CHAPTER - III

REVIEW OF LITERATURE

One must hold to his anchor of prosaic objective knowledge tested by research and even more so by experiment and practice and always beware of losing himself to speculation unconnected with day to day problems of life and the needs of men and women. A living philosophy must answer the problem of today.

Any research work warrants the previous related research work findings in order to get a better understanding of the problem, the tools adopted in the study and to identify the unexplored part of the study. In this chapter, an attempt has been made to summarise and report important findings of significant past studies. In this regard, the review of some of the previous studies in the field of present study has been undertaken and presented.

Rao and Ramana26 have made a study in Thammadapalli and Knur villages in Andhra Pradesh on the working of the scheme of bank finance in the installation of gobar gas plants. The study is based on field survey method and the data was collected from 13 beneficiary families of the selected villages. The secondary data was also used for the study which was collected from the financial banks. The study came with the result that the scheme has not benefited the weaker section of the community. Similarly the study reveled that gobar gas does not hold any appeal to the small and marginal farmers, the landless agricultural labourers and other weaker segment of the rural population. To them, the opportunity cost of bank loan and susbsidy from the KVIC is too much to take the risk.

Anjana Kalra and Rajinder Kaur Kalra\textsuperscript{27} conducted a study in the Bhabar area in Haldwani block of Nainital district of Uttar Pradesh. Halduchaur area which is a cluster of villages in Bhabar division was selected purposively for the study as biogas technology is common in this area and has been in use for the last several years and the area has been declared as hill area for the purpose of giving subsidy for the installation of biogas plants. The researches considered it important to identify the reasons for adoption and non-adoption of biogas technology. The data were collected through interviews specially designed for this purpose. The study concluded that the major constraints in the adoption of biogas technology were low economic status and lengthy procedures in obtaining loans.

Sharma and Pathania\textsuperscript{28} undertook a study to estimate the cost and returns in the use of biogas plants in Haryana during 1987-88. The data for the study was collected from 100 Janata type biogas plants comparing 20 each of the sizes 2, 3 and 4 cubic meters and 40 of 6 cubic meter capacity. The biogas units for the study was selected by using multi-stage stratified random sampling technique. The study came out with the result that the depreciation accounted for nearly 31 per cent of the fixed cost in the case of all sizes. Of the variable cost, the cost of dung accounted for about 63 per cent, labour 33 per cent and the rest 4 per cent on minor repairs. It was observed that the cost per cubic meter size of biogas plant decreased with the increase in size of the plant. The percentage variable cost

\textsuperscript{27} Anjana Kalra and Rajinder Kaur Kalra, "Constraints in Adoption of Biogas Plants in Uttar Pradesh: A Study,"\textit{Agricultural Extension Review}, March - April 1996, PP.26-28

decreased with the increase in the size of the plant. But the returns per unit of installed capacity decreased with the increase in size. However the net returns were observed to be positive in all the biogas plants and it increased with increase in the size of biogas plants.

Bhati and Laharia,29 in their study on the impact of biogas plants on time utilization pattern of women in their various activities, conducted in three districts of Haryana namely, Kurukshetra, Hissar and Bhiwani, observed that the women in biogas owning families can save time in various food preparation activities and such women spend considerably more time in personal care and livestock management. They have used survey data from selected villages.

Susheela30 has made a study on the extent of adoption of gobar gas technology in rural India using the data collected by the staff of Rural Home Science College working in All India Coordinated Research Project on Home Management in 4 selected villages of Darvar Taulk of Maharashtra during the year 1985-87. She has observed that the adoption of gobar gas technology had improved in study villages only after the end of 1984 mainly on account of denudation of forest in the last decade and the availability of loan and subsidy under developmental programmes. She has also observed that 64.58 per cent of adopters of biogas plants belong to the large landholding and medium landholding households. Majority of households who adopted gobar gas plants were joint family households. The study noted that gobar gas plants were installed both by the persons owning cattle and not owning cattle.

Ashok Lavasa\textsuperscript{31} made a study to find important factors contributing for the success of biogas programme in Karnal district of Haryana using the survey data collected in 1982-83 and 1983-84. The study indicated that even though there was uptrend in the bank lending for biogas plants, the landless labourers are not in a position to install biogas plants on account of their inability to absorb the loan. This coupled with lack of interest on the part of the farmers to use gobar gas and leakage in gas holder were found to be the main reasons for the failure of the programme.

Lahharia and Bhatia\textsuperscript{32} studied the relationship between socio-economic status of plant owners and adopting biogas technology in Kurukshetra, Hissar and Bhiwani districts of Haryana, using the survey data collected from 79 respondents of 14 selected villages. The study showed that most of the plants were located at dry place having through sunlight and sweet water supply. However, the recommendations such as distances from water pipe, the level of land, slant of gas pipe line and distance from cattle shed were found not observed in many cases. The study also observed that almost all the plants were located either at a satisfactory or at a tolerable sight and there was no variation between Janta and KVIC type plants with respect to their location. However, the site of the plant installed by the respondents with medium-socio economics status (SES) was found to be better than those with low SES. The study further revealed that the adoption of recommended practices was more among Janta type plant owners as compared with those having KVIC type plants. Similarly it was also observed that the adoption level was higher among the respondents of medium and high SES categories than those belonging to low SES category.


The study suggests that there is a strong need for follow-up measures and extension education activities to educate and persuade the biogas owners to adopt all the recommended practices.

Indra Yeshwanth\textsuperscript{33} conducted the study on the adoption of biogas technology by weaker sections in three villages surrounded by forest, located in Kamrup district of Assam. The study has revealed that the small farmers in northern region of Assam have started to accept the gobar gas programme despite the availability of cheap forest fuel due to other benefits such as quick and easy cooking, free of carbon deposits on vessels etc. This results in saving of time in cooking and cleaning the vessels, which facilitates them to use the surplus time in handloom weaving.

Kahlon and Harcharan Singh\textsuperscript{34} have made an economic and financial analysis of biogas plants in Ludhiana district of Punjab. The study showed that the adverse movement in the proportion of dung burnt before installation of plant and alternative fuels considered to compute the shadow prices of biogas and gobar fuel will affect the viability of the project adversely. The financial analysis of different size of plants indicated that 100 cubic feet plant was not viable. The difference in the result is due to low market price of biogas manure as compared to the shadow prices used for economic prices. The economic analysis showed that project could be made a greater success by providing subsidies on capital cost and by developing cheaper plant designs.


\textsuperscript{34} A.S.Kahlon and Harcharan Singh, "Economic and Financial Evaluation of Biogas Plants in the Ludhiana District, \textit{Agricultural Situation in India}, Vol:34, No:4, August 1979.
Bhavani\textsuperscript{35} has made the social-cost-benefit analysis of biogas production. Adopting modified estimation procedures established in the light of estimates made by different researchers in this field, she has estimated cost and benefit of biogas plants and came to the view that if all the benefits associated with biogas production could be properly qualified, the benefits might outweigh costs substantially.

Lakshmi and Karthikeyan\textsuperscript{36} made an attempt to find out the potential and actual installation of biogas plants, utilization pattern and its share in capital formation in agriculture of Mangalam Muruga village of Thanjavur district during 1992-93. The study observed that on an average the families who own 3 cubic meter size plants are getting gas for cooking purpose 3 hours per day and it is four hours in the case of the families who own 6 cubic meter size plants. The researcher has estimated that if the entire available dung in the village is used in the process of biogas production, it is possible to produce 94.5 Kgs of nitrogen per day or it is possible to energies 50 pump sets of 5 HP or to save 4685 litres of diesel per month.

Patel and Singh,\textsuperscript{37} while examining the cooking fuel consumption pattern of households of North Gujarat Agro Climatic Zone in 1988-89, came to conclusion that the use of gobar gas as fuel results not only in reduced annual expenditure on fuels in both per households and per capita terms but also results in increased manure worth.


Pathania and Sharma\textsuperscript{38} made an attempt to analyse the resource structure, its availability for biogas production and returns from biogas plant in Haryana state. They observed that the average investment per cubic meter of biogas plant decreased with increase in the size of biogas plant. Cement, labour and bricks were found to be major cost components in the installation of biogas plants. The quantity of cow dung produced and used in the biogas plants increased with the increase in the size of biogas plants. The percentage of net return to the total cost generally increased with the increase in the size of plant. The net returns computed without subsidy on an average was observed to be lower by 23-47 per cent as compared to that of the net returns computed with subsidy.

Manjappa\textsuperscript{39} conducted his study on economics of biogas in Surat and Valsal districts of Gujarat state during 1982-83. Using the data collected from 70 randomly selected sample respondents and making cost-benefit, internal rate of return and break-even analysis, the study indicated the viability of all sizes of biogas plants. The study further indicated that bigger the size of plant, lesser will be the benefit to the farmers and revealed that investment on bigger size plants is idle investment on biogas technology.

Subramanian\textsuperscript{40} analyzed the information gathered by field survey undertaken by him in different parts of Asia. The study brought fourth the fact that the use of biogas plant is restricted only to some selected village and has not spread over a wide rural region, mainly because very few small farmer household can afford an annual expenditure of such an amount on gobar gas for cooking purpose.


\textsuperscript{40} K.S. Subramanian, \textit{Biogas System in Asia}, Monograph No.2, Management Development Institute, New Delhi, 1977.
Mouli et al., have made a study on socio-economic evaluation of biogas energy in India. The study came with the result that the pay-back period declines with the increase in size except in the case of plant size 350 cf. It also revealed that the net present value increases with the increase in size, the exception being the case of 350 cft plant. From the society point of view, the study indicated that larger community size biogas plants are more economical than the family size biogas plants.

Moulik in his independent study, made on community plants in Kudadthal village of Dhamadabad district in Gujarat, found that the women folk of the gas consuming families are clearly and equivocally impressed with the usefulness and worth of biogas and adopted it as a better alternative fuel. To the biogas consuming households, the study observed that there was a net saving in expenditure on fuel. Similarly, the community biogas plants have been found to be potential in employment generation.

Jain carried out a study on the working of the biogas plants in Andhra Pradesh, Haryana and Karnataka by studying 75, 50 and 50 plants respectively from these districts. The study evaluated the impact of certain socio-economic factors such as age, family size, education, land ownership, occupation, livestock ownership, etc., on the biogas programme. From the study, the acceptance of biogas scheme was found to be related to socio-economic factors of the region. The biogas programme was found to have greater


42. J.K. Mouli "A Case Study of Community Biogas Plant", Biogas Energy in India, Ratilal N. Sha Academic Book Center, Ahmedabad, 15 July 1982, PP.105-124

acceptance among economically affluent rural households. The study also analyzed certain aspects of adoption behavior of beneficiaries such as period of plant, ownership, sources of finance, organizational and operational aspects and social acceptance of biogas technology.

Moulik in his another study with Murthy and Subramanian\textsuperscript{44} carried out socio-economic evaluation of biogas plants in India. The study found out that community plants have not made significant headway so far as many of them have been found to be economically non-viable. From the findings, the study concluded that the floating drum type plants are more reliable and appropriate than fixed dome janata design. Active participation of beneficiaries and adequate availability of wastes of feed were found to be crucially important for techno-economic feasibility of the biogas plants. Institutional plants are observed to be easier to manage than village community plants. Economic viability of community biogas plants are found to depend on optimal utilization of both digested slurry and biogas. The study viewed that the community plants offer greater promise of success of biogas programme than family plants.

This study carried out by Mital and Prem Vrat\textsuperscript{45} on socio-economic evaluation of Janata Biogas Plants revealed longer life of janata plants due to limited wear and tear and maintenance problem. The study noted that the gas yield of janata plants are higher than those of the other plants. The effluent obtained from janata biogas plants are observed to have the same carbon and nitrogen content but richer in phosphorus and potassium.


contents by 2.5 to 6 percent and 7.2 to 18.5 percent respectively as compared to those from other plants.

In his study, Khanna\textsuperscript{46} observed that dung produced by cattle heads is either lost in countryside in open or used in dump cakes and estimated that if all these dungs are used for biomethanation 300 cubic meters of gas and 200 million tones of humus-rich fertilizer can be produced. He opined that there exists scope for setting up of 40 million biogas plants in the country.

The field study conducted by the KVIC\textsuperscript{47} in 14 districts in Maharashtra, Tamil Nadu and Bihar revealed that out of 13,216 plants set up between 1974 and 1982, 72.5 per cent of them were found to be satisfactorily working. The study identified low gas output during winter, corrosion of gasholder and defective central guide frame in KVIC model, cracks in masonry domes, choked pipelines, water logging due to sub soil seepage and lack of adequate maintenance support as the reasons for the non-working of plants in Bihar and Maharashtra. The study revealed that the structural defects were more common in fixed dome type plants and KVIC plants with floating drum were more prone to corrosion.

Sushil Kumar and Biswas\textsuperscript{48} conducted a laboratory study to expose the potentiality of using agricultural waste as additives and partial substitutes of cow dung in biogas production. The waste materials investigated are water hyacinth (Eichornia crassipes) paddy straw, what straw, groundnut shell and sugarcane bagasse. In this study

\textsuperscript{46} K.C. Khanna, "Biogas in India and China", Times of India, New Delhi, January 28, 1986.

\textsuperscript{47} B.Bhusan, "Biogas Plant under Attack: Devaluing Decentralised Energy", Times of India, New Delhi, July 31, 1986, P.5.

\textsuperscript{48} Sushil Kumar and T.D. Biswas, "Cowdung Mixed with Water-Hyacinth can Augment Biogas Production", Agricultural Technology, Vol:2 No:1, October-November 1983, PP. 16-21
an attempt has also been made by analyzing the materials before and after digestion to identify the dominating factor in the biogas production. The study found that total yield of gas per unit mixture of cowdung and water hyacinth is higher than that of cowdung alone. The study also revealed that the production of biogas per unit weight of water hyacinth is higher than that of cowdung. The study indicated that the wheat straw mixture yields lowest quantity of biogas.

Rubab and Kandpal\textsuperscript{49} have made a financial evaluation of three designs of biogas plants in India based on recently developed cost functions by making a thorough examination of three different cost functions. They have developed analytical expressions for the unit cost of biogas and cost per unit of useful energy delivered by a biogas plant in combination with other suitable technologies. They have also calculated net present value and discounted pay-back period. They have studied sensitivity of the unit cost of biogas with respect to useful life of plant, discount rate, fraction of manure used for making dung cake and fraction of gas used for end use to identify their effects on the financial viability of gobar gas plants. They have also studied the change in cost per unit of useful energy and net present value with respect to a number of these variables. Based on the analysis, they reported that net present value is always positive and the corresponding values of pay-back period are much less than the expected useful lifetime of the biogas plants.

Pathania and Sharma\textsuperscript{50} have made an attempt to examine the economic viability of different size of biogas plants in Haryana state using capital budgeting techniques such as

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  \item Rubab and Kandpal\textsuperscript{49} have made a financial evaluation of three designs of biogas plants in India based on recently developed cost functions by making a thorough examination of three different cost functions. They have developed analytical expressions for the unit cost of biogas and cost per unit of useful energy delivered by a biogas plant in combination with other suitable technologies. They have also calculated net present value and discounted pay-back period. They have studied sensitivity of the unit cost of biogas with respect to useful life of plant, discount rate, fraction of manure used for making dung cake and fraction of gas used for end use to identify their effects on the financial viability of gobar gas plants. They have also studied the change in cost per unit of useful energy and net present value with respect to a number of these variables. Based on the analysis, they reported that net present value is always positive and the corresponding values of pay-back period are much less than the expected useful lifetime of the biogas plants.


benefit-cost ratio, net present value, internal rate of return and pay-back period. The data for the study were obtained by survey of 200 sample janata type biogas plants which were selected by applying multistage stratified random sampling technique. The study indicated economic viability of all sizes of janata biogas plants. The study revealed that the economic viability of biogas plants increases with the increase in the size of the plant as well as increase in the proportion of dung as fuel and decreases with the increase in the rate of interest. The method of evaluation is found to have a bearing on the economies of gobar gas plants.

Tomar\textsuperscript{51} has studied the technical and functional status of biogas plants in India. The data covered mainly the type of technical defects on digester, dome, pipes, burners, inlet-outlet chambers, drum, petromax guide frame, partition wall etc., The 24501 plants located in Madhya Pradesh were selected for the study. The study revealed that 52.52 percent of the plants are functional. The non-functional plants showed that 47.6 per cent defects were technical nature, 12.7 per cent operational, 20.8 percent incomplete installation and 18.9 per cent defects were of other nature. More defects were found to be in foundation, inlet-outlet chambers and digester walls.

Patel et.al.\textsuperscript{52} have undertaken a study in Mehsana district of Gujarat state during 1988-89 by selecting a sample of 60 gobar gas plant owners and 15 non-plant owners through three stage proportionate stratified random sampling method. The study attempted to analyse investment pattern in gobar gas plants of different capacities,

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and returns and to evaluate economics of different capacities. Applying net present
estimate their cost worth, benefit-cost ratio, internal rate of return and payback period
analyses, the study came with the result the average cost of production of gas was more in
relation to the smaller capacity plants due to inadequate availability of dung and
production of gas below their capacity. The study also showed that the investment in
gobar gas plants is a viable and profitable proposition.

Ramesh Bhatia\textsuperscript{53} have presented a framework for valuation of costs and benefits
and making a detailed social benefit cost analysis of investments in biogas plants. He
has assessed the available information on valuation of outputs such as fertilizer and fuel
and valuation of inputs in various studies of biogas system. He has also presented some
preliminary results on the profitability of investments in biogas units from the view point
of the society under alternative assumptions with regard to the use, social rate of discount
and shadow wage rate. He has also analysed the sensitivity of the social profitability of
investments in biogas plants under different valuation methods of costs and benefits.
Based on his analysis, Bhatia concluded that investment in a family size biogas plant is
not socially profitable.

Kurkure et.al.\textsuperscript{54} have undertaken a case study in the campuses and farms of
Punjabrao Krishi Vidyapeeth at Akola to provide a system to process all the available
wastes by anaerobic digestion through the construction of biogas plants and to provide a
suitable gas distribution system. The study also aimed at the evaluation of the feasibility

\textsuperscript{53} Ramesh Bhatia, "Economic Appraisal of Biogas Units in India: Framework for Social Benefit Cost

\textsuperscript{54} V.M. Kurkure, G.K. Muzumdar and N.N. Narkhede, "Biogasification of Agricultural Wastes on
and economics of biogas generation, distribution and utilization at the institutional level. They have estimated annual crop wastes to the extent of 1515 tonnes, animal dung and poultry waste of 4771.21 tonnes and human habitation wastes from residential quarters and hostels at 487 tonnes. Based on these estimates, the study suggested construction of 30 biogas plants in the project area. They worked out a fixed cost of 11.20 lakhs towards the construction of these plants. The cost of gas was calculated as Rs.1.06 per cubic meter and that of manure as Rs.4.50 per kg. The study has estimated a total production of 82.50 tonnes of nitrogen. The total receipt from the biogas project was estimated at Rs.5.96 lakhs per annum.

Soundrapandian\(^{55}\) has attempted to analyse the working and the economic impact of biogas technology in Virudhunagar (Kamarajar) district of Tamil Nadu during 1985-1990 by using secondary data as well as primary data. The primary data was collected through interview method by selecting 48 biogas owning families through multi-stage sampling procedure. The study noted that highest number of biogas plants was installed during seventh plan period. Majority of the plants owned by the families were 3 cubic meter size. The study revealed that on an average 1.57 hours per day was saved by the households in switching over to biogas. The study found that 3 cubic meter and 4 cubic meter sizes were economic sizes for 8 to 15 member family. The study revealed that income from gas value and manure value was higher for 6 cubic meter size than the 4 cubic meter and 3 cubic meter sizes. The electricity value was found to be higher for the small size plant.

Chatterjee et.al\textsuperscript{56} have made a study of 68 biogas households in Kankalitala Gram Panchayat in Bolpur-Sriniketan Block during March 1985 to February 1986. The study found that majority of the households consumed gas only for cooking purposes. Scheduled tribe households were found consuming gas for lighting purposes in much larger proportion compared to other communities. Majority of the biogas households consume the slurry as fertilizer cum fish food. The construction cost of small sized gas plant was observed to be relatively very high. However, the direct return to investment was also observed to be very high. The production of gas during summer was observed to be quite high and reduced to a half in the winter season.

Kamaraj et. al.\textsuperscript{57} have made a cost-benefit analysis of small, family size and Deenabandhu model biogas in Tamil Nadu. Based on the estimate on the availability of dung in Tamil Nadu, the study observed that there is a vast scope for biogas production. The study noted that as the size of the gas plant increases, the cost of investment on per cubic meter biogas production decreases. The cost of investment was observed to be minimum in the case of 4 cubic meter size plant. The scale economy in the installation of biogas plants was noted by the study. The capital recovery period was observed to be shorter and net present value, cost benefit ratio and internal rate of return were found to be increasing with the increase in the plant size. Both economic and financial analysis indicate increase in the viability of the plants when subsidy is provided for the installation.


of the plants. The study concluded that the investment in biogas plant lies in probable private profitability and investment in biogas plants become more attractive and viable if Social costs and benefits are included. However, the study noted problems in the quantification of social costs and benefits.

Moulik and Srivastava\textsuperscript{58} carried out socioeconomic evaluation of biogas plants in Gujarat during 1975. Analysis was carried out for three different discount rates, 10, 13 and 15 per cent. For analyzing economic viability of plants, cost and income streams were compared after discounting at successive intervals by computing net present value, internal rate of return, benefit-cost ratio and pay-back periods. It was found that for 60 cubic feet capacity plant with a 15 percent discount rate it was difficult to recover plant cost within the entire life span of the plant. Except this case, in all other cases, NPV, BCR and IRR were found to be positive which increase with the increase in the size of the plant indicating the operation of scale economy. This implies that community plants are more cost effective than family units.

Moulik et. al.\textsuperscript{59} have carried out a socio-economic evaluation of biogas systems in India during 1978 by selecting 173 plants consisting of 44 from U.P., 45 from Haryana, 44 from Andhra Pradesh and 40 from Madhya Pradesh. The study reveled that most of the beneficiaries of gobar gas were rich in economic status and education. The number of cattle possessed by beneficiaries ranged from 3 to 100 with an average of 12 animals. It


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had direct relationship with the plant capacity. Beneficiaries in general had large families with an average 7 members. The distance between household and plant were reported between 2 to 30 metres. The plant distance in U.P and Haryana are found to be greater than in Madhya Pradesh and Andhra Pradesh. In 41 per cent of cases owners themselves prepare and transport slurry. Only in 25 percent of cases external labour was engaged. The frequency of dung collection is not found to be related to any socio-economic factor or plant capacity. Biogas is found to be mainly used for cooking. While analyzing the factors for plant shut-down, the study identified the moisture in the connecting pipelines, gas leakage from gas holder and pipeline joints, corrosion of steel plants and parts, accumulation of water in plant, vicinity during rainy season, low gas output during winter and faulty choice of operating parameters as the reasons for the closure of the plants.

Muthukrishnan\(^60\) in his study on the utilization of biogas plants, conducted in Thondamuthur block of Coimbatore district and Gobichettipalayam block of Erode district, analysed the characteristics of biogas plant owners, their perception of the attributes of biogas plants and the factors responsible for accepting biogas plants. The study has also analysed the role of various agencies in the introduction of biogas plants and the various problems faced by the users of biogas plants. Using multistage purposive sampling procedure, 100 sample biogas plants were selected from the selected blocks. The study revealed that majority of the biogas households came under medium socio-economic group. All the attributes of biogas plants were perceived by the users favourably except for the cost. The variation in the perception of attributes of biogas

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\(^60\) S. Muthukrishnan, *Utilization of Biogas Plants: An Analysis*, M.Sc (Ag) Thesis submitted to the Tamil Nadu Agricultural University, Coimbatore, 1982.
plants were explained by 13 selected independent variables to the extent of 71.5 percent. These variables are education, family type, income, nature of the house, farm size, livestock possession, material possession, social participation, etc. The mass media contact and extension agency contact were found to be positively related with the perception of profitability of gas plants. It was found that KVIC model of biogas plant was more popular than TNAU model even though the users are aware of the most of the facilities provided by these models. The study found that securing loan in general for installation of biogas plants was very easy. The reasons like less time consuming for cooking, less dependability on firewood, more suitability for farm family and easy cleaning of vessels after use were identified by almost by all users for their preference. The problems like non-availability of technical guidance during and after installation of gobargas plants, problems of storing excess gas, non-availability of cement and trained mason in time were found to be highlighted by majority of users.

PRAD\textsuperscript{61} carried out a study on Janata Biogas System in Uttar Pradesh during 1980. The Study analysed the reasons for initial high acceptance of Janata Biogas Plants and assessed fuelwood and kerosene needs of gobargas beneficiaries for cooking and lighting prior to the installation of biogas plants. The study also analysed the pattern of biogas generated and economic returns from biogas plants and assessed the level of satisfaction achieved. The study came with the result that the plant owners were satisfied with the plant's performance. Available wastes generated by household animals were found to provide feed for these plants. The study found that the inadequacy of animal faeces generated within households was the reason for the biogas having not too wide acceptance.

Mehamani in her study in Sathyamangalam Block of Erode District during 1993-94, analysed the economics of gobar gas plants of different types and sizes. She has studied capital cost composition of gobar gas plants and estimated the cost and returns from gobar gas plants. Using multi-stage random sampling procedure, 100 gobar gas households were selected for the study from the purposively selected Erode district. Using the benefit-cost ratio, pay-back period, internal rate of return and break-even analyses, the study assessed the economic feasibility of gobar gas plants. The study came with the finding that the adoption of KVIC gobar gas plants entails greater capital investment as compared to that of Janata type gobar gas plants. The capital cost incurred per cubic meter capacity decreased with the increase in the size of the plants both in the case of KVIC and Janata type gobar gas plants. Drum cost and Cost of civil construction were found to be the major capital cost components respectively in the case of KVIC and Janata plants. The janata plants are found to be more economical than KVIC plants even though all type of plants were economically viable. The study found no scale economy in the installation of gobar gas plants.

Neelakantan assessed the availability of livestock and biomass and estimated statewise biogas potential and total wet dung production of 960.863 million tones comprises of 192.172 million tones of dry matter and 180.642 million tones of organic matter. Out of 180.642 million tones of organic matter, cattle dung accounts for 136.816 and buffalo dung 43.826 million tones. As for the organic matter utilization, a portion of


124.643 million tonnes are used as manure and remaining 52.385 million tonnes are burnt annually as cow dung cakes. The study observed that 21.47 lakhs biogas plants constructed upto 1994-95 cover barely over 1.5 per cent of total rural households. Hence he viewed that there is vast untapped potential for installing the plants. With an assumed norm of adult bovine generating 10 kg of animal wastes per day and collection of 75 per cent of them, 262 million adult bovines are estimated to generate nearly 2 million tones of annual wastes per day. With the norm that 25 kg of animal waste can produce one cubic meter of biogas, it is possible to feed 40 million biogas plants of 2 cubic meter capacity daily which is 25 times that of the 16 lakhs plants installed up to 1991-92. The study concluded that if biogas is produced to its fullest potential can meet fuel needs of 120 million rural households in India.

Bahadur and Agarwal\textsuperscript{64} have carried out cost-benefit analysis of two community biogas plants at Fateh-Singh-ka-Purwa in Bhagynagar block of Etawah district in Uttar Pradesh set up by PRAD, Lucknow based on the data of one year plant operation. The study estimated the cost of the project at Rs.394597 including a capital investment of Rs.392620. The annual feed of animal wastes, crop residues and water hyacinth was estimated at 450 tonnes. The study estimated that the plants provide an additional 225 tonnes of organic manure as enriched fertilizer. Out of which solid content is about 21 tonnes, comprising 4.2 tonnes of nitrogen, 2.1 tonnes of phosphorous and 2.7 tonnes of potassium, valued to Rs.15000 per annum. Thhe study estimated annual operation cost and annual benefits of the plants at Rs.8811 and Rs.34870 respectively. Applying cost-benefit

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\textsuperscript{64} S. Bahadur and S.C. Agarwal, Community Biogas Plant at Fateh-Singh-Ka-Purwa: An Evaluation, Planning Research and Action Division State Planning Institute, Lucknow, 1980.
\end{center}
analysis, the study concluded that even without taking into accounts several benefits like improved health, sanitation and extra leisure time, the gobargas project is economically beneficial.

Kaleeswaran\textsuperscript{65} has made a study on the utilization of gobar gas by the households of Nambiyur Panchayat Union in Erode District of Tamil Nadu by using time-series data for the period 1982-83 – 1986-87 and cross-section data obtained from 60 sample gobar gas beneficiaries for the period 1986-87. He has studied the trend in the installation of biogas plant in Nambiyr block. Using the interview data, he has analysed the factors influencing and the reasons for the adoption of biogas plants. The study has also analysed the capital structure of installed plants. Applying cost benefit analysis, internal rate of return and pay-back period analysis, he evaluated the economic feasibility of different type and sizes of gobar gas plants. He came with the result that the factors such as age, size of family, livestock size, asset holding, liability of the adopters and caste are the significant influencing factors in the adoption of gobar gas plants. The study also indicated that the janata type gobar gas plants are more economical than KVIC type biogas plants in all sizes and the feasibility of the Janata plant increases with the increase in the size of the plant. Fuel shortage is identified as the main reason for the adoption of biogas plants.

Kaleeswaran\textsuperscript{66} in his another study along with Vijayakumar analysed the cost and returns in the use of KVIC type bio-gas plants in the purposively selected Periyar district.


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during 1987-88 using the data obtained from 60 randomly selected households of KVIC biogas plants. They found that the operational cost per cubic meter capacity of biogas plant decreases and the total return as well as net return increases with the increase in the size of the plant. Using pay-back period and internal rate of return techniques the study concluded that all the KVIC type biogas plants are economically feasible.

Mukhopadhyay\textsuperscript{67} has carried out his research and development study of piolet 500 cubic meter capacity biogas plant constructed at Kanpur and came with the finding that about 200 cubic meter biogas could be generated from an installed capacity of 500 cubic meter capacity plant per day and the sludge residue of the digester could be found to yield wet biofertilizer of about 2 tonnes per tonne of dry organic mixed waste material. He has estimated the total capital cost of biogas plant at Rs.2740000, operation cost at Rs.1609250 per year, total receipts at Rs.1860000 per annum and an annual profit of Rs.251750. He found that on dry basis the biomanure contained 3.5 to 4 percent nitrogen, 2.0 to 2.5 percent phosphorous (as P2C) and 1.5 percent potash as K2O. In terms of N:P:K, he found that biomanure is superior to farm yard manure in its manorial efficiency.

Ramachandran\textsuperscript{68} in his study undertaken in Erode district during 1997-98 have analysed the economic feasibility of biogas plants by selecting a sample 240 biogas adopters and 240 non-adopters by using multistage sampling method. Applying


discriminant analysis, logistic functional analysis, cost-benefit ratio, internal rate of return and pay-back period, he has assessed the economic viability of gobar gas plants and came with the finding that the Janata type gobar gas plants are more economical than KVIC type gobar gas plants. The economic viability of gobar gas plant increases with the size of the plants. The farmers with greater size of livestock, larger family size and greater level of education are found to have adopted gobar gas.

On the whole, the review indicates that the studies in this field have used different procedures by modification of the old procedures in measuring costs and benefits of biogas plants taking the defects in the previous procedures. The studies in general indicated economy of all types of biogas plants in all sizes. The studies have also revealed that the Janata family type biogas plants are more economical than the KVIC type biogas plants and the economy biogas plants increases with the increase in the size of the plant. However, the studies indicated the failure of community biogas plants. From the utilization point of view, the smaller size plants are more viable on account of idle capacity in bigger size gobar gas plants. Most of the studies have used cost benefit analysis, net present value, internal rate of return and pay-back period in the economic evaluation of gobar gas plants.

Further the studies indicated the technical problems rather than economic problem are the main reasons for the failure of gobar gas programme and the gobar gas programme has benefited only the better sections of the society. Even though the social costs and social benefits flowing out of gobar gas are outlined by some of the studies, there is little attempt in the estimation of those benefits and costs.