Final Project Report

Food security in relation to household energy management in rural Ethiopia

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1. Summary

Energy scarcity in developing countries has a negative impact on food security, especially in rural areas. Increased use of biomass (wood, dung, crop residues, etc.) causes degradation of agricultural areas and reduces food production. Furthermore, especially women and children which spend lots of time in the house and close to the cooking site are exposed to noxious emissions. Eventually, family incomes decrease due to rise in fuel prices and the increased efforts to acquire sufficient fuel.

The study analyses the above problem for the case of Ethiopia from different perspectives: energy efficiency, soil fertility and food production, health effects of emissions, as well as the economic aspects thereof.

The study has two main objectives:

1. A comparison of the main energy sources (fuel, wood and dung) with respect to plant nutrient contents and the according effects of their use as fuel on the agricultural productivity and therefore food production, calorific value of the fuels, emissions of noxious and greenhouse relevant gases during combustion and eventually economic costs and benefits, whereby opportunity costs during the use (e.g. due to nutrient export) and the acquisition (e.g. market prices, opportunity cost of labour for gathering fuel) are considered.
2. An economic analysis of the implementation of biogas technologies and the availability of biogas plants as possible effective alternatives to traditional energy sources under the above mentioned aspects.

A field visit was carried out during April and May 2010 in Ethiopia. There, we examined the traditional fuels, firewood and dried cow dung, in comparison to the improved energy source, biogas. The field study employed household surveys, market surveys and stove tests to gather information on rural household's energy management in two Ethiopian districts, Dale and Arsi Negele. In addition, biogas plants were visited in Meskan district. Samples of dung, slurry and ash were taken at all sites for further analysis in the laboratory.

Survey results show that households in rural areas largely collect their own fuel, with female household members aged between 18 and 59 being mainly responsible for energy source collection. The same group has a significant contribution to crop production, namely fertiliser application and weeding. The time spent in collecting energy sources therefore carries opportunity costs in alternative contribution to farm production and hence food security. Yet, due to low productivity in agriculture as a result of capital constraints leading to low fertiliser usage and limited off-farm opportunities, own collected energy sources remain economical for the majority in rural areas. However, households stand to benefit through the use of slurry as fertiliser, energy expenditure savings and time savings by investing in biogas plants.

Biogas utilisation from the technical side of view proves double beneficial, as energy sources as well as a source for cost effective fertilizer. As energy source it features a similar calorific value as firewood but has the advantage of being more time efficient, especially in areas with wood scarcity. Far travels for fuel collection are eliminated since the cattle necessary for the production of biogas mostly are kept close to the household. Compared to cow dung as fuel, biogas has a

much higher calorific value and counts as "cleaner fuel". Further, biogas is a weather independent fuel which does not require time for drying.

Slurry gained from biogas production can be used in different ways. Chemical analyses exposed similar characteristics as fresh dung. Therefore its application as fertilizer is possible as well as drying and use as additional fuel for cooking. Economical benefit could be gained from the slurry by creating a market where it could be sold as fertilizer or fuel whereby the use as fertilizer would be more beneficial. Stove tests showed that dung as fuel only delivers satisfying results in combination with more efficient fuels like firewood, branches and leaves.

Nonetheless, biogas presents the best alternative energy source for cooking. Heating times are shorter and fuel consumption lower than during wood combustion. Even, biogas consumption could be reduced significantly by proper operation of the stove.

Field tests showed the same results as high flame tests in the laboratory. Low flame tests in the laboratory resulted in longer heating times but also in much lower gas consumption and higher thermal efficiency of the stove. Introducing a simple but better regulation system to control the amount of biogas to be used for cooking appears to be crucial to reach the aim of an efficient, gas saving cooking system.

Proper operation of the stove has a significant effect on emissions produced during incomplete combustion as well. Tests in Hohenheim demonstrated the importance of primary air entering the stove at the mixing tube through a closable hole for the combustion process of biogas. Closing the hole increased CO and CH emissions considerably.

Modification of those mixing tubes by adding two additional holes near the venturi valve reduced CO and CH emissions up to 60% and 75% respectively. Yet, improvement in thermal efficiency could not be found.

A Cost Benefit Analysis of biogas plants yields positive net present values for households collecting their own energy sources. Even higher values are obtained for households purchasing all their energy sources. Results are highly dependent on slurry being effectively used as a source of fertiliser and on the price of replaced energy source. Thus promotion of slurry use as fertiliser remains an integral part of the biogas programme. The potential of the biogas programme could be further exploited if current efforts to develop a stove that support *injera* baking come to fruition and an appropriate credit scheme is availed to potential biogas clients. Another option would be to develop gas storage and distribution systems to bridge peak and trough seasons and sell surpluses.

Overall, the study shows a close relationship between agricultural production, food security and energy management. The presently low opportunity costs of traditional energy collection and the resulting low incentives for biogas production and use could be offset by increasing agricultural productivity, both through standard productivity improvement like access to inputs and improved commercialisation, but also through innovative approaches like using the side products of biogas, slurry, for food crop fertilisation. Linking these two aspects should render food production more effective and at the same time set incentives for a more cost, emission and health efficient energy management.