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Comparative Analysis of the Impact of FPO on Paddy Farmers through Canonical Correlation Analysis

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HIGHLIGHTS

- The study emphasized the significant role that FPOs play in increasing paddy farmers' income in North Coastal Andhra Pradesh.
- Scientific orientation, and social participation, had significance for FPO; while occupational status and educational status showed significance for non-FPO members.
- The knowledge shows the strongest correlation for both FPO and non-FPO members.
- There is a distinct disparity in the impact of FPOs between FPO and non-FPO members.

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ABSTRACT

This study was conducted in 2023-24 in Srikakulam and Vizianagaram districts of Andhra Pradesh and examines the significant impact of Farmer Producer Organizations (FPOs) on paddy farmers' income, productivity, and sustainability in the study area. Canonical correlation coefficients analysis was used to identify the connection between independent variables and dependent variables for FPO members and non-members. For FPO members, the maximum canonical correlation was found between the first pair of variates (0.789), with strong relations indicated by Wilks statistics and Eigen values. Key influencing factors for FPO members included scientific orientation, awareness about FPOs, social participation, and innovativeness. In contrast, for non-FPO members, educational and occupational status was significant, with the highest canonical correlation at 0.840. The findings suggest FPOs are critical in enhancing agricultural productivity and farmer well-being, providing valuable insights for policymakers and stakeholders. Addressing these key elements may lead to targeted interventions, fostering sustainable agricultural development and improving rural livelihoods.

INTRODUCTION

Agriculture is vital to India's economy, employing 60 per cent of the workforce and directly impacting economic development (Gomase & Tekale, 2022). Small and marginal farmers, comprising 82 per cent of the farming population, highlight the sector's reliance on grassroots activities (Divya et al., 2023). These farmers often face challenges in crop yields for income generation (Nain et al., 2019; Kumar et al., 2020). To address this, the government raised the minimum support price (MSP) for paddy, promoting its cultivation. Paddy is globally significant, with India contributing 28.5 per cent to worldwide production and meeting 22 per cent of global rice demand. In Andhra Pradesh, paddy cultivation spans 2.32 million hectares, yielding 7.88 million metric tonnes annually at a productivity of 3393 kg/ha (Fukagawa & Ziska, 2019; Agricultural Statistics at a glance, 2022).

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To help small farmers with their marketing difficulties, Farmer Producer Organizations (FPOs) have become a viable option for farmers (Kumari et al., 2022). FPOs mobilize farmers, strengthen their collective production and marketing capabilities, and manage agricultural activities cooperatively, from production to direct selling to traders or consumers. This interruption of middlemen chains improves farmers' financial conditions and livelihood (Singh et al., 2023; Emraan et al., 2020; Anand et al., 2023). Through initiatives like the Formation and Promotion of 10,000 FPOs, India has registered 7,579 FPOs, including 355 in Andhra Pradesh (Mukherjee, 2023). FPOs offer small and marginal farmers a potent solution to enhance their socioeconomic situations by providing enhanced pricing negotiating power and benefiting from economies of scale (Singh et al., 2014; Jose et al., 2023). It also assists farmers in various agricultural schemes, influencing both quality and quantity of output (Parthiban et al., 2015). FPOs empower members with reduced market risks, access to extension services and technical expertise, improved inputs and loans, and upgraded storage and processing facilities (Kumar et al., 2023). Moreover, FPOs play a crucial role in bridging knowledge gaps, promoting adoption, addressing farmer concerns, and boosting income growth. They serve as critical platforms for transforming smallholder farming, enhancing agricultural productivity, and increasing farmer incomes (Avhad et al., 2015; Hakelius & Hassan, 2016; Gorai et al., 2022).

Canonical correlation analysis (CCA), a well-known method for determining the correlations between two sets of multidimensional variables, was used in this work to conduct a multivariate analysis (Sun et al., 2011). The purpose of canonical correlation is to find simultaneous correlations between two sets of variables, such as X and Y. CCA is used to determine the linear function of one set of variables that are strongly linked with the linear function of another set (Akour et al., 2023).

METHODOLOGY

The study was carried out in North Coastal districts of Andhra Pradesh, focusing Srikakulam and Vizianagaram districts.A sample size of 180 was randomly selected (90 FPO members from six Paddy-focused FPOs and 90 non-FPO members). Data was collected using well-structured interview schedule and analyzed using Canonical Correlation Analysis (CCA). It combines sets of variables to get the highest correlation between them. Because each set contains many variables, there are numerous possible combinations of the variables (Keskin & Yasar, 2007). CCA provides valuable insights into the key variables that influence Paddy farmers' knowledge, adoption, productivity, and income.

Two sets of variables were considered for the study, 18 independent variables (X) and 4 dependent Variables (Y) for both FPO and non-FPO members.

$$X= x_1,x_2,\ldots\ldots x_{18} \text{ and } Y= y_1, y_2, y_3, y_4$$

x_1= age, x_2=gender, x_3= educational status, x_4= occupational status, x_5= farming experience,x_6= social participation, x_7= extension agency contact, x_8= training undergone, x_9= mass media exposure, x_{10}= information seeking behavior, x_{11}= decision making ability, x_{12}= credit orientation, x_{13}= innovativeness, x_{14}= scientific orientation, x_{15}= economic motivation, x_{16}= risk orientation, x_{17}= achievement motivation, x_{18}= awareness about FPO; y_1= knowledge, y_2= adoption, y_3= productivity, y_4= income.

The number of canonical correlation pairs equals the number of variables in the smaller set. In the study 4 canonical correlation pairsare estimated: (U_1, V_1); (U_2, V_2); (U_3, V_3) and (U_4, V_4); (A_1, B_1); (A_2, B_2); (A_3, B_3) and (A_4, B_4) for FPO and non-FPO members, The linear combinations of independent and dependent variables for FPO and non-FPO membersare U_1 and V_1; A_1 and B_1 respectively, the linear combinations are called as Canonical variates (Sahoo et al*.,* 2024).

$$U_1= a_{11}.x_1+\ldots\ldots\ldots+a_{1i}.x_{1i,}$$
$$U_2= a_{21}.x_1+\ldots\ldots\ldots+a_{2i}.x_{2i}$$
$$.$$
$$U_p= a_{i1}.x_1+\ldots\ldots\ldots+a_{ii}.x_i$$
$$V_1= b_{11}.y_1+ b_{12}.y_2+ b_{13}.y_3 +b_{14}.y_4$$
$$V_2= b_{21}.y_1+b_{22}.y_2+b_{23}.y_3 +b_{24}.y_4$$
$$V_3= b_{31}.y_1+b_{32}.y_2+b_{33}.y_3 +b_{34}.y_4$$
$$V_4= b_{41}.y_1+b_{42}.y_2+b_{43}.y_3+ b_{44}.y_4$$
$$A_1= m_{11}.x_1+\ldots\ldots\ldots\ldots+m_{1i}.x_{1i}$$
$$A_2= m_{21}.x_1+\ldots\ldots\ldots\ldots+m_{2i}.x_{2i}$$
$$.$$
$$A_p= m_{i1}.x_1+\ldots\ldots\ldots+m_{ii}.x_i$$
$$B_1= n_{11}.y_1+ n_{12}.y_2+ n_{13}.y_3+n_{14}.y_4$$
$$B_2= n_{21}.y_1+n_{22}.y_2+n_{23}.y_3 +n_{24}.y_4$$
$$B_3= n_{31}.y1+n_{32}.y_2+n_{33}.y_3 +n_{34}.y_4$$
$$B_4= n_{41}.y_1+n_{42}.y_2+n_{43}.y3+ n_{44}.y_4$$

'i' refers to 18 independent variables, Standardized correlation coefficients for X and Y are denoted as $a_{11},\ldots\ldots..a_{1i}$; b_{11}, b_{12}, $b_{13,}$ b_{14}; $m_{11},\ldots\ldots\ldots m_{1i}$ and n_{11}, n_{12}, $n_{13,}$ n_{14}, Canonical correlation between (U_i, V_i); (A_i, B_i) = $\frac{cov\ (Ui\ ,Vi)}{\sqrt{var\ (Ui)\ var\ (Vi)}}$; $\frac{cov\ (Ai\ ,Bi)}{\sqrt{var\ (Ai)\ var\ (Bi)}}$

RESULTS

The statistical analysis in Table 1 reveals that at 0.01 level of significance, two pairs of canonical variates for FPO member category and at 0.05 level of significance two pairs of Canonical variates for the non-FPO member category were statistically significant and are considered further. In the case of the FPO members category, the canonical correlation coefficient ($\hat{\rho}_1$) of the first pair (U_1 and V_1) showed the maximum correlation (0.789) followed by the canonical correlation coefficient ($\hat{\rho}_2$) between U_2 and V_2 (0.662). Whereas in the case of the non-FPO members' category, the canonical correlation coefficients ($\hat{\rho}_1$) between A_1 and B_1 showed the maximum correlation of 0.840, followed by canonical correlation coefficients ($\hat{\rho}_2$) between A_2 and $B_2$was 0.643. The Square of the canonical correlation coefficient between U_1 and $V_1$was 0.623, raised highest followed by U_2 &V_2 (0.438); A_1 & B_1 (0.705) and A_2 & B_2 (0.662).

In the case of the FPO member category, the Wilks statistics of pair U_1, $V_1$was 0.120 and the Eigen value was (1.651) which described the strong relation and significant contribution between the two sets of variables with a greater proportion of variance explained in CCA and the Wilks statistics of pair U_2, V_2 was (0.317) and the Eigenvalue was (0.780) showed the moderate relation and significant contribution between the two sets of variables with a

Table 1. Canonical correlation analysis of profile characteristics of FPO members and non-FPO members with their Impact

Pair of canonical variates		Canonical Correlation ($\hat{\rho}_i$)		Square of Correlation		Eigenvalue		Wilks Statistics		Significance	
FPO	Non-FPO	FPO	Non-FPO	FPO	Non-FPO	FPO	Non-FPO	FPO	Non-FPO	FPO	Non-FPO
U_1, V_1	A_1, B_1	0.789	0.840	0.623	0.705	1.651	2.403	0.120	0.115	0.000	0.000
U_2, V_2	A_2, B_2	0.662	0.643	0.438	0.413	0.780	0.705	0.317	0.393	0.001	0.028
U_3, V_3	A_3, B_3	0.562	0.496	0.315	0.246	0.463	0.326	0.565	0.670	0.076	0.518
U_4, V_4	A_4, B_4	0.416	0.335	0.173	0.112	0.210	0.126	0.827	0.888	0.473	0.868

$\hat{\rho}_i$ is the canonical correlation between U_1, V_1 & A_1, B_1 (Canonical variates)

moderate proportion of variance explained in CCA. Whereas in the case of the non-FPO category, the Wilks statistics of pair A_1 $B_1$was (0.115) and the Eigenvalue was 2.403 which described the strong relation and significant contribution between the two sets of variables with a greater proportion of variance explained in CCA.

The Table 2 found that among the X & Y sets of independent and dependent variables in the case of FPO members, the standardized canonical coefficient with $\hat{U}_1$ & $\hat{V}_1$ was found that the Scientific orientation (-0.360) of the independent variables had a higher correlation with $\hat{U}_1$ and in the dependent variables, knowledge (- 0.652) had a higher correlation with $\hat{V}_1$. Similarly, the standardized canonical coefficient with $\hat{U}_2$ & $\hat{V}_2$ was found that awareness about FPO (-0.462); social participation (0.389) and innovativeness (-0.351) in independent variables had higher correlations with $\hat{U}_2$; productivity (-1.004) in the dependent variable had a higher correlation with $\hat{V}_2$. In the case of non-FPO members, the standardized canonical coefficient with $\hat{A}_1$ & $\hat{B}_1$, it was found that educational status (0.517) in independent variables had a higher correlation with $\hat{A}_1$ and in the dependent variables, knowledge (0.736) had a higher correlation with $\hat{B}_1$. Similarly, the standardized canonical coefficient with $\hat{A}_2$ & $\hat{B}_2$, the occupational status (0.601); in independent variables had higher correlations with $\hat{A}_2$; adoption (-0.548) in the dependent variable had a higher correlation with $\hat{B}_2$.

From the Table 3 it was found that among 18 independent variables in the set of X among, scientific orientation (-0.641) had a maximum correlation with the first canonical variate $\hat{U}_1$ and extension agency contact (-0.477) had maximum correlation with cross loading of canonical variate $\hat{V}_1$; awareness about FPO (-0.472) (-0.312) had maximum correlation with canonical variate $\hat{U}_2$ and cross loading of canonical variate $\hat{V}_2$. whereas in the case of non-FPO members, educational status (0.711) (0.597) had a maximum

Table 2. Standardized canonical coefficient and unstandardized canonical coefficients analysis of independent variables with different dependent variables of the FPO and non-FPO

Independent variable	Standardized Canonical Co-efficient				Unstandardized Canonical Co-efficient			
	FPO members		Non-FPO members		FPO members		Non-FPO members	
	$\hat{U}_1$	$\hat{U}_2$	$\hat{A}_1$	$\hat{A}_2$	$\hat{V}_1$	$\hat{V}_2$	$\hat{B}_1$	$\hat{B}_2$
Age	0.050	0.261	-0.008	-0.037	0.005	0.024	-0.001	-0.003
Gender	-0.108	0.081	0.069	-0.265	-0.247	0.186	0.151	-0.581
Occupational status	0.103	0.106	0.258	0.601	0.080	0.083	0.215	0.502
Educational status	-0.295	0.055	0.517	-0.150	-0.250	0.047	0.488	-0.142
Farming experience	-0.088	0.195	-0.047	0.542	-0.127	0.282	-0.065	0.749
Social participation	-0.260	0.389	0.172	-0.223	-0.076	0.113	0.058	-0.075
Credit orientation	-0.248	0.166	-0.059	-0.077	-0.088	0.059	-0.023	-0.029
Economic motivation	-0.139	0.197	0.115	-0.242	-0.027	0.038	0.039	-0.083
Training undergone	-0.141	-0.247	0.126	-0.242	-0.169	-0.295	0.176	-0.338
Extension agency contact	-0.102	0.275	0.074	0.387	-0.025	0.066	0.023	0.122
Mass media exposure	-0.060	0.086	-0.026	-0.322	-0.017	0.024	-0.006	-0.072
Information seeking behavior	-0.015	-0.273	0.168	0.105	-0.005	-0.095	0.051	0.032
Decision making ability	-0.248	0.166	0.059	-0.065	-0.088	0.059	0.023	-0.025
Innovativeness	-0.219	-0.351	-0.146	0.070	-0.117	-0.187	-0.051	0.024
Scientific orientation	-0.36	-0.372	0.264	-0.219	-0.438	-0.453	0.399	-0.331
Risk orientation	-0.153	-0.207	0.173	-0.058	-0.09	-0.121	0.05	-0.017
Achievement motivation	-0.152	-0.308	0.112	0.191	-0.053	-0.108	0.042	0.071
Awareness on FPO	0.079	-0.462	0.307	-0.545	0.034	-0.197	0.043	-0.077
Dependent variable	$\hat{V}_1$	$\hat{V}_2$	$\hat{B}_1$	$\hat{B}_2$	$\hat{U}_1$	$\hat{U}_2$	$\hat{A}_1$	$\hat{A}_2$
Knowledge	-0.652	0.7	0.736	0.261	-0.171	0.184	0.246	0.087
Adoption	-0.326	-0.1	0.313	-0.548	-0.045	-0.014	0.081	-0.142
Productivity	-0.175	-1.004	0.406	0.348	-0.043	-0.244	0.078	0.067
Income	-0.186	0.000	-0.132	0.618	0.000	0.000	0.000	0.000

Table 3. Sample correlation between original variable and canonical variables

Independent variable (X_i)	FPO members				Non-FPO members			
	$\hat{U}_1$	$\hat{V}_1$	$\hat{U}_2$	$\hat{V}_2$	$\hat{A}_1$	$\hat{B}_1$	$\hat{A}_2$	$\hat{B}_2$
Age	-0.122	-0.097	0.322	0.213	0.196	0.165	-0.029	-0.019
Gender	-0.042	-0.033	0.126	0.083	0.122	0.103	-0.453	-0.291
Occupational status	-0.501	-0.395	-0.134	-0.089	0.576	0.484	0.426	0.274
Educational status	-0.486	-0.384	0.162	0.107	0.711	0.597	0.021	0.013
Farming experience	-0.448	-0.354	-0.087	-0.058	0.495	0.416	0.156	0.100
Social participation	-0.501	-0.395	0.346	0.229	0.514	0.432	-0.087	-0.056
Credit orientation	-0.561	-0.443	0.176	0.116	0.188	0.158	0.190	0.122
Economic motivation	-0.480	-0.379	0.340	0.225	-0.021	-0.018	-0.340	-0.219
Training undergone	-0.442	-0.349	-0.297	-0.196	0.089	0.075	-0.339	-0.218
Extension agency contact	-0.604	-0.477	0.124	0.082	0.252	0.212	0.267	0.172
Mass media exposure	-0.111	-0.088	-0.145	-0.096	0.234	0.197	-0.149	-0.096
Information seeking behavior	-0.090	-0.071	-0.082	-0.055	0.434	0.365	0.254	0.163
Decision-making ability	-0.561	-0.443	0.176	0.116	-0.194	-0.163	0.206	0.132
Innovativeness	-0.433	-0.342	-0.298	-0.197	-0.160	-0.134	0.034	0.022
Scientific orientation	-0.641	-0.506	-0.274	-0.181	0.361	0.303	-0.206	-0.132
Risk orientation	-0.387	-0.305	-0.220	-0.146	0.484	0.407	-0.004	-0.003
Achievement motivation	-0.217	-0.171	-0.247	-0.163	-0.07	-0.059	0.349	0.224
Awareness about FPO	-0.203	-0.16	-0.472	-0.312	0.463	0.389	-0.120	-0.077
Dependent variable (Y_i)	$\hat{V}_1$	$\hat{U}_1$	$\hat{V}_2$	$\hat{U}_2$	$\hat{B}_1$	$\hat{A}_1$	$\hat{B}_2$	$\hat{A}_2$
Knowledge	-0.905	-0.714	0.307	0.203	0.86	0.722	0.129	0.083
Adoption	-0.695	-0.548	0.018	0.012	0.632	0.531	-0.559	-0.52
Productivity	-0.562	-0.444	-0.783	-0.519	0.407	0.342	0.46	0.296
Income	-0.454	-0.358	-0.031	-0.026	-0.031	-0.026	0.809	0.359

$\hat{U}_1$ & $\hat{A}_1$= Canonical Variates of Independent Variables; $\hat{V}_1$ & $\hat{B}_1$= Canonical Variates of Dependent Variables

correlation with canonical variate of cross loading $\hat{A}_1$ and cross loading of canonical variate $\hat{B}_1$; gender (-0.453) (-0.291) had the maximum correlation with canonical variate $\hat{A}_2$ and cross loading of canonical variate $\hat{B}_2$. Among the four dependent variables in set of Y, knowledge (-0.905) and (-0.714) showed maximum correlation with canonical variate $\hat{V}_1$ and canonical variate of cross loading $\hat{U}_1$ and knowledge with 0.307 and 0.203 showed maximum correlation with canonical variate $\hat{V}_2$ and canonical variate of cross loading $\hat{U}_2$; Whereas in case of non-FPO members category, knowledge with 0.860 and 0.722 showed maximum correlation with canonical variate $\hat{B}_1$ and canonical variate of cross loading $\hat{A}_1$. Similarly, adoption (-0.559) and (-0.52) had maximum correlation with canonical variate $\hat{B}_2$ and canonical variate of cross loading $\hat{A}_2$, respectively.

DISCUSSION

The canonical correlation analysis provides substantial information on comparative analysis about the impact of the Farmer Producer Organization on Paddy farmers adopting recommended Paddy cultivation practices. For FPO members, two pairs of canonical variates were found to be significant at a 1% level, with scientific orientation and awareness of FPO activities being important variables associated with the increase in Knowledge and Productivity. The canonical correlation between $\hat{U}_1$ & $\hat{V}_1$ was 0.789, which shows a strong scientific orientation and is more informed about Paddy cultivation practices. The canonical correlation between $\hat{U}_2$ & $\hat{V}_2$ as 0.662 which indicates that social participation and innovativeness are associated with an increase in productivity and Adoption this aligns with the findings of Kumar et al., (2019). Increasing productivity leads to an increase in the income of the farmers.

Among the non-FPO category, one pair of canonical variates was found to be significant at a 1% level. A canonical correlation between A_1 and B_1 was 0.840, showed that greater education was positively correlated with knowledge. The results highlight the prominent role of FPOs in increasing the knowledge and productivity of FPO members through social participation, training, demonstrations and technical guidance (Prasanna & Mazhar, 2022). The non-FPO members' adoption of cultivation practices, increases with occupational support, training programs and more extension agency contact is crucial to improve their income and livelihood security. To overcome these challenges, targeted interventions are necessary. Improved Paddy cultivation techniques, supported by government and local agricultural authorities, can significantly enhance productivity and efficiency.

CONCLUSION

Canonical correlation analysis underscores the involved interaction between various factors influencing agricultural outcomes for both FPO members and non-members. The relationships show that a number of factors have a major impact on agricultural productivity and farmer well-being, including adoption rates, knowledge levels, awareness of agricultural methods, active social participation, productivity indicators, and educational backgrounds. These findings are invaluable for policymakers, practitioners, and stakeholders looking to improve the effectiveness of FPOs and

agricultural projects. Recognizing and addressing these key elements allows for focused interventions to enhance sustainable agricultural development and improve rural livelihoods. As we move forward, additional research and personalized interventions based on these results have the potential to catalyze positive change and create resilience in the agriculture sector.

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