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Deenbandhu and KVIC models of biogas (Gobargas) plants under national biogas and manure management programme in Sehore district of Madhya Pradesh: An economic analysis

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Abstract
The Government of India started the National Biogas and Manure Management Programme (NBMMP) in 2005 which was as the result of merger of The National Project on Biogas Development and a manure management initiative. This study is confined to Sehore district of Madhya Pradesh. In this study researcher searched two types biogas (Gobar gas) plant design namely floating dome (KVIC) and fixed dome (Deenbandhu) 10% and 90% respectively in the study area and the size of biogas plant are exist 3 m^3 and 4 m^3 which is 18% and 82% respectively. The cost incurred in KVIC and Deenbandhu type of biogas plant installation is ₹ 34341 and ₹ 14118 respectively and direct benefit from biogas plant in the form of saving of fuel wood, kerosene, chemical fertilizer, LPG, time saving is ₹ 29319 and also found indirect benefit in the form of enhancement in crop production, soil health improvement, sanitation improvement, greenhouse gas reduction and also women health improvement etc.

Keywords: Biogas (Gobar gas) plant, KVIC, Deenbandhu, NBMMP, cost-benefit, doubling farmers' income

1. Introduction
In India, the recent problems or challenges in front of farmer community and government also that how improve the farmers' economic condition? At present farmers majorly using fertilizers, pesticides and many types of chemical using in different form for the higher production and due to use of these types of inputs, cost of production is very high and in other side farmers are suffering from low price of their produce. Sometime farmers are unable to receive their cost of production and ultimately farmers get loss, then the question arises that how increase the farmers' income for betterment of their living standard? In the village farmers are using the cow dung in the form of dung cake for the purpose of cooking and due to use of cow dung in this form, farmer depends on the chemical fertilizer for nutrient management which is very costly and increases the cost of production. Therefore the central government started the National Biogas and Manure Management Programme with the

Objectives of achieves the following goals
The new NBMMP scheme (MNRE, 2009), which aims to encourage people in rural areas to adopt biogas technologies to meet their household cooking and lighting needs, involves Khadi and Village Industries Commission concrete and plastic floating dome plants and cheaper, concrete, fixed-dome Janata and Deenbandhu plants (Singh and Sooch, 2004) [4]. The floating dome system, fed with animal manure and other organic wastes is arguably more popular in south India, while the fixed dome system fed only with animal manure more common in the north of the country (Balachandra, 2011) [1].
NBMMP household plants were designed to be multifunctional and to: (a) reduce dependency on LPG and kerosene for cooking and lighting purposes; (b) produce waste digested fertilizer which can help reduce the use of chemical fertilizers ; (c) remove the need for collection of fire wood which reduces the drudgery on rural women and children who under take his task (Kanagawa and Nakata, 2007) [5], as well help preserve forests; and (d) improve sanitation in villages by linking sanitary toilets with biogas plants. Subsidies and financial assistance were provided centrally to each state based on its economic profile (MNRE, 2009). These new policies have encouraged the provision of affordable and accessible modern energy to both rural households and the urban poor.

Estimated potential of biogas plants in India 120 lakh, Cumulative achievement 49.15 lakh (up to march 2015), potential harnessed 40.96 %, biogas plants installed in M.P. 2.41 lakh (2015), Sehore district 5236 (2015), Sehore district 357 (during 2014-15) and Target of NBMMP for 12th five year plan 6.50 lakh, achievement 2.86 lakh (March, 2015), target 1.11 lakh (during 2015 – 16), 350 biogas installed in Sehore district during the financial year 2015-16. The subsidy provides ₹ 9000 by central government and ₹ 2500 given in the form of top up by M.P. Govt. through M.P. State Agro and Development Corporation Ltd. Bhopal (M.P.). Thus NBMMP is helping in fulfill the government dream i.e. doubling the farmers' income, sustainable agriculture and climate change etc.

2. Methodology

This study was confined to Sehore district of Madhya Pradesh and it is selected purposively for the study because of the National Biogas and Manure Management Programme (NBMMP) is successfully running in Sehore district since 1985-86. Multi stage sampling technique was used for drawing a sample for this study. Sehore district comprises of 5 blocks namely Sehore, Ichhawar, Astha, Nasrullaganj and Budhani. In all the blocks of district Sehore the project is intervention since long back and there was 357 Biogas plant was installed in the year of study (2014-15). During the year of 2015 the total 5236 number of biogas plant was installed in the district and out of five blocks two blocks were selected namely Sehore and Ichhawar, then 11 villages from Ichhawar and 4 villages from Sehore block were selected, then 50 beneficiaries were selected by simple random sampling procedure. In this study Primary data was collected from sample beneficiaries and the required secondary data was collected from Government Publications, MNRE and M.P. State Agro and Development Corporation Ltd. Sehore. Data were collected using survey method. The data on different aspects of evaluation of NBMMP was collected through pre-tested interview schedule. The primary data were related to the financial year 2014-15. The analytical tools were applied percentage, mean, financial feature, computation costs (TC=VC + FC, the biogas plant life is about 20 years, maintenance charges are taken to be 2 per cent of the net installation cost of plant, labour charge was calculated as actual prevailing wage rate in area, cost of dung was calculated approximate to cost of dung-cake value in the area and depreciation per annum was calculated on the basis of 20 years of life on civil construction cost of plant.), Computation of Returns (The annual returns included the value of the fuel saved and sludge manure obtained per annum. The value of the fuel saved includes the value of the firewood, kerosene, electricity and commercial cooking gas. The value of the firewood, kerosene, electricity and commercial cooking gases was determined based on the market price prevailing in the study areas) and Computation of Income as below:

1. Annual biogas production (ABP) (m^3) =[Singh and Sooch (2004) [4]] calculated 1460 m^3
2. Net quantity available for use (NQA) (m^3) = 80% of the gas produce is available for cooking and 20% is wasted.
3. LPG equivalent of net quantity available (LPGE) (kg) = 0.43 X (NQA)
4. Income from gas (IFG) (₹)= 14.5 X LPGE
5. Cow dung needed (kg) = 100 kg per day
   *Source: National Biogas and Manure Management Programme, M.P. State Agro Industry-Bhopal (2011)
6. Dried slurry available (DSA) (kg) = 0.3 X Annual dung needed
7. Income from slurry (IFS) (₹) = 0.25 X DSA
8. Total Income (TI) = IFG + IFS

3. Results and Discussion

The data regarding models of biogas plants available with sampled household are classified into two i.e. floating dome type (KVIC) and fixed dome (Deenbandhu).

3.1 Cost incurred in different types of biogas plant

The basic principle of biogas production is the same in these two models, they differ in design, shape and their requirement of space and their installation cost. For studying the economics of different of models viz. KVIC and Deenbandhu, of average available family size ($4m^3$) biogas plant, the cost of construction and installation, annual operational cost and income from biogas thus produce are calculated by taking into account the current prices of the local market of Sehore.

3.1.1 Analysis for approximate installation cost per plant

The cost of installation was observed through three parameters: total cost of installation; subsidy provided by institution and self-investment from the biogas households. The detail of cost of material and labour required for constriction and installation of the KVIC model and Deenbandhu model are calculated and presented in table 3.1. The data shows that the total cost of construction and installation of KVIC model was found to ₹ 45841 per plant, which is higher than construction and installation of Deenbandhu model (25618 ₹/plant). The higher cost of construction in KVIC model was additional on the steel gas holder. Based on subsidy policy of Government of India (2011-12), a subsidy of ₹ 9000 per plant was provided for plants of $2m^3$ to $10m^3$ and ₹ 2500 provided by M.P. government through M.P. State Agro Industry-Bhopal in form of Top up. As the subsidy (9000+2500=11500) was provided in terms of construction materials, wage for mason, supervisor etc.

Table 3.1: Cost of construction and installation of KVIC and Deenbandhu model of biogas. (₹/ plant)

S. No.	Cost of components	KVIC model	Deenbandhu model
A.	Civil construction		
1	Bricks	16900	7611
2	Cement	6000	5087
3	Sand	1250	1292
4	Gittee	875	808
5	Bolder	0	366
6	Iron	256	1138
7	AC/PVC Pipe	1220	300
8	Gate valve	250	274
9	Cost of supply line and Pipe fitting	2270	612

10	Burner	1100	1027
11	Steel gas holder with guide frame	7800	0
12	Paint	740	367
	Subtotal (A)	38661 (84.4 %)	18882 (73.7 %)
B.	Labour cost		
1	Digging the pit	1980	2216
2	Construction	2340	902
3	Mason	2860	3618
	Subtotal (B)	7180 (15.6 %)	6736 (26.3 %)
C.	Total cost (A+B)	45841	25618
D	Subsidy	11500 (25 %)	11500 (45 %)
E.	Net cost of installation	34341	14118

After the deduction of subsidy obtained by biogas beneficiaries the cost of construction and installation per plant of KVIC model was found to ₹ 34341 per plant, which is higher than construction and installation of Deenbandhu model (14118 ₹/ plant).

Further, the cost of installation of the Deenbandhu model has come out to be the minimum because the constructional principle of minimization of the surface area has been applied during design and construction of the digester and gas holder (top dome structure) of this model without affecting the functional efficiency. Certainly less material is needed to construction this model, and hence, this is minimum installation cost.

3.1.2 Annual operational cost of biogas

Annual operation cost of biogas plant involves the annual variable charges incurred to run the plant on annual basis along with depreciation and interest on fixed cost known as overhead charges. The total operational cost of biogas per annum was calculated in Table 3.2.

Table 3.2: Operational cost incurred in KVIC and Deenbandhu model. (₹/ plant)

S. No.	Operational cost	KVIC model	Deenbandhu model
A.	Variable cost		
1	Annual maintenance cost	730	352
2	Labour used for feeding the dung	1200	1200
3	Dung feed to the plant	5000	5000
	Total variable cost	6930 (76.7%)	6552 (86.1%)
B.	Overhead charges		
1.	Depreciation on various component parts or investment of the plant	1866	944
2.	Interest on total investment	233	118
	Total Overhead charges	2099 (23.3%)	1062 (13.9%)
C	Total Operational cost (A+B)	9029 (100%)	7614 (100%)

The data shows that the annual operational cost of KVIC model and Deenbandhu model found to varying. The maximum operational cost was found to 9029 ₹/ annum for KVIC model followed by 7614 ₹/ annum for Deenbandhu model. On the other hand, it is found that on calculating the annual operation cost, though the cost of dung as input for corresponding capacities is the same for both the model. The other components of operational cost like maintenance charges and depreciation are found to variation as per the installation cost.

3.2 Comparative benefits of biogas plant

To know the benefits realized by biogas beneficiaries from different model is the main aim of economist. In economic term the return as an income from biogas plants and its net economics is determent of benefits. Taking into these considerations the detail of return (income) and economics of different biogas model is presented as follows.

3.2.1 Income from biogas plant

Table 3.3: Annual incomes obtained from biogas plant. (₹ / plant / annum)

S. No.	Source of income	Unit
1	Annual biogas production (ABP) (m^3)	1460
2	Net quantity available for use (NQA) (m^3)	1168
3	LPG equivalent of net quantity available (LPGE) (kg)	502
4.	Cow dung needed (kg)	36500
5.	Dried slurry available (DSA) (kg)	10950
6.	Income from gas (IFG) (₹)	7282
7.	Income from slurry (IFS) (₹)	2738
	Total Income (TI) IFS+IFG	10020

In study area the family size of biogas plant for both the model (KVIC and Deenbandhu model) i.e. 4m^3 was the popular model. The capacity of biogas preparation is the same; hence, the income from both the model will be same. Hence, the income calculation was made with the formula suggested by (Singh and Sooch (2004)) [4]. If cow dung is use to run a biogas plant, it provides to be a source of double income. Firstly, the biogas produces fuel of appreciable calorific value. Secondly, the residual slurry is a good manure of appreciable nutritional value. It is worth mentioning here that the quantity of residual slurry is the same as that of the cow dung fed in a biogas plant. The LPG equivalent of the biogas produced is calculated by (Singh and Sooch (2004)) [4] for finding the income from biogas. The detail calculation of

the income from a biogas plant from capacity 4m^3 plant are shown in Table 3.3.
Data shows that the biogas plants produced gas as a fuel used for cooking and lighting which provided the income from the same in the worth of 7282 ₹/ annum. The plant also provided slurry as a byproduct which is available for organic manure. The value of slurry was calculated to worth 2738 ₹/ annum. It is concluded that the biogas plant realized total income for biogas beneficiaries to worth Rs.10020 per annum.

3.2.2 Net economics of biogas plant

The economics of a biogas plant involves the calculation of annual profit and payback period for the different models under study. The detail study of net economics of different biogas plants is presented in Table 3.4.

Table 3.4: Annual economics of KVIC and Deenbandhu model of biogas plant. (₹ / plant / annum)

S. No.	Economic trait	KVIC model	Deenbandhu model
1.	Total installation cost	45841	25618
2.	Net installation cost	34341	14118
3.	Actual income	10020	10020
4.	Operational cost	9029	7614
5.	Profit (₹/ annum) (3 - 4)	996	2414

3.2.3 Financial feature

One important point for the popularization of a technology is to examine its economic benefits, known as financial feature. If profitability is higher, a condition for rapid popularization is available. If economic benefit is low, it is difficult to popularize the technology. Same is realized with biogas plant also. The economics of biogas plants depends on whether output in the form of gas and slurry can substitute for fuels, fertilizers or feeds which were previously purchased with money. If so, the resulting cash savings can be used to repay the capital and maintenance costs and the plant has a good chance of being financially viable. However, if the output does not generate a cash inflow, or reduce cash outflow, then plants lose financial viability.
The financial feature may be determine goals to achieve direct economic gain through saving of money through replace the several energy sources with biogas, indirect benefits through improvement in health of women and soil, sanitation and environmental benefits and benefits through improvement in productivity by use of by-product of biogas slurry. The economic features also determine income from biogas plants through its out lay an annual monitory gain

3.2.3.1 Direct saving

Biogas is one of the promising source of alternative energy at house hold and farm level, assumed that a life span of 20 years (East Consult, 2004) [2]. The economic gain may be analyzed included the saving in the form of operationally benefit displace of the use of fuel wood, kerosene, LPG, time saving and replace chemical fertilizers and other resources by use of bio fertilizer. The detail of saving through use of bio-fertilizer gain by beneficiaries is presented in table 3.5. Data on different economic aspects regarding saving through biogas plant in rural area per household per annum was accumulating. Data shows that the production and utilization of biogas are found to be beneficial in many ways for rural household. They have both direct and indirect economic benefits and social benefits. The direct economic benefit of biogas as a fuel, in place of firewood and coal, is a reduction in fuel expenses. Compared with kerosene lamps, biogas lamps not only reduce the cost of fuel, but also increase light level and improve living quality. Compared with direct burning of stalks, biogas produced from biomass fermentation increases the quantity of organic manure which can be sold to production teams, increasing the direct benefit to farmers.

Table 3.5: Economic benefits through saving of different energy sources replaced by biogas. (Annum / household)

S. No.	Source of energy	Saving (₹)	% to total
1.	Fuel wood	5084.00	17.34
2.	Kerosene	660.80	2.25
3.	Chemical fertilizer	1911.00	6.52
4.	LPG	1406.00	4.80
5.	Electricity	0.00	0.00
6.	Time saving	20257.50	69.09
	Total	29319.30	100.00

Data on total direct saving of biogas beneficiaries depicted that the biogas use has contributed in regarding fuel wood consumption, the total resultant annual saving per household was found to ₹ 5084.00 which is 17.34 per cent to annual saving in the use of biogas. Data on total direct saving of biogas beneficiaries depicted that the biogas use has contributed in regarding kerosene consumption, the total resultant annual saving per household was found to ₹ 660.80 which is 2.25 per cent to annual saving in the use of biogas. Data on total direct saving of biogas beneficiaries depicted that the biogas use has contributed in regarding chemical fertilizer consumption, the total resultant annual saving per household was found to ₹ 1911.00 which is 6.52 per cent to annual saving in the use of biogas. Data on total direct saving of biogas beneficiaries depicted that the biogas use has contributed in regarding LPG consumption, the total resultant annual saving per household was found to ₹ 1406.00 which is 4.80 per cent to annual saving in the use of biogas. Data on total direct saving of biogas beneficiaries depicted that the biogas use has contributed in regarding time saving hours/day consumption, the total resultant annual saving per household was found to ₹ 20257.50 which is 69.09 per cent to annual saving in the use of biogas.
In nutshell form the study point of view it is concluded that biogas produced in a small scale biogas plant is an energy source that can be accessed in rural areas. The gas can replace different commercial fuels such as liquefied petroleum gas (LPG) and Kerosene as well as noncommercial fuels such as wood fuel, dried dung cakes and crop residues. Study depicted that the biogas use has contributed the total saving in direct form accounted to ₹ 29319.30 per annum per household.

3.2.3.2 Indirect benefit

Biogas production also has many indirect benefits, which sometimes play a very important role in biogas development. Biogas technology is also potentially useful in the recycling of nutrients back to the soil. Burning non-commercial fuel sources, such as dung and agricultural residues, in countries where they are used as fuel instead of as fertilizer, leads to a severe ecological imbalance, since the nutrients, nitrogen, phosphorus, potassium and micronutrients, are essentially lost from the ecosystem. Biogas production from organic materials not only produces energy, but preserves the nutrients, which can, in some cases, be recycled back to the land in the form of slurry. The organic digested material also acts as a soil conditioner by contributing humus. Fertilizing and conditioning soil can be achieved by simply using the raw manure directly back to the land without fermenting it, but anaerobic digestion produces a better material. Survey method was used to know the response of biogas beneficiaries regarding they realized indirect benefits from biogas or non. The responses of the indirect benefit from biogas plant are determined in table 3.6. The data of study showed that 90.00 per cent of the surveyed biogas households realize benefit regarding soil health improvement through use of biogas and 10.00 per cent of the surveyed biogas households not realize benefit regarding soil health improvement through use of biogas. The data also showed that 94.00 per cent of the surveyed biogas households realize benefit regarding women health improvement through use of biogas and 6.00 per cent of the surveyed biogas households not realize benefit regarding women health improvement through use of biogas.

Table 3.6: Indirect benefit realized by beneficiaries of biogas

S. No.	Source of benefit	Benefit realized		Benefit not realized	
		Frequency	%	Frequency	%
1.	Soil health improve	45	90.00	5	10.00
2.	Women health improve	47	94.00	3	6.00
3.	Sanitation improve	42	84.00	18	36.00
4.	Greenhouse gas reduction	39	78.00	11	22.00

The data also showed that 84.00 per cent of the surveyed biogas households realize benefit regarding sanitation improvement through use of biogas and 36.00 per cent of the surveyed biogas households not realize benefit regarding sanitation improvement through use of biogas. The data also showed that 78.00 per cent of the surveyed biogas households realize benefit regarding greenhouse gas reduction through use of biogas and 22.00 per cent of the surveyed biogas households not realize benefit regarding greenhouse gas reduction through use of biogas.

4. Conclusion

Based on study survey it is clear that the NBMMP delivers improved energy service out comes to a majority of households in Sehore where biogas units have been installed. The use of biogas for cooking and heating water provides household monetary savings in the cost of fuel wood to power biomass stoves as well as forest conservation benefits, improved indoor air quality and associated health benefits which are particularly notable for women and children who regularly spend hours in kitchen areas close to polluting cook stoves. Despite the apparent success of the scheme, there is much that could be done to improve its impact and uptake. The total cost of construction and installation of KVIC model and Deenbandhu model was found to 45841 ₹/ plant and 25618 ₹/ plant respectively. The profit from the KVIC and Deenbandhu model were 996 ₹/annum/plant and 2414 ₹/annum/plant. The top-down approach to developing policy enables government to set targets and require individual states to roll-out the scheme which benefits households able to afford to participate.

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