new coordinate system that has inherent statistical properties. The set of principal components yields a convenient set of coordinates, and the accompanying variances of the components characterize their statistical properties. The method of principal components is used to find the linear combinations with large variance. Firstly, a principal components analysis (PCA) was conducted, a technique which is necessary to summarize the datasets into smaller and non-correlated dimensions or components (Vyas and Kumaranayake, 2006).

Prior to proceeding with the PCA approach, the Bartlett’s test (Bartlett, 1950) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were performed to evaluate the appropriateness of the variables to be used as inputs to the PCA approach (Field, 2009). The Bartlett’s test of

sphericity checks the null hypothesis that the inter-correlation matrix came from a population in which the variables to be used in the PCA are all non-collinear. The results from this test using the survey data revealed a significant test (Chi-square = 884.901 and p -value = 0.000) suggesting that the variables are uncorrelated and hence suitable for a PCA. On the other hand, the KMO test compares the correlations and the partial correlations between the variables with a small KMO suggestive of highly correlated data. Using the Kaiser (1974) characterization of the KMO values revealed that the study's KMO statistic of 0.748 is middling and suggestive of less correlated data. which all support the appropriateness of the analyzed data for the multivariate analysis procedures.

The PCA approach followed the Kaiser criterion of retaining all the components with eigenvalues greater than one (1). Also, to simplify the interpretability of the PCA results, the components were rotated, using the Kaiser's normalization applicable when the number of variables does not exceed 30, which is the case with the analyzed data. This approach has also been applied in recent and related studies (Bidogeza et al.2009 and Nainggolan et al. 2013). All the statistical analysis was conducted in SPSS version 19.0 and results were described in different sub heads .

RESULTS AND DISCUSSION

The Watershed guideline envisages clear cut institutional arrangements for effective implementation of the programme.

Table 1: Knowledge about institutional arrangements

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Village consulted before implementation	1.09	1.25	12.80	1.17	41.50
2	Analysis of priorities	1.07	1.60	33.13	1.34	33.00
3	Formation of users and Self Help Groups	1.13	1.39	18.71	1.26	37.00
4	Volunteers employed on common agreement	0.83	1.13	26.55	0.98	51.00
5	Contribution of users in each activity	0.99	1.33	25.56	1.16	42.00

6	Sufficient training to develop competency	0.49	0.79	36.97	0.64	68.00
7	PIA & WDT guide sufficiently	0.96	1.33	27.83	1.15	42.50

It is revealed from (Table -1) that the respondents of both the districts were somewhat agreed on that the analysis of priorities, formation of users and Self Help groups, village consulted before implementation, contribution of users in each activity, Programme Implementation Agency (PIA) and Watershed Development Team (WDT) members guide sufficiently. But the respondents had poor knowledge about sufficient training to develop confidence and volunteers employed on common agreement.

All the watershed people should have detailed understanding about community organization as well as role and responsibility of each individual in the watershed area. Analysis of data (Table-2) revealed that the respondents had better knowledge about watershed association formed before implementation and membership mandatory, development fund used exclusively for post project activities, committee members selected with common decisions, watershed secretary maintain all accounts and beneficiaries contribution deposited in the revolving fund account. Poor knowledge observed on regular meeting of the association, association approve accounts, monitor and review progress needs further exposure to guidelines.

Table 2: Knowledge about Community Organization.

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Association formed before implementation	1.30	1.41	7.80	1.36	32.00
2	All people to be the member of association	1.17	1.48	20.95	1.33	33.50
3	Watershed Committee formed with common decision	1.18	1.32	10.60	1.25	37.50
4	Conducting regular meeting of the association	0.91	1.05	13.23	0.98	51.00
5	Association approve accounts, monitor and review progress	0.78	1.41	21.58	0.96	52.00
6	Watershed secretary maintains all accounts	1.22	1.22	0.00	1.22	39.00
7	Contribution deposited in the account of development fund	1.09	1.20	9.17	1.15	42.50
8	Development fund exclusively used for post project activities.	1.36	1.15	15.44	1.26	37.00

Watershed development programme has clear cut objectives for the all round development of the watershed. Detail understanding of the objectives will facilitate effective implementation of the programme. As observed from Table-3 that the respondents had poor

Table-3 : Knowledge about objectives of the programme.

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Covers all developmental activities	1.06	0.97	8.49	1.02	14.00
2	Employment generation	1.13	1.59	28.93	1.36	32.00
3	Management of adverse situation	1.34	1.27	5.22	1.31	34.50
4	Conservation of soil and water	1.65	1.86	11.29	1.76	12.00
5	Restoration of ecological balance	1.27	1.82	30.22	1.55	22.50
6	Emphasis on indigenous knowledge	0.76	0.73	3.95	0.75	62.50
7	Optimum use of available resources	0.93	0.98	5.10	0.96	52.00
8	More attention towards poverty alleviation	0.90	1.05	14.29	0.98	51.00
9	Empowerment of rural poor	0.92	1.02	9.80	0.97	51.50

knowledge towards emphasis on indigenous knowledge, optimum use of available resources, more attention towards poverty alleviation and empowerment of rural poor which are emphatically indicated in the guideline for sustainability of the livelihood system. However, better knowledge was observed on conservation of soil and water, restoration of ecological balance, employment generation, management of adverse situation as well as cover all developmental activities.

The programme purely based on participatory approach where the watershed people activity involved in the process of programme development. As revealed from the (Table-4), the

Table – 4: Knowledge about programme development.

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		

1	Involvement in problem diagnosis	1.14	1.52	25.00	1.33	33.50
2	Participation in programme formulation	0.96	1.32	27.27	1.14	43.00
3	Participatory decision for programming in Govt. land	1.01	1.23	17.89	1.12	44.00
4	Adequate programme for each family	0.72	0.92	21.74	0.82	59.00
5	Emphasis on plantations	1.27	1.34	5.22	1.31	34.50
6	Adequate programme for conservation of soil and moisture	1.09	1.17	6.84	1.13	43.50
7	Repair, restoration and up gradation of community assets	1.20	1.18	1.67	1.19	40.50
8	Renovation of water resources	1.20	1.11	7.50	1.16	42.00

respondents had better participation in problem diagnosis, programme formulation, programming in Govt. land with emphasis on plantations, conservation of soil and moisture, renovation of water resources, repair, restoration and up-gradation of community assets. Poor Knowledge observed on adequate programme for each family will definitely demand for further exposure to the guideline.

Programme implementation is the sole responsibility of the watershed people. The individual beneficiary has to receive funds from the Watershed association, purchase inputs, materials etc. and implement the approved programme.

Table –5: Knowledge about programme implementation.

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Each family implement own programme	1.27	1.34	5.22	1.31	34.50
2	Technical expertise by WDT	1.38	1.34	2.90	1.36	32.00
3	Immediate action on field problem	1.01	1.07	5.61	1.04	48.00
4	Timely monitoring of progress	1.17	1.04	11.11	1.11	44.50
5	Close supervision by WDT	1.26	1.06	15.87	1.16	42.00
6	Timely use of inputs and materials	1.11	1.01	9.01	1.06	47.00
7	Regular review of progress	1.14	0.94	17.54	1.04	48.00

It is observed from the (Table-5) that the respondents had better knowledge about programme implementation. However, further exposure is necessary for their clear understanding on regular review of the progress, immediate action on field problems, timely use of inputs and materials.

The guideline clearly spelled out the details of procedure for release of funds, utilization pattern and maintenance of accounts. The watershed beneficiaries should have detail understanding about all the aspects since he has to utilize the funds and maintain all records.

Table – 6.: Knowledge about funding pattern.

Sl. No.	Knowledge level	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Adequate fund for developmental activities	0.46	0.53	13.21	0.50	75.00
2	Funds for community organization	1.19	1.33	10.53	1.26	37.00
3	Adequate fund for capacity building	0.75	1.07	29.91	0.91	54.50
4	Freedom to people in fund utilization	0.99	1.00	1.00	1.00	50.00
5	Compulsory contribution to development fund	1.50	1.28	14.67	1.39	30.50
6	Scope for credit facilities	0.10	1.36	25.74	1.19	40.50
7	Revolving fund for SHGs	0.96	1.08	11.11	1.02	49.00
8	Well defined procedure in fund utilization	1.11	1.24	10.48	1.18	41.00

It is observed from the (Table-6) that the respondents had poor knowledge on adequate funds for developmental activities, capacity building, freedom in fund utilization and revolving fund facilities for self help group activities which needs further exposure for their clear understanding.

Table –7: Knowledge about monitoring and evaluation.

Sl. No.	Knowledge	Mean Score			Pooled mean score	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)		
1	Capacity building for record maintenance	1.08	1.49	27.52	1.29	35.50
2	Regular meeting by WDT	1.33	1.18	11.28	1.26	37.00
3	Close supervision of each activity	1.15	1.14	0.87	1.15	43.00
4	Timely technical guidance	1.07	0.97	9.35	1.02	49.00

5	Documentation of each activity	1.02	0.86	15.69	0.94	53.00
6	Solving problems and difficulties	0.89	0.86	3.37	0.88	56.00
7	Participatory evaluation of progress	0.94	0.71	24.47	0.83	58.50
8	Raising Watershed Development Fund	1.33	1.10	17.29	1.22	39.00

Regular monitoring and evaluation of the progress in participatory mode have also been emphasized in the guideline. It is observed from the (Table-7) that the respondents were lacking in knowledge on documentation of each activity, solving problems and difficulties, participatory evaluation of progress and timely technical guidance for which further exposure are required for effective monitoring and evaluation of the programme.

Comparative analysis of the knowledge as revealed from table-8 indicated that the knowledge level of the respondents of both Nuapada and Kalahandi district were at par.

Table –8: Comparative analysis of the knowledge level.

Sl. No.	Knowledge	Mean Score			C.R. value	Pooled mean score (N=192)	Gap (%)
		Nuapada district (N=96)	Kalahandi district (N= 96)	Diff. (%)			
1	Institutional arrangement	0.94	1.26	25.40	0.148	1.10	45.00
2	Community organization	1.13	1.25	9.60	0.053	1.19	40.50
3	Objective	1.11	1.25	11.20	0.063	1.18	41.00
4	Operational procedure	1.17	1.09	6.84	0.037	1.13	43.50
5	Programme development	1.07	1.22	12.30	0.068	1.15	42.50
6	Programme implementation	1.19	1.11	6.72	0.036	1.15	42.50
7	Funding pattern	1.00	1.11	9.91	0.052	1.06	47.00
8	Monitoring and evaluation	1.10	1.04	5.45	0.028	1.07	46.50
	Average	1.09	1.17	6.84	0.037	1.13	43.50

Significant gaps of 40.5% to 47.00% were observed on various aspects of implementation of the watershed development programme with maximum in funding pattern (47.00%). Average gap of 43.50% had suggested for further exposure towards detail understanding of the guideline.

The data in the table revealed that all the socio-economic variables covered under study had significantly and positively influenced the knowledge level of the respondents of Nuapada district towards effective implementation of the watershed programme except family type, family size, and occupation. But, in case of the respondents of Kalahandi district, education, extension contact, use of communication materials and type of house positively and occupation negatively influenced the knowledge level. The pooled mean score value indicated that education, social participation, cosmopolitaness, extension contact, communication materials used, type of house, holding size and annual income of the respondents were the important variables accelerating the knowledge level of the respondents in implementation of the watershed Development Programme .

Attempt was also made in the study to assess the influence of socio-economic variables increasing the knowledge level of the respondents towards effective implementation of the Watershed development programme.

Table – 9 : Influence of socio-economic variables on knowledge level of respondents

Variable	Nuapada district (n=96)		Kalahandi district (n=96)		Pooled mean score,(n=192)	
	'r' value	't' value	'r' value	't' value	'r' value	't' value
Age (X1)	0.392*	4.131	-0.131	-1.281	0.172	2.407
Education (X2)	0.552**	6.418	0.380*	3.983	0.470**	7.340
Family type (X3)	-0.086	-0.837	-0.103	-1.004	-0.059	-0.815
Family size (X4)	0.041	0.398	0.184	1.815	0.117	1.624
Social participation(X5)	0.301*	3.060	0.180	1.774	0.257*	3.666
Cosmopolitaness (X6)	0.480**	5.305	0.167	1.642	0.375*	5.576
Extension contact (X7)	0.687**	9.166	0.415**	4.422	0.581**	9.840
Communication material use (X8)	0.526**	5.996	0.516**	5.840	0.515**	8.281
Type of house (X9)	0.216*	2.145	0.243*	2.429	0.238*	3.378
Land holding (X10)	0.431**	4.631	0.118	1.152	0.301*	4.351
Occupation (X11)	-0.141	-1.381	-0.348*	-3.599	-0.195	-2.740
Annual Income(X12)	0.357**	3.705	0.056	0.544	0.210*	2.961

* Significant at 0.05 level of probability, ** Significant at 0.01 level of probability

The data in the table revealed that all the socio-economic variables covered under study had significantly and positively influenced the knowledge level of the respondents of Nuapada district towards effective implementation of the watershed programme except family type, family size, and occupation. But, in case of the respondents of Kalahandi district, education, extension contact, use of

communication materials and type of house positively and occupation negatively influenced the knowledge level. The pooled mean score value indicated that education, social participation, cosmopolitaness, extension contact, communication materials used, type of house, holding size and annual income of the respondents were the important variables accelerating the knowledge level of the respondents in implementation of the watershed Development Programme.

Table 10: Correlation Matrix among the selected socio economic variables

Correlation Matrix

Variable	Age (X1)	Education (X2)	Family type (X3)	Family size (X4)	Social participation (X5)	Cosmopolitaness (X6)	Extension contact (X7)	Communication material use (X8)	Type of house (X9)	Land holding (X10)	Occupation (X11)	Annual Income (X12)
Age (X1)	1.000	.291	.062	-.071	.219	.115	.107	.159	.080	.057	.033	.071
Education (X2)	.291	1.000	-.037	.093	.334	.331	.499	.654	.275	.242	-.161	.231
Family type (X3)	.062	-.037	1.000	.404	-.010	-.129	-.061	-.152	.150	.197	.248	.201
Family size (X4)	-.071	.093	.404	1.000	.105	-.066	.071	.099	.208	.209	.250	.321
Social participation (X5)	.219	.334	-.010	.105	1.000	.255	.260	.372	.120	.073	-.020	.152
Cosmopolitaness (X6)	.115	.331	-.129	-.066	.255	1.000	.530	.452	.362	.334	-.140	.191
Extension contact (X7)	.107	.499	-.061	.071	.260	.530	1.000	.624	.360	.289	-.049	.365
Communication material use (X8)	.159	.654	-.152	.099	.372	.452	.624	1.000	.343	.182	-.123	.285
Type of house (X9)	.080	.275	.150	.208	.120	.362	.360	.343	1.000	.604	.109	.677
Land holding (X10)	.057	.242	.197	.209	.073	.334	.289	.182	.604	1.000	.058	.716
Occupation (X11)	.033	-.161	.248	.250	-.020	-.140	-.049	-.123	.109	.058	1.000	.145
Annual Income (X12)	.071	.231	.201	.321	.152	.191	.365	.285	.677	.716	.145	1.000

The data in the table revealed that all the socio-economic variables covered under study had significantly and positively influenced the knowledge level of the respondents of towards effective implementation of the watershed programme. . The Pearson’s Coefficient of correlation (r) value indicated that education, social participation, cosmopolitaness, extension contact, communication materials used, type of house, holding size and annual income of the respondents were the important variables accelerating the knowledge level of the respondents in implementation of the watershed Development Programme . Similar findings were reported by (Gautam and Shahare, 2020) that the education, size of holding social participation and socio-economic status of the respondents was positively associated with increased knowledge and increase the adoption level of intervention technologies while age was found to be negative and significantly correlated.

Concerning farming experience, as the age of the household head increases, the household acquires more farming experience, becomes more risk averse and diversifies its production (Bogale and Shimelis 2009) which can increase its appetite for new technology. Positive and significant

association of size of holding, social participation, and socioeconomic status with the attitude scores have also been reported by(Kumar 1993).

The education of the farmer and technology adoption have a positive correlation that is well acknowledged in the adoption literature (Mahapatra and Mitchell, 2001) . Educated farmers are expected to relate technology activities and are also more likely to take a shorter time to adopt technologies (Upadhyay et al. 2003) adoption to the betterment of their farming.

. Watershed management increased agricultural production and income of the households, while protecting the sustainability and ecological function of the environments. Mixed farming system which involves crop production and animal husbandry was adopted by farmers in the two micro-watersheds. The main sources of household incomes of respondents were from crop production, animal production, natural resource use, employed earning by salary, vegetable production, and from off-farm activities and results indicated that farm size and Farming experience was significant at ($p < 0.05$) and positive relationship with the adoption of watershed activities (Dufera, et al 2020) .

Agriculture extension access is another important source of information for farming communities. Agricultural extension officers link farmers with research and they decode information from researchers into a language and format that farmers can understand. In addition, they also provide feedback from farmers to the researchers. It, therefore, implies that extension access and frequency of extension services can be important determinants of technology adoption.

Several studies have reported use of extension services to be an important determinant of technology (Tizale, 2007). Empirical studies have found arable land size to be an important determinant of farm technology adoption (Feder and Umali ,1993).

Resource endowments (e.g. farm assets and other equipment) can influence farming technology adoption at household level (Bidogeza et al. 2009) . Households who own or have access to resources are more likely to have increased chances and ability to adopt new technologies. So far as land holding is concerned, it seems to have positive association with economic motivation which was found to be statistically significant. The size of holding affects the state of economic motivation. It may be due to the fact that almost all were small and marginal land holders and engaging themselves in intensive cultivation. They want to earn more income from limited area. This indicated the positive association between the variables. (Singh et al. 2009). The education level, income from agriculture, farmer cooperative and credit were determinant factors for adoption of most of the agricultural practices (Diaz et al. 2021) .

Age, land holding and socio- economic status have been found to have significant association with economic motivation. Land holding is having positive association with economic motivation which was found to be statistically significant. The size of holding affects the state of economic motivation.

Socio-economic status was significantly associated with economic motivation. Good socio- economic status acts as supplementary factor to influence state of motivation regarding good earnings. (Singh et al 2009). “Similar findings were reported by (Lwayo and Maritim , 2003) , stated that there was significant relationship between land size, age and education with the farmer's decision to adopt technologies in farm forestry . The age of the farmer affected the farmer's knowledge and the awareness of the activities in the surrounding environment among other farmers.”

Similar findings were reported by (Gautam et al. 2020) and it was revealed that socioeconomic characters like education, caste, size of holding, social participation, socioeconomic status, and annual family income were positively and significantly correlated with attitude scores towards intervened technology. The above table further shows that age was found to be significantly associated but in a negative direction with the knowledge level of the respondents. A negative and significant association between age and knowledge level of the respondents indicated that relatively the elderly respondents had neutral to un favourable attitudes towards watershed technologies. This might be because the older age people are generally tradition-bound and conservative. Education was found to be positively and significantly associated with knowledge level of the farmers and education usually changes the outlook of a person which helps him in changing the attitude and adopt the new technologies .

Attempts have also been made for the multiple regression analysis to assess the causal factors exhibiting influence on the knowledge level of the respondents and to locate the important socio-economic variables to assess the causal impact on the consequent factors. The results obtained from the multiple regression analysis have been reflected in Table - 11 as below Most of the correlations are well above 0.3 (a good indication that we will obtain a result) .

Table-11 -Regression Analysis of socio economic variables on knowledge

Variables	Un standardized Co-efficient		Standardized Co-efficient		't' value	Significance
	Beta	Std. Error	Beta	Std. Error		
Age (X1)	3.121	1.983	0.093	0.045	1.573	0.117
Education (X2)	0.933	1.194	0.061	0.081	0.781	0.435
Family type (X3)	-1.668	2.648	-0.040	0.071	-0.630	0.529
Family size (X4)	5.379	2.619	0.132	0.052	2.053	0.041
Social participation(X5)	0.477	0.590	0.049	0.045	0.808	0.419
Cosmopolitaness (X6)	-0.224	0.421	-0.039	0.079	-0.533	0.594
Extension contact (X7)	2.295	0.423	0.424	0.081	5.421	0.000

Communication material (X8)	1.059	0.532	0.173	0.058	1.989	0.048
Type of house (X9)	-0.544	1.896	-0.023	0.083	-0.286	0.774
Land holding (X10)	5.883	1.682	0.302	0.067	3.497	0.000
Occupation (X11)	-5.732	2.182	-0.155	0.065	-2.626	0.009
Annual Income (X12)	-4.198	1.756	-0.228	0.062	-2.390	0.017

R²: 0.465 Adj.R²: 0.429 S.E. : 14.846

As observed from Table- 11, that the best fitted regression analysis could explain 46.50% of the total variance in influencing the knowledge level of the respondents. Among the twelve variables, extension contacts, holding size, occupation, income, use of communication materials and family size exhibited significant influence in increasing the knowledge level of the respondents towards effective implementation of the Watershed Development Programme.

PCA data analysis and results and discussions

The results from the KMO and Bartlett sphericity test showed that the variables under study are related justifying the use of PCA. A total number of 12 variables from 192 respondents were included in PCA, the overall KMO was greater than 0.5 (0.748), while the Bartlett's sphericity test was significant (p -value = 0.000).

Table : 12 PCA -Descriptive Statistics

PCA -Descriptive Statistics			
Variables	Mean	Std. Deviation	Analysis(N)
Age (X1)	2.2656	.58539	192
Education (X2)	3.0990	1.28853	192
Family type (X3)	1.3281	.47076	192
Family size (X4)	1.6250	.48539	192
Social participation(X5)	5.8854	2.03565	192
Cosmopolitaness (X6)	10.1823	3.40512	192
Extension contact (X7)	5.1094	3.63714	192
Communication material (X8)	6.6042	3.21638	192
Type of house (X9)	2.5990	.83797	192
Land holding (X10)	2.6198	1.01105	192
Occupation (X11)	1.5885	.53415	192
Annual Income(X12)	2.0104	1.06829	192

PCA approach is to reduce the number of variables and such an approach is often called a “data reduction” or “dimension reduction” technique. What this basically means is that we start off with a set

of variables and then by the end of the process we have a smaller number but which still reflect a large proportion of the information contained in the original dataset. The way that the ‘information contained’ is measured is by considering the variability within and co-variation across variables, that is the variance and co-variance (i.e. correlation). Either the reduction might be by discovering that a particular linear computation of our variables accounts for a large percentage of the total variability in the data or by discovering that several of the variables reflect another ‘latent variable’. The following output has been generated in SPSS using a Varimax Rotation. Varimax rotation is a way of transforming the solution so that Rotated Component Matrix is relatively easy to understand. In particular, it identifies a solution where, to the maximum extent possible, correlations in the rotated component matrix are close to 1, -1 or 0

Table : 13 Extraction Method: Principal Component Analysis. Communalities

Communalities is the total amount of variance on original variable shares with all other variables included in the analysis . PCA assumes that total variance of the original variables can be explained via the components and uses as starting values for the Communalities 1.0. PCA does not explicitly estimate communalities as in the underlying theoretical communalities are set equal to the total variance.

Communalities		
Variables	Initial	Extraction
Age (X1)	1.000	.353
Education (X2)	1.000	.646
Family type (X3)	1.000	.569
Family size (X4)	1.000	.526
Social participation(X5)	1.000	.485
Cosmopolitaness (X6)	1.000	.542
Extension contact (X7)	1.000	.609
Communication material use (X8)	1.000	.707
Type of house (X9)	1.000	.709
Land holding (X10)	1.000	.733
Occupation (X11)	1.000	.391
Annual Income(X12)	1.000	.769

Communalities is the proportion of each variable’s variance that can be explained by the factors (e.g., the underlying latent continua). It is also noted as h^2 and can be defined as the sum of squared factor

loadings for the variables. The communalities are computations of the extent to which a variable is explained by the components. Note that Age (X1) has the lowest communality, which indicates that age is less well explained by the analysis than any of the other variables and (increasing the number of factors increases the communality of all the variables), the variables annual income (X12), Type of house (X9), Communication material use (X8), and Land holding (X10) and Extension contact (X7) has the highest communalities. Factor loadings for the PCA is correlation between a specific observed variable and a specific factor. Higher values mean a closer relationship

However the factor loadings or the component loadings for the PCA are larger in absolute values as are the communalities and as a consequence the total variance explained is also greater, Factor loadings for the PCA is correlation between a specific observed variable and a specific factor. Higher values mean a closer relationship. Higher the value the better. Communality for the PCA is the total influence on a single observed variable from all the factors associated with it. It is equal to the sum of all the squared factor loadings for all the factors related to the observed variable and this value is the same as R^2 in multiple regressions. The value ranges from zero to 1 where 1 indicates that the variable can be fully defined by the factors and has no uniqueness. In contrast a value of 0 indicates that the variable cannot be predicted at all from any of the factors.

Table – 14: KMO and Bartlett's Test for studying appropriateness of multivariate analysis

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.748
Bartlett's Test of Sphericity	Approx. Chi-Square	884.901
	Df	78
	Sig.	.000

Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity; unrotated solution, including factor loadings, communalities, and eigenvalues; and rotated solution, including rotated pattern matrix and transformation matrix. Bartlett's Test of Sphericity compares an observed correlation matrix to the identity matrix. Essentially it checks to see if there is a certain redundancy between the variables that we can summarize with a few number of factors. The null hypothesis of the test is that the variables are orthogonal, i.e. not correlated.

We can see that we have good values for all variables for the MSA (Measures of Sampling Adequacy) but the overall value is at 0.748, however Bartlett's Test of Sphericity has an associated p value (sig in the table) of $< .001$. So from the above results it was concluded that that we can now

continue and perform a valid factor analysis. The KMO value indicates good value and also, however Bartlett's test of sphericity with an associated p value of $< .001$ indicates that we can proceed for PCA.

Fig I : Scree plot for identifying the number of components

The scree plot graphs the eigenvalue against the factor number. It is seen that these values in the first three columns of the table immediately above. From the fourth factor on, you can see that the line is almost flat, meaning the each successive factor is accounting for smaller and smaller amounts of the total variance.

The following scree plot shows the number of Eigenvalues (λ) from the example shown on the main principal components analysis, ordered from biggest to smallest. Some researchers concluded that the correct number of components is the number that appear prior to the elbow (in this case it is three components). In PCA the Kaiser criterion drops the components, for which the eigenvalues are less than 1 (when the data is standardized). Greater than 1 eigenvalue suggests that the corresponding component explains more variance than a single variable, given that a variable accounts for a unit of variance. A widely recognized criterion is called the Kaiser-Guttman rule (Kaiser, 1960) and simply states that the number of factors is equal to the number of factors with eigenvalues (λ) greater than 1.0. From the above Scree plot it was evident that only the first three components have eigenvalues (λ) over 1.00, and together these explain over 58.66 % of the total variability in the data. This leads us to the conclusion that a three factor solution will probably be adequate.

Rotated Component Matrix (Extraction Method)

The rotated component matrix, referred to as the loadings, is the key output of principal components analysis. It contains estimates of the correlations between each of the variables and the estimated components as in table below. Extraction – The values in this column indicate the proportion of each variable's variance that can be explained by the retained factors. Variables with high values are well represented in the common factor space, while variables with low values are not well represented. (In this example, we don't have any particularly low values.) They are the reproduced variances from the factors that you have extracted. You can find these values on the diagonal of the reproduced correlation matrix.

Table 15 : Rotated Component Matrix (Extraction Method)

Rotated Component Matrix			
Variables	Component		
	1	2	3
Land holding (X10)	.843		
Annual Income (X12)	.826		
Type of house (X9)	.822		
Cosmopolitaness (X6)	.484	.405	-.380
Education (X2)		.755	
Communication material use (X8)	.350	.733	
Social participation (X5)		.689	
Extension contact (X7)	.497	.564	
Age (X1)		.554	
Family type (X3)			.747
Family size (X4)			.680
Occupation (X11)			.621
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			

The number of principal components extracted can also be defined by the user and a common method used is to select components where the associated eigenvalue (λ) is greater than one. In the rotated factors, the variables like Land holding, Annual Income, Type of house, Extension contact and Cosmopolitaness all have high positive loadings on the first component and the variables like Education, Communication material, Social participation, Extension contact and Age have high positive loading in second component and variables like Family type, Family size and Occupation have high positive loading in third component. The eigenvalue (variance) for each principal component indicates the percentage of variation in the total data explained. Besides using the eigen value >1 criteria

we could have inspected a scree plot and worked out where the factors levelled off. Now we have our three factors we need to find a way of interpreting them to enable this we carry out a process called factor rotation. The next thing we do is to disregard those loading below a certain threshold on each factor often this is something like 0.3 or 0.4. Looking at the above the values more than 0.4 were highlighted, states the high loadings for each factor and we can see immediately it makes sense, that is they seem to appear logical. Only factor loadings of 0.3 or more were considered significant as earlier reported by Comrey (1973) and Gorsuch (1974). To ease identification of relatively larger loadings, correlations above 0.44 are indicated in bold

Here we have extracted three (3) principal components from the above table. However the factor loadings or strictly speaking the component loadings for the PCA are larger in absolute values as are the communalities and as a consequence the total variance explained is also greater. Factor loadings for the PCA is equal to correlation between a specific observed variable and a specific factor. Higher values mean a closer relationship. The PCs will be ranked according to how much of the original variance they explain: PC1 will explain the most variance, PC2 the second most and so on.

Table – 16 : Extraction Method: Total Variance Explained by Principal Component Analysis,

Component	Initial Eigenvalues (λ)			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.692	30.767	30.767	3.692	30.767	30.767	2.814	23.446	23.446
2	2.097	17.473	48.240	2.097	17.473	48.240	2.415	20.122	43.568
3	1.251	10.429	58.669	1.251	10.429	58.669	1.812	15.101	58.669
4	.968	8.071	66.740						
5	.822	6.850	73.590						
6	.722	6.017	79.607						
7	.674	5.620	85.226						
8	.490	4.085	89.312						
9	.419	3.488	92.800						
10	.404	3.367	96.166						
11	.270	2.246	98.412						
12	.191	1.588	100.000						

The Kaiser Rule is the most commonly used approach to selecting the number of components and it is the default in most programs. As the total number (12) of variables were considered for the factor analysis and according to Kaiser's (1958) criterion was followed to retain only those factors with Eigen values (λ) > 1.00, hence a total of three factors all having Eigen values >1.00 have been reported in the above Table. The more variables that load onto a particular component (i.e., have a

high correlation with the component), the more important the factor is in summarizing the data. An eigenvalue (λ) is an index that indicates how good a component is as a summary of the data. An eigenvalue of 1.0 means that the factor contains the same amount of information as a single variable.

Only the first three components have eigen values over 1.00, and together these explained over 58.66% of the total variability in the data. This leads us to conclude that a three factor solution will probably be adequate. In PCA simply selecting the Eigen values (λ) greater than 1 is considered as Principal component .

The first component (comp 1) could be explained by four socio economical variables, viz. Land holding, Annual Income , Type of house , degree of cosmopolitaness and extension contact as indicated in Table 15, by the communality values (h^2) of 0.843, 0.826 , 0.822 , 0.484 and 0,497 respectively . Farmers with higher level income and more land holding strive to keep themselves abreast with recent technological breakthroughs in agriculture and continually try to gather scientific knowledge of improved watershed practices . Farmers with more land hoding are much more capable to rightly diagnose farming related problems and find out innovative solutions to overcome those. Superior scientific orientation facilitates systematized thinking and makes decision making effective (Harilal 2014). This factor termed as ‘resource rich ness’ contributed the highest variance (23.44%) in total variability of data. In this context, it must be mentioned here that there are number of extension agencies, both public and private to cater the information and input needs of the farmers, but the benefits in general are availed by those farmers having the specific attribute of cosmopolitaness. This is evident from studies that cosmopolitaness has a high degree of association with extension use efficiency (Malathesh et al. 2009)

The second component (comp 2) comprised five variables, namely Education (0. **755**), Communication material use (0 **.733**), Social participation (0. **.689**), Extension contact (0**.564.**) and age (0.554) communality values (h^2) respectively . The variables as mentioned clubbed together, clearly depicting that they have high degree of inter-correlation to determine knowledge level of farmers. Education and social participation, extension contact and use of communication materials are such important attributes that lead to success of a farmer to adopt more scientific know how by gathering farm information . An educated farmer can readily access information on the value of farming technology and how it can be effectively implemented. The factor termed as ‘**education and extension contact**’ and it contributed the second highest (20.12%) variance in total data variability..

The third component (comp 3) comprised three variables namely Family type (0. **.747**), Family size (0 **.680**) and occupation (0**.621.**) as communality values. Family type and family size and farming as primary occupation are much important attributes that lead to success of a

farmer to engage in farming for higher income by adopting new technologies in more scientific manner by gathering farm related new innovation . The factor termed as “ **farm family occupation** ” it contributed the second highest (15.10%) variance in total data variability.

From the above table it is revealed that , Component 1 contributes 23.44% variance in knowledge level and Component 2 contributes 20.12 % variances and Component 3 contributes only 15.10% of variances in dependent variable , the knowledge level of the respondents under study. Total variance explained in this case was 58.66 % , this indicates the amount of the variability in the data has been modelled by the extracted factors. It is indicated that the PCA analysis models contributed 58.66 % of the variability in this study.

Third principal components with eigen values greater than one (1) explaining (58.66 %) variability were retained for further analysis , From the results, we could define each of the three components according to the variables with which each component is most strongly associated. The first component (comp1), which explains 23.44 % of variance, is positively correlated with Land holding , Annual Income , Type of house, Cosmo politeness and extension contact . Thus, we can say (comp-1) represents resourcefulness with high extension contact and it implies that households with relatively large farm sizes are more likely higher farm income , more cosmopolite in nature due to contact with developmental agencies , acquires more knowledge about the project that leads active involvement in different watershed activities .

The second component (comp2) explains about 20.12 % of the variance and is positively correlated with Education , communication materials use , Social participation Extension contact and age of the farmers. Thus,(comp 2) represents the young , educated experienced and innovative and progressive farmers. Age of the farmer is an influencing and important factor in the pursuit of state of economic motivation with risk motivation and it pursuits towards high economic motivation by higher adoption of improved farm technologies .

Component 3 (comp3) represents 15.1 % of the variance and correlates positively with Family type , Family size and Occupation of the respondents . The component thus implies that big families with farming as main occupation and more number of available family workforce seeks more knowledge . It was due to the fact that , bigger the household size or joint family type and number of farm workers will be more and farming will be the primary occupation .

Good socio- economic status (SES) acts as supplementary factor to influence state of motivation regarding higher income and the farmers were unevenly distributed among various socio-economic status groups. It means that they have been differing in their perception and knowledge about developmental activities in watershed areas.

In this above table-16 , the eigen values (λ) and percentage of variance explained again. The middle part of the table shows the eigen values and percentage of variance explained for just the three factors of the initial solution that are regarded as important factors . Clearly the component 1 of the initial solution is much more important than the second component . However, in the right hand part of the table, the eigen values (λ) and percentage of variance explained for the three rotated factors are depicted . Whilst, taken together, the three rotated components explain just the same amount of variance (58.66 %) as the three components of the initial solution, the division of importance between the three rotated factors is very important . The effect of rotation is to spread the importance more or less equally between the three rotated factors. It was noted that in the above table the eigen values (λ) of the initial solutions of component are 3.692 and 2.097 and 1.251 compared to eigen values (λ) 2.814 and 2.4145 and 1.812 in the rotated factors , this makes it clear how important it is that to extract an appropriate number of factors.

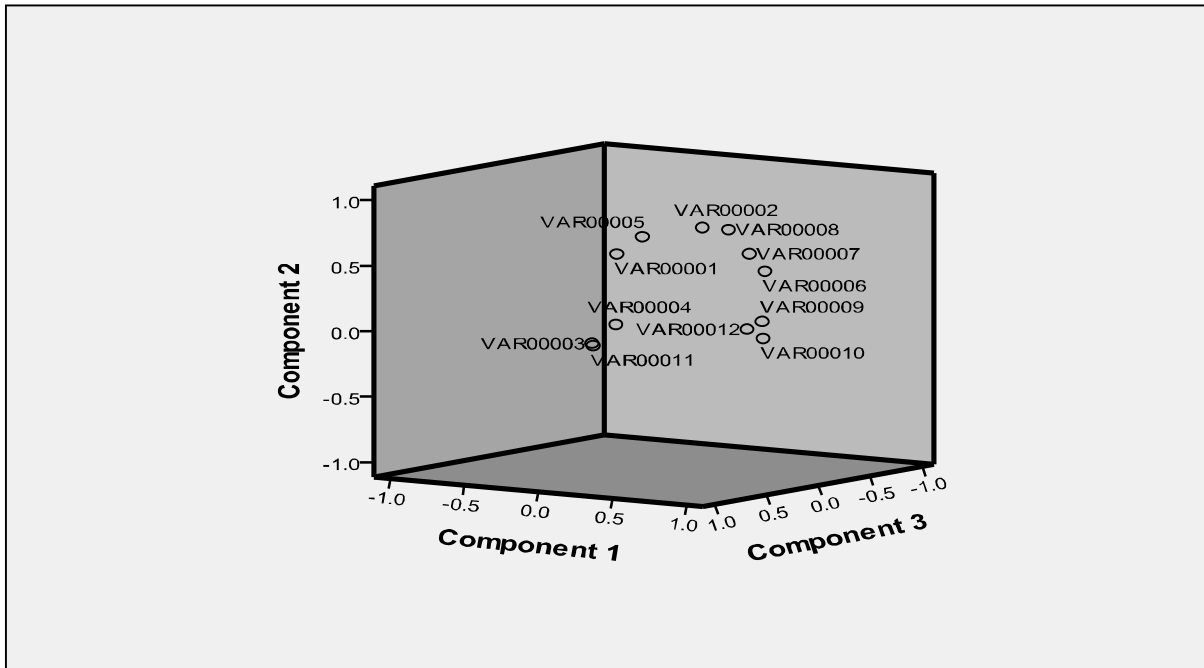
Table – 17 : Component Transformation Matrix (Rotation Method: Varimax with Kaiser Normalization)

Component	1	2	3
1	.773	.634	.027
2	.352	-.464	.813
3	-.528	.619	.582

The above table gives information about the extent to which the factors have been rotated. In this case, the factors have been rotated through 45 degrees. (The angle has been calculated by treating the correlation coefficient as a cosine. The cosine of 45 degrees is 0.77)

Fig II : Component Plot in Rotated Space

Component Plot in Rotated Space



Component plot in rotated space for three PCA components

Rotations are done for the sake of interpretation of the extracted factors in factor analysis (or components in PCA) , The components in space rotated graph allow a clearer presentation in which both the position of data in relation to the axes and the relationship between data provide information on the similarities of environmental data (Rosner, 2000).PCA is a powerful tool that attempts to identify a new set of variables as linear combinations of the measured variables so that the observed variations in the system can be reproduced by a smaller number of these causal factors. These new variables (PCs) are orthogonal and uncorrelated to each other and altogether explain the total variance of the data. The percentage of explained variance decreases from the first principal component to the second and so on. Since the first principal components retain most of the variance, many variables can be summarized by a few components and a plot of the first two or three PCs enables one to visualize most of the information contained in the data. Therefore, PCA can also be considered as a technique of projection of a dataset to a lower dimensional space.

CONCLUSION

The study revealed that though the respondents had some knowledge on implementation of the Watershed Development Programme, the respondents were lacking knowledge on various important aspects particularly on adequate funds for developmental activates, training for community organization, emphasis on indigenous knowledge, adequate programme for each family, participatory evaluation of progress, documentation of each activities, freedom to people in fund utilization, timely technical

guidance, regular review of progress, more attention, towards poverty alleviation etc. Since the watershed development programme based on participatory approach with bottom up planning, detail knowledge of the beneficiaries about operational procedure are very much essential.

Principal component analysis , a multivariate analysis approach used and clearly identify the socio economic factors of the respondents of the study area with respect to the knowledge level of the watershed user group members and their level of adoption of watershed activities and practices. Data were evaluated by multivariate statistical models. Firstly, data reduction was conducted through principal component analysis to identify three components accounting for slightly more than 58.66 % of the total variability in the data. It is evident from the results that socioeconomic factors such as Land holding , Annual Income , Type of house, Cosmo politeness and extension contact , Education , more use communication materials , Social participation and age of the farmer, can be associated with higher knowledge and adoption of watershed activities and practices. Conversely, big farmers , resource rich farm families with family labour and large farm sizes, and farmers with more extension contact and exposure were found to be better adopters of watershed practices .

From the findings of the study, it can be concluded that three principal components viz. **‘resource rich ness’** , **‘education and extension contact’** and **farm family and farming occupation ”** were found to have exerted significantly high influence and contributed 23.44%, 20.12% and 15.1% variance in determining the extent of farmers’ knowledge level about watershed activities . The study clearly indicated that technical guidance, timely farm information and advisory services, training and psychological boost up for achievement motivation and entrepreneurial aptitude alongside farm input support will be highly effective in enhancing knowledge technology adoption level of farmers in watershed area for effective implementation of the project with active involvement of the stake holders . It was concluded that establishing socioeconomic variables is an essential step in encouraging the use of watershed technology. By understanding the heterogeneities in the targeted groups, these typologies provide critical support and policies aimed at promoting adoption of technologies/practices. Furthermore, we concluded that multivariate analysis (principal component analysis) are useful tools for identifying important socioeconomic characteristics of the farmers that influence their clear understanding and compliance with guidelines and technologies, as well as their full participation in the adoption of various watershed practises. The findings therefore concluded that the project authorities have to further exposed the watershed people for a detail understanding of the operational procedures for effective implementation of the programme ensuring all round development of the watershed project .

REFERENCES

Abdi, H., Williams, L., J. and Valentin, D. (2013). Multiple factor analysis: principal component analysis for multi table and multi block data sets, *WIRES COMPUTATIONA STATISTICS* , Vol 5 . (3): 149-179.

Association of Socio-economic Status with Economic Motivation of the Farmers, *Indian Res. J Ext. Edu.* 9 (2), 53-56.

Ayalneh, B., and Shimelis, A. (2009) “Household Level Determinants of Food Insecurity in Rural Areas of Dire Dawa, Eastern Ethiopia.” *African Journal of Food, Agriculture, Nutrition and Development* 9 (9):1914–1926.

Bidogeza, J. C., Berentsen , P. B. M., J. De Graaff, and A. G. J. M. Oude Lansink.(2009). “A Typology of Farm Households for the Umutara Province in Rwanda.” *Food Security* 1 (3): 321–335.

Chachlakis , Dimitris G., Bennette, P., Markopouls A., and Panos P.(2019). L1- norm Tucker Tensor Decomposition , *IEEE, aCcess* 7, 178454-178465.

Comrey, A. L. (1973). *A First Course in Factor Analysis*. Academic Press, New York and London.

Darghouth, S., Ward, C., Gambarelli, G., Styger, C. and Roux, J. (2008). *Watershed management approaches, policies, and operations: Lessons for scaling up water sector board discussion paper series*, paper No: 11, The World Bank, Washington. DC.

Diaz, D. Osorio, P., Medina Hernández E. et al. (2021), Socioeconomic determinants that influence the agricultural practices of small farm families in northern Colombia, *Journal of the Saudi Society of Agricultural Sciences*, <https://doi.org/10.1016/j.jssas.2021.12.001>.

Doan, N., Termansen, M., Reed, M., Cebollero, E. and Hubacek. K. (2013). “Farmer Typology, Future Scenarios and the Implications for Ecosystem Service Provision: A Case Study from South-Eastern Spain.” *Regional Environmental Change* 13 (3): 601–614.

Duferu, B. , Dube, D.K. , Aschalew, A. (2020) Socio-Economic Impacts, and Factors Affecting Adoption of Watershed Management Practices Between the Treated and Untreated Micro-Watersheds in the Chiracha sub-Watershed of Ethiopia -- *Palarch's Journal Of Archaeology Of Egypt/Egyptology* 17(9). 4528-4533.

Feder, G., and Umali, D. L. (1993). "The Adoption of Agricultural Innovations: A Review." *Technological Forecasting and Social Change* 43: 215–239.

Gautam, M. and Virendra, and Shahare, B. (2020) Study the correlation between socio economic with knowledge adoption, attitude and reaction of beneficiary's farmers towards CSR programme in Ranchi district of Jharkhand, India. *International Journal of Humanities and Social Science Invention (IJHSSI)* ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714 ||Volume 9 (7) , PP 56-65 .

Gorsuch, R. L. (1974). *Factor Analysis*. W B Saunders company, Philadelphia.

Gwatkin, D.R., Rustein, S., Johnson, K. (2000). *Socio-economic differences in Brazil*. Washington, DC: HNP/Poverty Thematic Group of the World Bank. Accessed 5 January 2004 online at: [<http://www.worldbank.org/poverty/health/data/index.htm#lcr>].

Harilal, R. (2014). Scientific orientation of commercial poultry farmers of Andhra Pradesh. *International Journal of Scientific*

Hemalatha, B., Surekha S. and Nagaraja, N. (1996). A study of knowledge level of farmers about watershed development, *Karnataka Journal of Agriculture Sciences*, 9:4, 666-669.

Joshi, P. K., Pangare, V., Shiferaw, B., Wani, S. P., and Scott, C. (2004), *Watershed development in India: Synthesis of past experience and needs for future research*. *Ind. J. Agric. Econ.* 59(3): 303-319.

Kaiser, H. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika* 22: 187–200.

Kaiser, Henry F. 1974. "An Index of Factorial Simplicity." *Psychometrika* 39 (1): 31–36.

Kumar, A. (1993). *Impact assessment of frontline Demonstration in summer mung-an experimental study*. an Unpublished Ph. D. Thesis, RAU, Pusa

Lwayo , M.K. and Maritim, H.K. (2003) . *Socio-economic factors affecting farmers' decisions to adopt farm forestry: an application of multivariate logistic analysis in busia district, Kenya ; an FAO Publication*.

Mahapatra, A. K., and Mitchell, C. P . (2001). "Classifying Tree Planters and Non Planters in a Subsistence Farming System Using a Discriminant Analytical Approach." *Agroforestry Systems* 52 (1): 41–52.

- Makate, C., Makate, M., & Mango, N.(2018). Farm household typology and adoption of climate-smart agriculture practices in smallholder farming systems of southern Africa, *African Journal of Science, Technology, Innovation and Development*, 10:4 421-439.
- Malathesh, G. B., Shivamurthy. M, Lakshman. Reddy B. S. and Ramakrishna, Rao L. (2009). Socio-economic factors and extension use efficiency of the farmers in selected farming systems. *Karnataka Journal of Agricultural Science* 22(2): 357–61.
- Rakesh, Kumar, K. , Paul, S. , Singh , P. and Chahal, V. P. (2015). Factors of farmers' progressiveness: A Principal Component Analysis, *Indian Journal of Agricultural Sciences · Indian Journal of Agricultural Sciences* 85 (8): 1026–1209.
- Rao, R., Reddy, C. A., . Y. V. R., and Ramakrishana, Y. S. (2004). A comparative analysis of performance of watershed development programmes in India. *Ind. J.Agric. Econ.* 59(3): 369.
- Regis, C., Zingore, S., Snapp, S., and Adrian Johnston, A. (2014). “Farm Typologies, Soil Fertility Variability and Nutrient Management in Smallholder Farming in Sub- Saharan Africa.” *Nutrient Cycling in Agroecosystems* 100 (1): 1–18. *Research* 3(8): 456.
- Rosner, B., (2000). Duxbury Thomson Learning , Stanford .
- Seema . N . and Khare N. (2006) Role of tribal women in watershed development programme , *Indian Research Journal of Extension Education* Volume 6, (3) : 1-3.
- Singh, D.K., Singh, A.K.,Yadav, V.P., Singh, R.B., Baghel, R.S and Singh, M. (2009) Association of Socio-economic Status with Economic Motivation of the Farmers, *Indian Res. J Ext. Edu.* 9 (2), 53-56.
- Singh, R .A. , Sharma, V.K.and Pal, S.B. (2013). Watershed based frontline demonstration is a path of prosperity to Bundelkhand farm families. *Agriculture Update. Hind Agricultural and Training update, Mujafforpur (UP) .8 (1&2):42-44.*
- Trivedi, G.(1963). Measurement and analysis of socio-economic status of rural families, Ph.D. Thesis, Division of Agril. Extension, I.A.R.I., New Delhi.
- Uddin, M. N. , Bokelmann, W, and Entsminger, J. S. (2014). Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh, *Climate* , 2(4), 223-241.
- Upadhyay, B. M., Douglas, L.Young., Holly, H. W. , and Wandschneider, P. (2003). “How Do Farmers Who Adopt Multiple Conservation Practices Differ from Their Neighbors?” *American Journal of Alternative Agriculture* 18 (1): 27–36.
- Usai, M. G., Sara Casu, G. Molle, M. Decandia, S. Ligios, and A. Carta. (2006). “Using Cluster Analysis to Characterize the Goat Farming System in Sardinia.” *Livestock Science* 104 (1): 63–76.

Vyas, S. and Kumaranayake, L. (2006) . Constructing socio-economic status indices: how to use principal components analysis, *Health Policy and Planning*, Volume 21, Issue 6, Pages 459–468.

Yirga, T. C.(2007). *The Dynamics of Soil Degradation and Incentives for Optimal Management in the Central Highlands of Ethiopia*. Pretoria: University of Pretoria.