Renewable Energy 96 (2016) 1111–1118

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

The role of subsidy in ensuring the sustainability of small-scale anaerobic digesters in Odisha, India

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ARTICLE INFO

Article history:
Received 30 November 2015
Received in revised form
17 March 2016
Accepted 19 March 2016
Available online 27 March 2016

Keywords:
Biogas
Cost-benefit analysis
Manure
Dairy
Smallholder
Sustainability

ABSTRACT

Small-scale anaerobic digester installation has been a development objective of the Indian government to provide rural households clean fuel. Anaerobic digester installation is heavily subsidised. Depending on caste, the rate of subsidy offered for the smallest system available (1 m^3) varies between 32.35% and 41.18% of the total installation price. Yet, there are gaps in knowledge regarding the usefulness of such subsidies from a sustainability perspective. A cost-benefit analysis was conducted to evaluate the circumstances required for digester sustainability. The analysis used household data collected from 115 cattle owning households in Odisha, India to evaluate profitability at three levels of subsidy (none, General caste subsidy, and Schedule Caste/Schedule Tribe subsidy). Additional analyses considered the effect of; taking a loan, replacing electric lighting with biogas lighting, and the wealth level of the household. The results indicated that access to subsidy improved profitability. Yet, profitability could be achieved without the use of subsidy. The level of benefit accrued by households was similar independent of wealth. However, the provision of subsidy was essential for ensuring profitability for those households required to take a loan to meet the expense of installation. Such findings highlight the importance of subsidy as a means of including the poor.

1. Introduction

The Indian dairy sector is one of the largest in the world composed of approximately 44.5 million milking cows [1]. However, the sector is characterized by animals with low levels of milk production. National average milk production is 2.36 kg/cow/day for indigenous and 7.02 kg/cow/day for crossbred cows [1]. Levels of milk production differ between states. For example, in the state of Odisha average milk production levels are lower with an average of 1.47 kg/day for indigenous and 6.15 kg/day for crossbred cows [1].

The Indian dairy sector is primarily reliant on smallholder producers. Approximately 83% of India's 137 million agricultural land holders own less than 2 ha, with that number estimated to be increasing by 1.7 million per year [2]. These smallholders are responsible for 70% of India's bovine population [2]. However, the level of dairy development and involvement in dairy production is seen to differ between the states.

Odisha is amongst the poorest performing states in terms of dairy development. Odisha's milking herd remains dominated (81.13% of total population) by large numbers of indigenous cows, the per capita milk availability (114 g/day) remains well below the national average (299 g/day), and the state only achieved 86% of its milk production target for the period 2012–2013 [1]. Thus, despite being home to 3.87% of India's milking cow population, the state only supplies 2.47% of the nation's milk [1]. Such poor performance becomes particularly poignant as Odisha has some of the highest rates of poverty in India. In 2011–2012, it was estimated that 35.69% of Odisha's 12.61 million rural households were below the poverty line [1]. The average rate of rural poverty across India is estimated to be 25.7% [1].

The installation of anaerobic digesters throughout rural Odisha offers the opportunity to capitalise on the large numbers of cattle and improve the livelihoods of the poorest members of Indian society. Under the National Biogas & Manure Management Program (NBMMP), the installation of smallscale anaerobic digesters attempts to; provide clean gas for cooking, reduce labour

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http://dx.doi.org/10.1016/j.renene.2016.03.064

requirements for women (via a reduced need to collect firewood), improve sanitation, reduce the requirement for purchased inorganic fertilizers, and generally combat climate change via a reduction in CO_2 and CH_4 emissions from the burning of firewood [3].

The Government of India has a long-history (approximately 30 years) of supporting anaerobic digester installation. Government documents noted that by mid-2011, 4.5 million family anaerobic digester systems had been installed with a target of 5.6 million by the end of 2017 [4]. While by 2022, government estimates indicate that the number of constructed anaerobic digesters will surpass 6.5 million [4]. In Odisha, according to official figures a total of 225,725 systems were installed from 1984 to 2013 [5] with a further 7100 to be installed during 2014–2015 [3]. It is estimated Odisha has the potential for 605,000 smallscale anaerobic digesters [6].

The cost of installation of a biogas digester system is viewed as the greatest obstacle to the widespread usage of the technology [7–10]. The cost of installation is expected to vary with location and system size [11–14]. The 3 main designs of digesters are the; fixed dome, floating dome and bag type. Sizes range from 1 m^3 to 6 m^3 [3]. The fixed dome Deenbandhu design is the most popular design in India as it can be built with locally available materials [15,16]. The most commonly installed size in Odisha is 2 m^3 [6]. Government documents indicate the average price of a 2 m^3 system to be Rs. 17,000 [11].

Due to the requirement for a large capital investment the Indian government subsidizes installation cost [3]. The rate of subsidy offered to households is caste based with the Schedule Caste/Scheduled Tribes (SC/STs) receiving higher rates of subsidy [3]. This is expected to reduce the importance of capital investment as an adoption barrier amongst the poorer sections of society.

Existing cost-benefit analyses of anaerobic digester installation in India tend to present a comparable narrative regarding the profitability of the digester installation. Estimates of payback period for a 1 m^3 Deenbandhu system include; 3.21 [12] – 4.70 years with subsidy [17], and 4.07 years without subsidy [12]. Yet, the differing assumptions which underpin the analyses limit comparability. For example, the labour saved from firewood collection is often not included in analyses [12,17].

Examination of existing analyses also highlights significant gaps in knowledge, particularly regarding sustainability. Sustainability is the ability to maintain system performance over time without damaging the integrity of the system [18]. In terms of anaerobic digester installation, sustainability is the long-term functionality and usefulness of the system without causing any negative impact on the household. A number of authors cite the variable and often high rates of non-functionality (up to 40%) as an indicator of poor sustainability [13,15,19]. However, it could be argued that the financial benefits and profitability determined by cost-benefit analyses [12,17,20] may be perceived by the household as being insufficient grounds to warrant further investment in the technology (i.e. repairs). For example, Riek et al. [20], demonstrated that the labour saved from collecting firewood was a key determinant of profitability. Yet, this labour is primarily provided by women. Gender roles dictate that women's labour will be considered of low value [13] by male members of the household who would likely decide whether to further invest in the digester.

Alternatively, the rates of non-functionality may be an artefact of government provided subsidies which attempt to improve participation of the poor. The continued use of subsidies (over a 30 year period) could indicate the intervention is not demand-driven [21–23]. The lack of long-term sustainability may be a function of the top-down implementation approach [13] indicative of an ineffective intervention. However, analyses of anaerobic digester installation have not evaluated the technology from a sustainability perspective. Rather, only an absence and/or presence of subsidy has been examined [12,17,20].

Therefore, in the following study, the overall sustainability of anaerobic digesters on small-scale dairy producers residing in Odisha India will be explored. The costs and benefits of the systems will be analysed across three different subsidy levels (none, General caste subsidy, and SC/ST subsidy). In total, 115 small-scale dairy producing households participated in the study across Puri (n = 31) and Khurda (n = 84) districts in Odisha, India.

2. Materials and methods

2.1. Sampling and data collection

Villages were randomly selected within high potential dairying areas characterized by sufficient water, market access, and relatively reliable animal health infrastructure. Villages are peri-urban due to their close proximity (<40 kms straight-line distance) to the State capital Bhubaneswar. Cattle owning households were identified during key informant interviews with village leaders. One hundred and fifteen cattle owning households were purposively sampled from Puri (n = 31) and Khurda (n = 84) districts. The survey was conducted in the local language (Oriya). Responses were translated into English at the time of the interview. A voice recorder ensured all interviews were recorded verbatim. Interviews were transcribed into Microsoft Access 2010.

2.1.1. Household characteristics

Collected data included; demographic information, utility (electricity, water) access, household income and expenditure. Household income included; milk sales, dung sales, wage labour, remittances, crop sales, land rentals and livestock sales. Household expenditure included; animal healthcare, livestock feed, agricultural inputs (such as; fertilizers, labour, pesticides etc.), human food, electricity, human healthcare, and education.

2.1.2. Herd characteristics

Only cattle aged >1 year old were included in the inventory of cattle holdings for each household. Total manure production was determined from feeding strategies (via Volatile Solid (VS) calculation). Feedipedia [24] was used to determine the nutritional value of identified feeds. VS was determined with the use of IPCC [25] protocols. Eq. (1) (below) was created to describe the relationship between the variables. The maximum methane producing capacity (B_o) was assumed to be 0.13 m^3 CH_4/kg VS [25]. It was assumed that the methane concentration of biogas was 60% [26–28] and 0.04 m^3 of biogas was produced per kg of cow manure [14,17,29].

Eq. (1): The equation used to determine the total quantity of manure produced by cattle aged >1 year in Odisha, India.

$$TM_{cow_n} = \frac{\left[(VS*B_o)*\left(\frac{100}{methane\ concentration}\right)\right]}{Biogas\ yield} \tag{1}$$

TM_{cow_n} = Total Manure (kg) produced by an individual cow_n per day

VS = daily volatile solid content of cattle manure, kg per cow per day

B_o = maximum methane producing capacity for manure produced by Indian cattle, 0.13 m^3 CH_4 per kg of VS excreted [25]

Methane concentration = the concentration of methane in biogas, 60% of total biogas produced [26–28]