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DETERMINANTS OF BENEFICIARIES' ATTITUDE TOWARDS BIOGAS TECHNOLOGY

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ABSTRACT

Biogas technology has emerged as a viable renewable energy option that supports sustainable agriculture, enhances rural energy availability and contributes to environmental conservation. The present investigation was conducted to examine the attitude of biogas beneficiaries towards biogas plants and to determine the factors influencing their attitudes. An ex-post facto research design was adopted for the study and primary data were collected from 100 biogas plant beneficiaries through personal interviews using structured and pre-tested interview schedule. The results indicated that a majority of the respondents revealed favourable attitude towards biogas plants, while a considerable proportion demonstrated a highly favourable attitude. Correlation analysis revealed that education, occupation, annual income, animal possession, access to credit, economic motivation and knowledge regarding biogas plants were positively and significantly related to the respondents' attitudes towards biogas technology. Further, stepwise regression analysis showed that four variables-education ($\beta = 0.309$), annual income ($\beta = 0.307$), economic motivation ($\beta = 0.252$) and age ($\beta = 0.250$) were significant predictors of farmers' attitudes towards biogas plants. The coefficient of determination ($R^2 = 0.289$) indicated that these variables collectively accounted for 28.90 per cent of the total variation in attitude. The findings underscore the crucial role of socio-economic characteristics, motivational factors and technological awareness in influencing farmers' perceptions of biogas technology. Therefore, efforts aimed at improving educational levels, facilitating access to financial support and increasing awareness about the economic and environmental benefits of biogas plants may help develop more positive attitudes among biogas beneficiaries and encourage wider adoption of biogas technology for sustainable rural and agricultural development.

Keywords: *biogas plants, attitude, renewable energy, rural households*

INTRODUCTION

Energy serves as a fundamental driver of economic growth, agricultural advancement and overall human well-being. In recent years, concerns regarding energy security have intensified due to escalating global energy demand, finite fossil fuel reserves and disturbances caused by geopolitical conflicts. International disputes and wars have created uncertainties in energy supply systems, leading to increased fuel costs and highlighting the risks associated with excessive dependence on conventional energy sources. Consequently, greater attention is being directed towards renewable and locally available energy resources as sustainable solutions to emerging energy challenges. Agriculture is a cornerstone of the Indian economy and its functioning depends heavily on the availability of energy. Biogas beneficiaries require energy for a wide range of farm and household activities, including irrigation, transportation, crop processing, cooking and lighting. In recent years, the increasing cost of conventional energy sources such as diesel, electricity and liquefied petroleum gas (LPG) has significantly raised both agricultural production expenses and household energy costs. At the same time, excessive reliance on conventional fuels has intensified environmental concerns, including air pollution, greenhouse gas emissions and climate change, which threaten the long-term sustainability of agriculture. To address these challenges, green energy technologies have gained importance as sustainable alternatives for meeting rural energy requirements (Rao *et al.,* 2024).

From the green technologies, biogas plant has emerged as an effective, environmentally friendly, and decentralized source of renewable energy (Geddafa *et al.,* 2023). Biogas is generated through the anaerobic digestion of organic materials such as cattle dung, crop residues, animal waste and other biodegradable materials, producing a clean fuel that can be used for cooking, heating, and electricity generation (Kabeyi and Olanrewaju, 2026; Shallo and Sime, 2025). India possesses immense potential for biogas production because of its large livestock population

and abundant availability of organic biomass resources. The productive utilization of these resources through biogas technology not just provides green energy but also promotes efficient management of agricultural and household waste.

The adoption of biogas technology offers several socio-economic and environmental advantages. Besides providing a reliable source of fuel for cooking and other domestic uses, biogas plants facilitate effective waste management, improve sanitation and help reduce indoor air pollution (Rasimphi *et al.,* 2024). Furthermore, biogas technology has been documented to reduce household energy expenditure by replacing conventional fuels such as firewood, charcoal, kerosene and LPG (Shallo and Sime, 2025). The residual product from the digestion process, commonly known as bio-slurry, serves as a valuable organic fertilizer rich in plant nutrients. Its application improves soil fertility, enhances crop productivity and reduces farmers' dependence on chemical fertilizers (Kebede *et al.,* 2023). In addition, biogas contributes to reducing greenhouse gas emissions and supports the circular utilization of organic waste resources, thereby playing important role in the global transition towards sustainable energy systems (Kabeyi and Olanrewaju, 2026). Recent literatures have showed that although biogas technology unlocks the considerable opportunities for enhancing rural energy security and environmental sustainability, several challenges continue to hinder its widespread adoption. Rasimphi *et al.* (2024) identified barriers such as high installation costs, limited technical support, inadequate awareness and weak institutional mechanisms that restrict the expansion of biogas programmes in rural areas. These evidences indicate that socio-economic, informational and institutional factors play a crucial role in shaping farmers' perceptions and utilization of biogas technology. Similarly, Farrukh *et al.* (2024) reported that financial constraints, policy and regulatory gaps, lack of technical expertise, insufficient stakeholder coordination and limited access to information are among the major barriers affecting biogas adoption in developing economies.

Recognizing the multiple benefits of biogas, the Government of India has executed various programmes to promote its adoption in rural areas. Initiatives such as the National Biogas and Manure Management Programme (NBMMP) and the New National Biogas and Organic Manure Programme (NNBOMP) have facilitated the establishment of biogas plants across the country. Nevertheless, despite government support and the availability of adequate feedstock resources, the adoption and continued utilization of biogas technology vary considerably among farmers. Understanding farmers' attitudes towards biogas plants and the factors influencing these attitudes is therefore essential for designing effective extension strategies and policy interventions. With this consideration, the present investigation was undertaken with the following objectives.

OBJECTIVES

(1) To study profile of the biogas beneficiaries

(2) To assess the attitude of the biogas beneficiaries towards biogas plants

(3) To ascertain the relationship between the profile of the biogas beneficiaries and their attitude towards biogas plants

(4) To determine the relative importance of variables influencing beneficiaries' attitude towards biogas plants

METHODOLOGY

The study on biogas beneficiaries was conducted in Anand district using an *Ex-post facto* research design (Kerlinger, 1976). A total of 100 biogas plant users were selected through purposive sampling, as the district has a high cattle population, a well-developed dairy sector and a higher adoption of biogas technology. The data were collected during March-April 2026 using a structured interview schedule developed according to the study objectives. Personal interviews were conducted with the respondents at their homes, workplaces or community locations to collect information about the profile characteristics and attitude towards biogas plants. Age, education, occupation, size of landholding, annual income, animal possession, access to credit, extension contacts, digital media exposure, innovativeness, scientific orientation, economic motivation, risk orientation and knowledge about biogas plant were selected as an independent variable. Whereas, attitude towards biogas plants was selected as a dependent variable. The data was collected, processed and analysed to draw the meaningful conclusions. The statistical tools used for the data analysis were percentage, frequency, standard deviation, karl pearson's correlation coefficient and regression.

The attitude of the biogas beneficiaries towards biogas plants was measured by using the scale developed by Kumar and Godara (2017) with some modifications. The scale consisted of 10 statements, including both positive and negative statements related to biogas technology. The beneficiaries were asked to indicate their level of agreement with each statement on a five-point continuum, namely strongly agree, agree, undecided, disagree and strongly disagree. For positive statements Scores of 5, 4, 3, 2 and 1 were given respectively, while for negative statements, reverse scoring was followed. The total attitude score for

each respondent was obtained by summing the scores of all statements. A higher score indicated a more favourable attitude towards biogas plant technology. The maximum score one could get was 50 and minimum score was 10. So, the five categories were made by using arbitrary method.

RESULTS AND DISCUSSIONS

Table 1: Profile of the biogas beneficiaries (n = 100)

Sr. No.	Particulars	Categories	Frequency	Percentage
1	**Age**	Young age group (up to 35 years)	15	15.00
		Middle age group (36 to 50 years)	60	60.00
		Old age group (above 50 years)	25	25.00
2	**Education**	Illiterate	31	31.00
		Primary (1st to 8th standard)	41	41.00
		Secondary (9th to 10th standard)	23	23.00
		Higher secondary (11th and 12th standard)	04	04.00
		Graduation & above	01	01.00
3	**Occupation**	Only farming	02	02.00
		Farming + Animal husbandry	82	82.00
		Farming + Animal husbandry + Service	10	10.00
		Farming + Animal husbandry + Business	06	06.00
4	**Size of landholding**	Marginal (up to 1.00 ha)	70	70.00
		Small (1.01 ha to 2.00 ha)	24	24.00
		Semi medium (2.01 to 4.00 ha)	06	06.00
		Medium (4.01 to 10.00 ha)	00	00.00
		Large (above 10.00 ha)	00	00.00
5	**Annual income**	₹50,000 to ₹1,60,000	41	41.00
		₹1,60,001 to ₹2,70,000	32	32.00
		₹2,70,001 to ₹3,80,000	12	12.00
		₹3,80,001 to ₹4,90,000	09	09.00
		₹4,90,001 to ₹6,00,000	06	06.00
6	**Animal possession**	Small (up to 3)	33	33.00
		Medium (4 to 6)	35	35.00
		Large (above 6)	32	32.00
7	**Access to credit**	Yes	82	82.00
		No	18	18.00
8	**Extension contacts**	Very low (Up to 3.20 score)	00	00.00
		Low (3.21 to 6.40 score)	13	13.00
		Medium (6.41 to 9.60 score)	46	46.00
		High (9.61 to 12.80 score)	34	34.00
		Very high (Above 12.80 score)	07	07.00
9	**Digital media exposure**	Very low (Up to 2.80 score)	11	11.00
		Low (2.81 to 5.60 score)	41	41.00
		Medium (5.61 to 8.40 score)	43	43.00
		High (8.41 to 11.20 score)	05	05.00
		Very high (Above 11.20 score)	00	00.00
10	**Innovativeness**	Very low (7.00 to 12.60 score)	01	01.00
		Low (12.61 to 18.20 score)	11	11.00
		Medium (18.21 to 23.80 score)	40	40.00
		High (23.81 to 29.40 score)	35	35.00
		Very high (29.41 to 35.00 score)	13	13.00

Sr. No.	Particulars	Categories	Frequency	Percentage
11	**Scientific orientation**	Very low (10.00 to 18.00 score)	00	00.00
		Low (18.01 to 26.00 score)	00	00.00
		Medium (26.01 to 34.00 score)	21	21.00
		High (34.01 to 42.00 score)	48	48.00
		Very high (42.01 to 50.00 score)	31	31.00
12	**Economic motivation**	Very low (6.00 to 10.80 score)	00	00.00
		Low (10.81 to 15.60 score)	06	06.00
		Medium (15.61 to 20.40 score)	09	09.00
		High (20.41 to 25.20 score)	65	65.00
		Very high (25.21 to 30.00 score)	20	20.00
13	**Risk orientation**	Very low (8.00 to 14.40 score)	00	00.00
		Low (14.41 to 20.80 score)	09	09.00
		Medium (20.81 to 27.20 score)	35	35.00
		High (27.21 to 33.60 score)	46	46.00
		Very high (33.61 to 40.00 score)	10	10.00
14	**Knowledge about biogas plant**	Very low (Up to 20.00% score)	00	00.00
		Low (20.01 to 40.00% score)	00	00.00
		Medium (40.01 to 60.00% score)	16	16.00
		High (60.01 to 80.00% score)	48	48.00
		Very high (Above 80.00% score)	36	36.00

Table 1 indicates that a majority (60.00%) of the biogas beneficiaries were in the middle-age category (36–50 years), followed by 25.00 per cent in the older age group and 15.00 per cent in the younger age group. This suggests that middle-aged biogas beneficiaries were more actively involved in biogas technology adoption. With respect to educational attainment, 41.00 per cent of the respondents had completed primary education, whereas 31.00 per cent were illiterate, reflecting a relatively low level of formal education among the sampled beneficiaries. Regarding occupational status, a large proportion (82.00%) of the respondents were engaged in both agriculture and animal husbandry, highlighting the complementary role of livestock rearing in the operation and maintenance of biogas plants. The distribution of landholdings revealed that 70.00 per cent of the respondents were marginal farmers, while 24.00 per cent belonged to the small farmer category. In terms of annual income, 41.00 per cent of the respondents reported earnings ranging from ₹50,000 to ₹1,60,000, followed by 32.00 per cent earning between ₹1,60,001 and ₹2,70,000 annually, indicating that a substantial proportion of beneficiaries belonged to economically weaker sections. Animal possession was fairly balanced among the respondents, with 35.00 per cent maintaining a medium herd size (4-6 animals), 33.00 per cent possessing a small herd size and 32.00 per cent owning a large herd size. Furthermore, 82.00 per cent of the respondents reported having access to institutional credit facilities, which may have facilitated investment in biogas technology. The analysis further showed that 46.00 per cent of the respondents maintained a medium level of extension contact, suggesting moderate interaction with extension personnel and advisory services. In terms of digital media exposure, 43.00 per cent of the biogas beneficiaries showed a medium level of exposure, whereas 41.00 per cent had low exposure, indicating limited utilization of digital information sources by considerable segment of the respondents.

Regarding personal attributes, 40.00 per cent of the respondents exhibited a medium level of innovativeness, while 35.00 per cent demonstrated a high level. Scientific orientation was notably high, with 48.00 per cent of the respondents falling under the high category and 31.00 per cent under the very high category. Similarly, economic motivation was found to be strong among the respondents, 65.00 per cent possessed a high level and an additional 20.00 per cent displayed very high level of economic motivation. Risk orientation was also relatively favorable, with 46.00 per cent of the respondents categorized under high-risk orientation and 35.00 per cent under medium risk orientation. Concerning knowledge of biogas technology, 48.00 per cent of the respondents possessed a high level of knowledge, while 36.00 per cent demonstrated very high level. Notably, none of the respondents were classified under low or very low knowledge categories, indicating a satisfactory level of awareness and understanding regarding biogas plants among the beneficiaries. These findings corroborate the observations reported by Patil and Murthy (2021), Baflipara and Prajapati (2024), Gebretsadik *et al.* (2025), Zala *et al.* (2025), and Situmeang *et al.* (2026).

Table 2: Distribution of the beneficiaries according to attitude towards biogas plants (n=100)

Sr. No.	Categories	*f*	%
1	**Strongly unfavourable** (10.00 to 18.00 score)	00	00.00
2	**Unfavourable** (18.01 to 26.00 score)	00	00.00
3	**Neutral** (26.01 to 34.00 score)	08	08.00
4	**Favourable** (34.01 to 42.00 score)	62	62.00
5	**Strongly favourable** (42.01 to 50.00 score)	30	30.00

The Table 2 indicated that more than three-fifths (62.00%) of the respondents had favourable attitude towards biogas plant, followed by 30.00 per cent and 8.00 per cent of them had strongly favourable and neutral attitude towards biogas plant, respectively. This might be because biogas beneficiaries have experienced direct benefits such as reduced cooking fuel expenses, effective utilization of cattle waste, availability of nutrient-rich bio-slurry and a cleaner household environment. These benefits may have contributed to the development of a positive attitude towards biogas plants. The findings are in agreement with Arfin *et al.* (2020), Dudhatara *et al.* (2022), Prajapati *et al.* (2025) and Mallappa and Bansal (2026).

The results presented in Table 3 revealed that, out of the fourteen independent variables examined, namely age, education, occupation, size of landholding, annual income, animal possession, access to credit, extension contacts, digital media exposure, innovativeness, scientific orientation, economic motivation, risk orientation and knowledge about biogas plants, seven variables exhibited a positive and highly significant association with farmers' attitudes towards biogas plants. These variables were education, occupation, annual income, animal possession, access to credit, economic motivation and knowledge about biogas technology. The significant relationships observed may be attributed to the fact that successful adoption and sustained utilization of biogas plants depend largely on the availability of resources, financial capacity, and technological awareness. Biogas beneficiaries with higher levels of education are generally better equipped to understand the technical and environmental benefits of biogas systems. Similarly, respondents with higher income levels, adequate livestock resources and access to credit facilities are more capable of meeting the investment and maintenance requirements associated with biogas plants. In addition, individuals possessing strong economic motivation and greater knowledge of biogas technology are more likely to recognize its long-term economic and environmental advantages, thereby developing a favourable attitude towards its adoption and use. The findings are in line with Sarker *et al.* (2020), Gebretsadik *et al.* (2025) and Situmeang *et al.* (2026).

Table 3: Correlation between the profile of the biogas beneficiaries and their attitude towards biogas plants (n=100)

Sr. No.	Profile Characteristics	Correlation Co-efficient (r)
X_1	**Age**	0.077
X_2	**Education**	0.248**
X_3	**Occupation**	0.246**
X_4	**Landholding**	0.031
X_5	**Annual income**	0.371**
X_6	**Animal possession**	0.223*
X_7	**Access to credit**	0.235**
X_8	**Extension contacts**	-0.052
X_9	**Digital media exposure**	0.089
X_{10}	**Innovativeness**	0.014
X_{11}	**Scientific orientation**	-0.045
X_{12}	**Economic motivation**	0.310**
X_{13}	**Risk orientation**	-0.001
X_{14}	**Knowledge about biogas plant**	0.251**

Table 4: Stepwise regression analysis showing relative importance of independent variables of beneficiaries on their attitude towards biogas plants (n = 100)

Sr. No.	Factors	Unstandardized coefficients		Standardized coefficients	't' value
		B	S.E.	Beta	
1	**Annual income**	1.256	0.361	0.307	3.483**
2	**Economic motivation**	0.280	0.097	0.252	2.884**
3	**Education**	1.403	0.463	0.309	3.030**
4	**Age**	1.610	0.650	0.250	2.477**

**Significant at 0.05 level of probability* $R^2 = 0.289$

***Significant at 0.01 level of probability*

On the other hand, variables such as age, size of landholding, extension contacts, digital media exposure, innovativeness, scientific orientation and risk orientation did not show any significant relationship with the attitude of respondents towards biogas plants. This suggests that these characteristics had limited influence on shaping farmers' perceptions and attitudes regarding biogas technology in the present study area. The findings of the study are consistent with the results reported by Sarker *et al.* (2020), Gebretsadik *et al.* (2025), and Situmeang *et al.* (2026), who also documented the importance of socio-economic and knowledge-related factors in influencing farmers' attitudes toward renewable energy technologies.

Stepwise regression analysis was carried out to identify the variables contributing significantly to farmers' attitude towards biogas plants. The final regression model retained four variables, namely annual income, economic motivation, education and age. The coefficient of determination (R^2 = 0.289) showed that these four variables together explained 28.90 per cent of the variation in farmers' attitude towards biogas plant. Among the selected variables, education (β = 0.309) emerged as the most influential variable, followed by annual income (β = 0.307), economic motivation (β = 0.252) and age (β = 0.250)**.** The positive beta coefficients indicate that an increase in these variables leads to a corresponding increase in favourable attitude towards biogas plants. The regression coefficients further showed that annual income, economic motivation, education and age significantly contributed to the prediction of farmers' attitude. Therefore, these variables may be considered important determinants influencing farmers' attitude towards biogas plants.

CONCLUSION

The study revealed that the majority of biogas beneficiaries possessed a favourable attitude towards biogas plants, reflecting their positive perception of the technology and its benefits. Education, occupation, annual income, animal possession, access to credit, economic motivation and knowledge about biogas plants showed a significant positive relationship with attitude. Stepwise regression analysis identified education, annual income, economic motivation and age as the major determinants influencing farmers' attitude towards biogas plants. These findings suggest that improving awareness, educational exposure and economic support can further strengthen favourable attitudes and promote the sustained adoption of biogas plant for sustainable agricultural development and rural energy security.

POLICY IMPLICATIONS

Based on the literatures, it is recommended that policy makers, development agencies, and extension organizations focus on the key factors influencing farmers' attitudes towards biogas plants, namely education, annual income, economic motivation, and age. Strengthening these factors through appropriate interventions can help promote a more favourable attitude and encourage the wider adoption of biogas technology. Educational and extension efforts should be intensified through regular training programmes, demonstrations, field visits, and awareness campaigns to improve farmers' understanding of the operational, economic, and environmental benefits of biogas plants. Enhanced knowledge and exposure are likely to positively influence farmers' perceptions and acceptance of the technology.

The positive effect of economic motivation on farmers' attitudes indicates the need to emphasize the economic benefits associated with biogas plants. Extension agencies and development organizations should highlight advantages such as reduced expenditure on conventional fuels, efficient utilization of livestock waste, production of nutrient-rich bio-slurry as an organic fertilizer, and improved household energy security. Furthermore, since age was found to play a significant role in attitude formation, special efforts should be directed toward motivating younger biogas beneficiaries through targeted awareness programmes, skill development initiatives, and exposure to successful biogas adopters. Such measures can foster long-term interest and sustainability in biogas technology adoption.

In addition, the promotion of biogas plants should be integrated with programmes related to sustainable agriculture, organic farming, waste management, and climate-resilient agricultural practices. An integrated approach would not only enhance the utilization of renewable energy resources but also contribute to environmental conservation, improved soil health, and sustainable agricultural development. Financial support mechanisms, including subsidies, easy access to credit, and technical assistance, should also be strengthened to reduce adoption barriers and encourage wider acceptance of biogas plants among farmers. Collectively, these efforts can play a vital role in improving rural energy security, enhancing farm sustainability, and promoting environmentally friendly agricultural practices.

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CONFLICT OF INTEREST

This is to declare that there is "No conflict of interest" among researcher.

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