



Evaluating benefits of low-cost household digesters for rural Andean communities

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ABSTRACT

Low-cost household digesters are a promising appropriate technology which can help reducing the pressure on the environment due to deforestation and greenhouse gases emissions. The biogas and biofertilizer produced can alleviate poverty, by improving health conditions, increasing crops productivity and saving working time and burden for women and children. The aim of this study is to evaluate low-cost digesters technical, environmental and socio-economic impacts in rural communities of the Peruvian Andes, where a pilot project was developed during the last 3 years. Although the benefits are restricted by the performance of anaerobic digestion at high altitude, the results show that the digesters improve household living conditions and economy, while reducing environmental impacts. Biogas production covers around 60% of fuel needs for cooking, leading to 50–60% decrease in firewood consumption (i.e. deforestation) and greenhouse gases emissions; the annual income is increased by 3–5.5% due to fertilizer savings and potato sales. These values could be improved by enhancing digesters performance and the sustainability of the technology.

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1. Introduction

During the last decade there has been a greater concern than ever for sustainable development, which is changing the way international development aid is provided [1]. As expressed by the Millennium Development Goals, the aim is to make aid more effective in supporting progress and meeting the needs of the poor [1]. International development agencies stated that the guiding principles behind a new policy for successful development cooperation include [1–3]: (i) ownership by developing countries of their own development process; (ii) increased attention and priority to the social dimension and poverty reduction; (iii) ensuring sustainability of effect. To improve the chances of success, attention needs to be placed on some of the common areas of weakness in programmes and projects. Three main areas are identified consistently [3]: (i) planning and project formulation; (ii) stakeholders involvement; (iii) monitoring and evaluating programmes and projects.

This paper is focused on the evaluation of a project. By definition, evaluation aims to make an assessment, as systematic and objective as possible, of an ongoing or completed project, programme or policy [2]. Generally, evaluation tries to determine the relevance and fulfilment of objectives, developmental efficiency, effectiveness, impact and sustainability. Evaluation, like monitoring, can apply to many things, including an activity, project, programme, strategy, policy, topic, theme, sector or organization.

The project evaluated in this study deals with the implementation of low-cost household digesters in rural communities of the Peruvian Andes. A low-cost household digester is a “modern” appropriate technology to improve the traditional energy use of biomass resources in developing countries [4], where 28% of the population lack access to electricity and 56% still rely on solid fuels, traditional biomass and coal [5]. Apart from capturing methane, a greenhouse gas (GHG) 21 times more powerful than carbon dioxide, household digesters are also believed to provide social and economic benefits, like poverty alleviation, indoors environment improvement, crop productivity increase, workload reduction for women and children [5–10].

Up to date, only a few studies have been carried out to assess household digesters advantages. Arthur et al. [5] presented the status of biogas technology and its potential benefits in Ghana. Their qualitative analysis showed that the benefits (e.g.: environmental sustainability, improved health, increase in agricultural productivity) could be significant; although financial activities and subsidies should be introduced at the initial stage. Yu et al. [11] estimated the environmental benefits of small scale household digesters in rural China, by determining GHG emissions reduction. The study highlighted that biogas, as a renewable clean fuel, had reduced $45.59 \times 10^6 \text{ tCO}_{2\text{eq}} \text{ year}^{-1}$ from 1991 to 2005 in rural China. Bhat-tacharya and Salam [12] compared the GHG emission factor of biogas combustion to that of firewood, agriculture residue and charcoal in Asian countries. This study showed that the emissions generated by using firewood and improved cookstoves are around 8 times higher than biogas. Van Groenendaal and Gehua [10] carried out a survey to assess the increase of family's income in rural China thanks to the digester implementation, by evaluating the reduction of expenditure on fuels and fertilizer. This study suggested that low-cost household digesters are mainly seen as a renewable energy technology, and that its benefits as a technology to produce fertilizer are insufficiently appreciated. Katuwal and Bohara [8] carried out a survey in rural communities of Nepal, concluding that family-size digesters considerably improve households living quality, because they reduce the firewood consumption by 54% and save 1.56 h day^{-1} on firewood collection.

In this context, systematic studies which quantify altogether technical, environmental and socio-economic benefits of household digesters are still missing. Moreover, most of the studies have

been carried out in Asian countries, where socio-economic conditions are different from Latin America, and where brick masonry digesters have been mainly implemented. The adaptation of low-cost tubular digesters to the Andes is a new issue that dates back only 4 years ago [13–15]. For this reason, the quantification of technical, social, economic and environmental impacts in rural households is of great interest for Non-Governmental Organizations (NGOs) and other aid and financial entities.

The aim of this study is to assess and quantify technical, environmental and socio-economic benefits of low-cost household tubular digesters implemented in rural communities of the Peruvian Andes. To this end, during 2009–2010, 12 digesters were monitored and their benefits quantified.

2. Project description and evaluation

2.1. Project description

In the Department of Cajamarca, located at the Northern region of the Peruvian Andes, around 50% of the population lives in rural areas [16], with an economy based on self sufficient agriculture and farming. The main crops are potatoes and sweet corn, while the main livestock are cows, guinea pigs and llamas. In most cases, there is still a lack of basic services such as potable water or electricity. Biomass consumption, including firewood and air-dried cattle dung, accounts for 65–75% of the total fuel consumption for cooking [16]. Improved cookstoves or smoke control systems are generally missing, generating indoor air pollution (especially particulate matter) and unhealthy environments [17,18].

In 2007 local and international NGOs (Practical Action from Peru, Engineers without Borders from Spain and Green Empowerment from USA) together with research institutions (Technical University of Catalonia) started a pilot project dealing with the implementation of low-cost tubular digesters adapted to Andean Plateau [13]. The project involved 12 households in rural communities of Cajamarca, located at 3300 m.a.s.l. At the same time, a pilot plant was implemented and monitored in the National Institute for Agricultural Innovation (INIA) (Cajamarca) with the aim of characterizing digesters operation and biogas production at high altitude [13,19].

The main purpose of the project was to improve the living quality of rural families, by providing a clean fuel which can substitute traditional biomass. The project also aimed to: preserve the environment by reducing GHG emissions and deforestation; decrease family's expenses for fuel or fertilizer; and reduce the workload and time spent by women and children for wood collection. Beneficiaries belonged to associations already involved in previous projects of the involved NGOs. They had to meet the following criteria: low income, availability of cattle dung and lack of improved cookstoves. Beneficiaries and technical staff collaborated during biogas systems implementation. Local organizations also organized workshops to build the capacity of stakeholders for the implementation, management and maintenance of the technology. The pilot project was completely financed by development aid funds and the cost of each biogas plant (including the PVC tubular bag, biogas storage and cook-stove) was estimated around \$400 per family.

2.2. Project evaluation

Evaluation science is very wide and there are a number of tools that can be used to assess a project. Due to the scarcity of resources and logistics, the method used in this study is “planned vs. actual”, which aims to analyze the achievement of the objectives established in a project [2]. The simplicity of this method allows transferring evaluation results to all stakeholders ensuring a participatory approach. It consists of comparing what was

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