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Determinants of nano fertiliser adoption among farmers in Nellore district of Andhra Pradesh.

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ABSTRACT

Nano-fertilisers are emerging as a promising innovation to improve nutrient use efficiency, reduce input costs, and enhance sustainable agricultural practices. This study examines the socio-economic determinants influencing the adoption of nano-fertilisers among farmers in Nellore district of Andhra Pradesh. Primary data were collected from 120 respondents (52 adopters and 68 non-adopters) randomly from four mandals and 8 villages by using personal interview method with a pre tested schedule. Descriptive statistics and Z-tests were used to compare socio-economic characteristics, while binary logistic regression was applied to identify the factors influencing adoption. The study revealed that a significant differences between adopters and non-adopters in terms of age, education, landholding size, annual income, and farming experience. Logistic regression analysis showed that age, education, landholding size, farming experience, access to agricultural information and annual farm income significantly influenced adoption. The findings highlight the need for targeted policy interventions focusing on awareness creation, capacity building, and improved information dissemination to enhance nano-fertiliser utilisation.

Keywords:*Andhra Pradesh, Logistic regression, Nano fertiliser and Socio economic characters*

Fertilizers play a pivotal role in enhancing agricultural productivity and ensuring food security. However, the excessive and inefficient use of conventional fertilizers has led to environmental challenges such as nutrient runoff, soil degradation, and water pollution. According to the United States Department of Agriculture (USDA), nutrient runoff from traditional fertilizers is a leading cause of water quality deterioration in over 40% of rivers and streams in the United States (USDA, 2020). These concerns highlight the urgency for more sustainable agricultural practices and the adoption of innovative technologies.

In recent years, the development and application of nano fertilizers have gained attention as a sustainable and efficient alternative to conventional fertilizers. Nano fertilizers are materials engineered at the nanoscale (1–100 nm), designed to deliver nutrients to crops in a controlled and targeted manner (Naderi & Danesh-Shahraki, 2013) high surface area and reactivity enhance nutrient solubility, absorption and use efficiency. Studies have demonstrated that nano fertilizers can improve nutrient use efficiency (NUE) by 20–30% compared to traditional fertilizers (Rai *et al*., 2012)

Nano fertilizers are often composed of essential nutrients like nitrogen, phosphorus, potassium, and micronutrients, encapsulated with carriers such as zeolites, chitosan, or clay. These carriers enable the controlled release of nutrients that match the physiological needs of plants at different growth stages (Ditta, 2012). This targeted delivery system reduces nutrient losses due to leaching, volatilization, or fixation, thus lowering input costs and mitigating environmental damage.

Furthermore, nano fertilizers facilitate deeper penetration into plant tissues, leading to improved plant health, productivity, and resistance to abiotic stress (DeRosa et al., 2010). In India, where agricultural systems face issues such as declining soil fertility, escalating input costs, and inefficient fertilizer application, nano fertilizers present a viable solution. Empirical studies have shown notable increases in crop yield and nutrient uptake across various crops, including paddy, maize, wheat, and vegetables (Prasad et al., 2014).

Given these advantages, understanding the drivers behind the adoption of nano fertilizers is critical for promoting their widespread use. Therefore, the

present study investigates the factors influencing adoption of nano fertilizers among the farmers in crop production in Nellore district of Andhra Pradesh. The findings aim to contribute to policy formulation, extension services, and technological dissemination strategies to enhance sustainable agricultural practices.

MATERIAL AND METHODS

Sampling procedure

A multistage random sampling technique was employed. Andhra Pradesh was selected proportionately in A.P. SPSR Nellore district was purposively selected as it ranked fourth in total cropped area. The district comprises four revenue divisions, from which one mandal was randomly selected, and two villages were selected from each selected mandal. From each selected village, both adopters and non-adopters of nano fertilisers were proportionately selected. The total sample consisted of 120 respondents, comprising 52 adopters and 68 non-adopters from a total of 32 villages. Primary data were collected through personal interviews using a pre-tested, interview schedule. The study pertains to the agricultural year 2024–2025.

Analytical techniques

Descriptive statistics and Z-tests were used to compare socio-economic characteristics of adaptors and non-adopters. To identify the determinants of nano fertiliser adoption, a binary logistic regression model was applied, which is appropriate when dependent variable is dichotomous (adopters-1, non-adopters-0).

The logistic regression model estimates the probability P_i that the ith farmer adopts nano fertilisers, based on a set of explanatory variables:

$$p_i = \frac{1}{1+e^{-z}i}, \quad \text{where} \quad Z_i = \alpha + \sum_{j=1}^{n} B_j x_{j_i}$$

The model is typically presented in its log-odds form:

$$log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \mu_i$$

Marginal effect of a continuous independent variable on the probability. The marginal effect is

$$\frac{dp}{db} = f(bX)b$$

RESULTS AND DISCUSSION

Socio - Economic characteristics

The descriptive statistics comparing adopters and non-adopters of nano-fertiliser and the significance of differences in their socio-economic characteristics are presented in Table 1.

Age

It can be observed from the table that 53.8 per cent of the adopters were in the age group of 36–50 years, while 42.6% of the non-adopters were above 50 years of age. Adopters had a significantly lower mean age (44.2 years) compared to non-adopters (50.6 years), with a Z-value of 3.21, which is statistically significant at the 1% level. This indicates that younger farmers are more likely to adopt improved agricultural practices, likely due to their openness to innovations and new technologies.

Education Level

The education level of respondents showed a marked difference between adopters and non-adopters. Among adopters, 53.8% had primary to secondary education, while 38.5% had education above the secondary level. In contrast, 26.5% of non-adopters were illiterate, and only 19.1% had education above the secondary level. The mean years of education were significantly higher for adopters (8.6 years) compared to non-adopters (5.2 years), with a Z-value of 4.30, which is statistically significant at the 1% level. This suggests that higher education is positively associated with the adoption of agricultural innovations, likely due to increased awareness, better access to information, and enhanced decision-making capacity.

Landholding Size

There was a significant difference in landholding size between adopters and non-adopters. Among the adopters, 46.2% belonged to the medium category (2–5 ha), and 15.4% were large farmers (>5 ha), whereas a vast majority (85.3%) of non-adopters were smallholders with less than 2 ha of land. The mean landholding size of adopters was 2.84 ha,

Table 1. Socio economic characteristics of respondents

S. No	Particulars	Category	Adopters (N= 52)		Non-Adopters (N = 68)		Mean		Z Value	p-Value
			Frequency	Percentage	Frequency	Percentage	Adopters	Non Adopters		
I	Age Group (Years)	Below 35	11	21.2	8	11.8	44.2	50.6	3.21**	0.001
		36–50	28	53.8	31	45.6				
		Above 50	13	25	29	42.6				
2	Education Level (Years)	Illiterate	4	7.7	18	26.5	8.6	5.2	4.30***	0
		Primary–Secondary	28	53.8	37	54.4				
		Above Secondary	20	38.5	13	19.1				
3	Landholding Size (ha)	Small (<2 ha)	20	38.5	58	85.3	2.84	1.62	4.12***	0
		Medium (2–5 ha)	24	46.2	10	14.7				
		Large (>5 ha)	8	15.4	0	0				
4	Annual Farm Income (₹)	< ₹1 lakh	9	17.3	28	41.2	₹ 2,45,000	₹ 1,68,500	2.96**	0.004
		₹1–2 lakh	18	34.6	27	39.7				
		> ₹2 lakh	25	48.1	13	19.1				
5	Farming Experience (Years)	Below 10	12	23.1	9	13.2	15.77	18.53	-2.09*	0.036
		11–20 years	24	46.2	26	38.2				
		Above 20 years	16	30.8	33	48.5				

significantly higher than that of non-adopters at 1.62 ha. The Z-value of 4.12 was statistically significant at the 1% level. This indicates that farmers with larger landholdings are more likely to adopt improved agricultural practices, possibly due to better resource availability, greater risk-bearing capacity, and higher expected returns from innovation adoption.

Annual Farm Income

A significant variation was observed in annual farm income between adopters and non-adopters. Nearly half (48.1%) of the adopters reported annual farm income exceeding ₹ 2 lakh, whereas only 19.1% of non-adopters fell into this income bracket. Conversely, a larger proportion of non-adopters (41.2%) had incomes below ₹1 lakh, compared to only 17.3% among adopters. The mean income of adopters (₹2,45,000) was notably higher than that of non-adopters (₹1,68,500), with a Z-value of 2.96 statistically significant at the 1% level. These results suggest that higher income levels are positively associated with the adoption of improved agricultural practices, possibly due to greater financial flexibility to invest in new technologies and innovations.

Farming Experience

Differences were also noted in the farming experience of adopters and non-adopters. 48.5% of non-adopters had more than 20 years of experience, only 30.8% of adopters belonged to this category. Conversely, a greater share of adopters (23.1%) had less than 10 years of experience compared to 13.2% among non-adopters. The mean farming experience of non-adopters (18.53 years) was higher than that of adopters (15.77 years), and the Z-value of -2.09 was statistically significant at the 5% level. This indicates that farmers with relatively fewer years of experience were more inclined to adopt improved agricultural practices, possibly due to greater adaptability, openness to change, and exposure to modern technologies.

Determinants For the Adoption of Nano Fertiliser

Logistic regression was used to analyse the determinants for the adoption of nano fertilisers in Nellore district of Andhra Pradesh, and the results were presented in Table 2. The Cox & Snell R^2 (0.48) and Nagelkerke R^2 (0.64) indicated that the model explained a substantial proportion of variation in farmers' adoption decisions. The model chi-square value of 46.27 was significant at the 1 per cent level, confirming the overall goodness of fit of the logistic regression model. The pseudo-R^2 value of the model was 0.69. Thus, the overall model was statistically significant and demonstrated a good fit. The explanatory variables used in the model collectively explained the respondents' decision to adopt nano fertilisers in the study area. The results also revealed that the decision to adopt nano fertilisers was a function of the farmer's age, education level, farming experience, access to information, and average annual farm income.

Table 2. Factors influencing adoption of nano fertilizers in Nellore district of Andhra Pradesh logistic regression results

S. No	Variable	Coefficient (β)	Std. Error	p-Value	Marginal Effect
1	Age of the farmer (X1)	-0.167	0.038	0	-0.061*
2	Education Level (X2)	0.34	0.15	0.001	0.144***
3	Landholding Size(X3)	2.306	0.691	0.001	0.117
4	Experience in farming (X4)	0.47	0.20	0.021	0.207**
5	Access to information(X5)	1.21	0.30	0	0.0300***
6	Perceived Cost-Benefit(X6)	0.76	0.19	0.901	0.189
7	Average annual farm income(X7)	0.002	0	0.044	0.002**
8	-2 Log Likelihood	92.35			
9	Chi-square (χ^2)	46.27			
10	Nagelkerke R^2	0.64			
11	Cox and Snell R^2	0.48			
12	Classification Accuracy	82.50%			

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively

Age of the farmer

Age showed a negative relationship with the adoption of nano fertilisers and was statistically significant at the 10 per cent level. The negative coefficient indicated that age and adoption had an inverse relationship. The marginal value of "0.061 for this variable suggested that the probability of adoption decreased by 6.1 per cent with each additional year of age. Compared to older farmers, younger farmers were more inclined to adopt nano fertilisers. As farmers grow older, they tend to become more risk-averse and less interested in adopting new technologies. Younger farmers are often more innovative and resourceful, enabling them to have better access to advanced technologies. These results were consistent with Abubakar et al. (2019) and Digal et al. (2020).

Education of the farmer

Education was found to be positive relationship with the adoption of nano fertilisers and was statistically significant at the 1 per cent level. This indicated a direct relationship between education and adoption decisions. The marginal value for this variable, 0.144, suggested that the probability of adoption increased by 14.4 per cent with each additional year of education. Farmers with higher education levels had a greater capacity to adopt nano fertilisers, as the knowledge and skills gained through formal education may give them a clearer vision for progressive farming. This finding was consistent with Kadafur *et al.,* (2020) and Feleke and Zegeye (2006).

Experience of the farmer

Farming experience showed a positive relationship with the level of adoption of nano fertilisers and was statistically significant at 5 per cent level. A marginal value of 0.020 for this variable indicated a 2.0 per cent increase in the level of adoption with each additional year of farming experience. Experienced farmers were more familiar with the performance of nano fertilisers and better equipped to address conventional fertiliser problems such as transportation and application. These results were in line with Lamichhane et al. (2018) and Adenuga et al. (2014).

Access to information

Access to information among farmers showed a positive relationship with the intensity of adoption of nano fertilisers and was statistically significant at 1 per cent level. The marginal effect value of 0.030 indicated a 3.0 per cent increase in adoption intensity with improved access to information. Farmers with better access to information were more willing to adopt innovative farm practices, possibly due to constant awareness campaigns and educational efforts on innovative technologies. This finding was in consonance with Kadafur *et al*., (2020).

Average annual farm income

Average annual farm income showed a positive relationship with the intensity of adoption of nano fertilisers and was statistically significant at the 5 per cent level. The marginal effect value of 0.002 suggested a 0.2 per cent increase in adoption intensity for each unit increase in farm income. Farmers with higher incomes were more likely to adopt cost-effective innovative technologies. These results were consistent with Atinafu *et al.* (2022).

CONCLUSION

The study revealed that socio-economic and perceptual factors significantly influence the adoption of nano-fertilisers among farmers in Nellore district of Andhra Pradesh. Logistic regression results indicated that age education levels landholdings, farming experience, access to agricultural information, and perception of cost–benefit were positively associated with adoption. Younger and more educated farmers demonstrated greater openness to innovative inputs, while larger landholders and experienced farmers showed a higher capacity to experiment with and integrate new technologies. Access to timely and credible information emerged as one of the most decisive factors, highlighting the importance of strengthening extension services.

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