Universiteit Antwerpen

Faculteit Politieke en Sociale Wetenschappen

The Social and Economic Impact of Biogas on Smallholders

Case-Study in Andhra Pradesh, India

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Masterproef voorgelegd met het oog op het behalen
van de graad van Master na Master Internationale
Betrekkingen en Diplomatie

Jan Beyne

Juni 2013

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List of abbreviations

BRGF	Backward Regions Grant Fund Program
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFC	Chlorofluorocarbon
DOE	Designated Official Entities
EC	European Commission
ER	Emission Reduction
EU	European Union
FCN	Fair Climate Network
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSDP	Gross State Domestic Product (India)
HFC	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
JCB	Engineering Vehicle
JI	Joint Implementation
LCF	Low Carbon Farming
MPCE	Monthly Per Capita Expenditure
NGO	Non-Governmental Organization
PDD	Project Design Document
RET	Renewable Energy Technology
Rs	The official currency of the Republic of India (Rupee)
SEDS	Social Education and Development Society
SSN	Société Suisse de Nutrition
STATA	Data Analysis and Statistical Software for Professionals
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
VER	Verified Emission Reduction
VLV	Village Level Volunteers
WHO	World Health Organization
WWF	World Wildlife Fund

Acknowledgement

I have been provided with lots of supports and suggestions by many people in the process of completing this thesis. In the first place I want to thank SEDS (Social Education and Development Society) for welcoming me to their NGO and supporting me in my research in India. This was only possible thanks to Rajen Joshua and Manil J. Jayasena, who founded the NGO. I want to thank them for their hospitality and friendship.

Many thanks go to Nagabushana, M. Hussein, Ashwartappa, M. Govindappa, Rathnamma, Pakkirappa, Hanumantha Rayudu and Shaik Basha for helping me with interviewing the farmers during the survey. Thanks also to the drivers Shankar, C. Reddy, Srinivas and Saifulla for guiding me to various research locations within the district.

Especially I am grateful to all farmers (biogas and non-biogas users) for showing interest in the research and patiently answering the questions. Without the help and cooperation of these people, this research would not have been possible.

Also I thank Kasi Viswanath Rao, Rabbani and P. Nagamani for translating the questionnaire from English into Telugu.

Many thanks go to Raj Kumar, Filip Tetaert and the FCN (Fair Climate Network) for the innovative ideas on improving the questionnaire and conducting the survey.

This Master thesis is submitted in order to fulfil the requirements under the International Relations and Diplomacy Master programme. I would like to express special gratitude to Prof. Dr. Danny Cassimon as my supervisor and Martin Prowse for providing me with the initial idea for this study. Also I thank Dennis Essers for the support on the statistical analysis and Sarah Clarke for the checking of the vocabulary and spelling.

Last but not the least, I am grateful to all my family members for their full encouragement and support to make this thesis successful. They have continuously supported me throughout my academic pursuits and have provided me with constant stimulation and love enabling me to complete my Master’s degree to the best of my ability.

Executive summary

This Master thesis investigates a biogas project carried out by the NGO Social Education and Development Society (SEDS) in the district of Anantapur, India. The project approach and the resulting socio-economic effects of biogas on the rural population are explored, assessed and statistically analyzed in detail. In order to answer my main research question '*What is the social and economic impact of biogas on smallholders',* I constructed questionnaires that cover and explore the social, economic and environmental impacts of this Clean Development Mechanism (CDM) project.

In chapter 1 of this thesis, I will explain the emergence of environmental policy as a new policy field, climate change negotiations and how the world is reacting to climate change. Secondly, I will explain the most important features of the Kyoto Protocol.

In chapter 2, I define sustainable development and clarify the particulars of the CDM, and how biogas technology works. Thereby, I will focus on the social and economic impact of a CDM biogas project. I will explain how the co-benefits of biogas projects are based around the three pillars of sustainable development. In the explanation of these benefits, especially the environmental benefits, it is clear that the biogas program is an agricultural development program which centres around people and their surroundings. Therefore, I describe the importance of agriculture as a vital development tool.

In chapter 3, I develop some hypotheses focusing on the social, economic and environmental improvements related to biogas, which have ensued from literature. I discuss the positive environmental effects, health improvement, social development, economic well-being, and other consequences of the CDM project.

In chapter 4, I explain the case-study that is utilised to answer my research question. I commence with a description of NGO's in India, and the specific NGO involved in the case-study. In 4.2, I bring out a geographic description of the project area. Furthermore, I explain the CDM project description. In 4.4, I define the methodology I have used and highlight any problems and limitations of the study before starting the objectives and criteria of my research selection.

In chapter 5, I present the results from the statistical analysis. I make a descriptive analysis with means, frequencies, t-tests and percentages in order to test the hypotheses I made in the previous chapters.

Finally, in the conclusion, I reflect to the research question, the main conclusions of the research, and a number of constraints of this study.

Introduction

We have reached a critical point. The scientific community has accepted that climate change is a real threat to our livelihood. Especially in developing countries like India, where the livelihoods of many people depend on the environment and where ultimately climate change could have fatal consequences. This present risk is partly attributed to an increase in atmospheric greenhouse gases, such as carbon dioxide, caused by human activity. To reverse this threat will require many arrows in the quiver. Foremost, a large scale reduction of greenhouse gas (GHG) emissions (i.e. carbon dioxide and methane etc.) will be required. The farming sector, which currently accounts for 14% of global GHGs, offers significant opportunities for carbon sequestration and emission reductions. Farmers can remove carbon dioxide from the atmosphere and sequester it as soil carbon by changing tillage practices. They can also modify agricultural practices to reduce GHGs such as methane and nitrous oxide. More specifically, in India, farming contributes to 28% of the national GHG emissions. In addition to farming, afforestation or the planting of trees can absorb large volumes of carbon dioxide from the atmosphere. The main obstacle, however, is that communities have been conducting their livelihoods/farming practices in a particular way for centuries and are not open to large scale change (Willy & Chameides, 2007).

In this investigation I will focus on the impact of one specific technique in rural India used to reduce GHG emissions: Clean Development Mechanism (CDM). This biogas technology can be an important contribution, in many different ways, to a farmers' own development objectives. It enables farmers to substitute inputs, such as fertilizers, household and engine fuels, by biogas slurry and biogas itself. A biogas system can relieve farmers from labour and time formerly spent on dung disposal or dung application to their fields and, moreover, improved farmyard manure may raise the yields of plant production. In addition, using biogas instead of wood for cooking the quality of life and living standards for the whole family can improve. In terms of climate change, the utilization of biogas can have a substantially favorable impact on the GHG balance and if farmers can be compensated for their actions to reduce emissions through the CDM under the Kyoto Protocol, a win-win situation ensues for all parties.

The measurement and analysis of socio-economic development and impact is one of the major themes of development literature. The study of social indicators has contributed to the evolution of a framework for social indicator analysis and a better understanding of the development process. While economic parameters such as GDP, per capita income and growth rate of GDP have been impressive in the Indian context since independence in 1947, the progression of Indian society regarding social indicators, such as literacy, nutritional status, incidence of poverty, and infant mortality rate, has been far from encouraging. The reasons identified for such low levels of social development have been inadequacy of social infrastructure and lack of access to basic amenities, particularly among the socially and economically disadvantaged (Shariff, 2001).

By performing a case study based investigation, I have tried to tackle the question: "***What is the social and economic impact of biogas on the smallholders in the Anantapur district, India?"*** To formulate and critique strategies for human development, their effect on various strata of communities and different profiles of the community need to be analysed and this is what the investigation has set out to achieve. This study is an attempt in that direction. It presents the relationship between a new development technique, such as CDM, and its varying social-economic impacts on smallholders within a particular community within rural India.

This thesis examines, in an indirect way, the impact of globalization and the Kyoto-protocol on the local population in India. Although India believes in maintaining the current stark division where only countries labeled as "developed" have to reduce their greenhouse gas emissions, many organizations and NGO's within this country are trying to make use of the market-based mechanisms of the Kyoto Protocol. For this research I have worked for six months at the NGO SEDS (Social Education and Development Society) in Andhra Pradesh, India. I participated in their CDM project, which helps stimulate green investment and development and helps parties meet their emission targets in a cost-effective and a socially beneficial way.

1 Environmental policy

Our climate system is extremely complex and consists of a vast array of atmospheric and oceanic circulations and currents which are sensitive to fluxes within the atmosphere. An increase in our industrial, agricultural and energy practises over the last 150 years has contributed to a build-up of GHGs in the atmosphere. These gases are primarily responsible for global warming and ozone depletion and are having a profound, often little understood, effect on the atmospheric and oceanic systems previously mentioned. The days of 'dump it in your own backyard' are over, as we realise that there is only one big planetary backyard and with the globalisation of our planet this analogy will only become ever more relevant and applicable.

1.1 The greenhouse effect

Global warming and climate change refer to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in GHGs. The Earth's atmosphere is a gaseous envelope which surrounds the planet and revolves with it. The atmosphere is nearly uniform up to approximately 80 km above Earth's surface. The main constituents of the atmosphere are oxygen (21%), nitrogen (78%), and argon (0.93%). The energy from the sun drives the earth's weather and climate, and heats the earth's surface and in turn, the earth radiates energy back into space. Some atmospheric gases (water vapor, methane, nitrous oxide, carbon dioxide, and other gases) however trap some of the outgoing energy, retaining heat and enabling the earth to be inhabitable, somewhat like the glass panels of a greenhouse. These gases are therefore known as GHGs (Nordhaus, 1994).

The problem, however, we are currently faced with is the enhancement of the greenhouse effect, leading to global warming. This enhanced greenhouse effect has been caused by the addition of huge volumes of greenhouse gases into the atmosphere throughout the industrial age. To improve our understanding, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 under the wing of the United Nations Environment Programme and the World Meteorological Organization. The work of the IPCC represented the most complicated and comprehensive scientific investigation of the United Nations system in its half century of existence. The IPCC concluded, in the 1990 final report of its working group 1, that human activities have substantially increased the atmospheric concentrations of carbon dioxide, methane, nitrous oxide and chlorofluorocarbon (CFCs), and that these increases will continue to enhance the greenhouse effect, resulting in a warming of the earth's average surface temperature. The IPCC predicted an increase of one degree Celsius in the global average temperature every year if GHG emissions were not subjected to controls (IPCC, 1990). Due to these findings it can be said that human induced change to the earth's climate is one of the greatest challenges confronting the international community today (Breidenich, 1998).

1.1.1 Climate change negotiations

Climate change is becoming an increasingly important issue in our lives. Confronting the overall challenges of climate change, global warming, ozone depletion, biodiversity loss, deforestation, and air and water pollution - to name but a few - requires real commitment and effective cooperation at an international level. The EU is recognized as an important proponent of international action concerning the environment and has been engaged in the promotion of sustainable development worldwide. Since 1997, environmental integration is a requirement under the EC Treaty. This means that environmental concerns are fully considered in the decisions and activities of all other sectors. As an active participant in the development and implementation of multilateral environmental agreements and other environmental negotiations and processes, the EU's constructive position has on several occasions proved crucial to ensuring progress. For instance, the EU was widely praised for bringing about the successful conclusion of negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), in particular the adoption of the Kyoto Protocol, and more recently for being a leading player at the 2011 World Top in Durban (European Commission, 2011).

The proposed deal in Durban would see the EU extend its commitments to reduce GHG emissions under the 1997 Kyoto Protocol, but only if all other countries agree to negotiate a new treaty with legally binding obligations by all countries, not just the wealthy Kyoto group. The EU plan sets a 2015 target date for a new deal that would impose binding cuts on the world's biggest emitters of the heat-trapping gases (i.e. GHGs), a pact that would come into force up to five years later (Boyle 2011). At the World Top in South Africa, the European Union tried to forge a coalition of the willing behind its plan in order to put pressure on the world's top three carbon emitters, namely China, the United States and India, to sign up. None of which signed up and therefore are not bound by the Kyoto Protocol; the only global pact that enforces carbon cuts. But the US says it will only pledge binding cuts if all major polluters make comparable commitments. China and India on the other hand say it would be unfair to demand they make the same level of cuts as the developed world, which caused most of the pollution during the twentieth century which is now responsible for global warming (The Guardian, 2011).

Time is running out to achieve change. UN reports show a warming planet with increased crop failures, droughts, floods and a rise in sea levels. Countries like the US, China and India have to commit to the EU roadmap if we want to do something about climate change. The world leading countries are good in making political agreements, with states promising to start talks on new regimes of binding cuts to greenhouse gases, but those talks won't prevent global warming (Hedegaard, 2011). Ever since 2009's disappointing Copenhagen climate summit, the 194-nation UN members have remained indecisive on a climate deal. Currently, only industrial countries have legally binding emissions goals under the 1997 Kyoto Protocol. Those commitments were due to expire in 2012, but will now be extended at least another 5 years under the new accord adopted in Durban. It is time to take action. Governments should have a responsibility to educate both the public and industry about the hazards. It becomes increasingly clear that the world needs one group with one protocol; a system that reflects the reality of today's mutually interdependent world (Economic Times & the Guardian, 2011).

1.2 Kyoto Protocol

According to the United Nations Environment Programme (UNEP), the Kyoto Protocol is an agreement under which industrialized countries will reduce their collective emissions of GHGs by 5.2% compared to the year 1990 over the five-year period (2008-2012). It is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC). The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European Community. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of 'common but differentiated responsibilities'. The EU takes the third place, after China and the US, with a percentage of 11% of the total GHG emissions and India takes the fifth place with 5%. India signed the Kyoto protocol on 26th August 2002 (UNEP, 1997).

The treaty was negotiated in Kyoto, Japan in December 1997 and the agreement came into force on February 16, 2005. As of May 2009, a total of 184 countries and other governmental entities have ratified the agreement. At its heart, the Kyoto Protocol establishes the following principles:

- Governments are separated into two general categories: developed countries, referred to as Annex I countries (who have accepted GHG emission reduction obligations and must submit an annual GHG inventory); and developing countries, referred to as Non-Annex I countries (who have no GHG emission reduction obligations but may participate in the Clean Development Mechanism);

- As of January 2008, and running through 2012, Annex I countries had to reduce their GHG emissions by a collective average of 5% below their 1990 levels. The Kyoto Protocol includes "flexible mechanisms" which allow Annex I economies to meet their GHG emission reduction by purchasing GHG emission credits (i.e. carbon trading) from elsewhere. These can be bought either from financial exchanges, from projects which reduce emissions in non-Annex I economies under the Clean Development Mechanism (CDM), from other Annex 1 countries under the Joint Implementation (JI), or from Annex I countries with excess allowances. Only CDM Executive Board-accredited Certified Emission Reductions (CER) can be bought and sold in this manner. Under the guidance of the UN, Kyoto established this Bonn-based Clean Development Mechanism Executive Board to assess and approve projects ("CDM Projects") in Non-Annex I economies prior to awarding CERs.

The final goal of the Kyoto Protocol is to lower overall emissions of six GHGs - Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydro fluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6) (UNEP, 1997).

2 Sustainable Development: CDM

The Clean Development Mechanism (CDM) is designed with the dual aim of assisting developing countries in achieving sustainable development and of assisting industrialised countries in achieving compliance with their GHG emission reduction commitments. The sustainable development dimension is often seen as a main driver for developing countries to participate in CDM projects. Apart from just GHG emission reductions, CDM projects will have a number of positive impacts in the host countries, including impacts on economic and social development and on the local environment. Furthermore, CDM brings important *co-benefits*, such as poverty reduction, access to energy efficient lighting and cooking, improvement of air quality and living conditions, reduction of costs and generation of jobs and skills (Eco Securities, 2002).

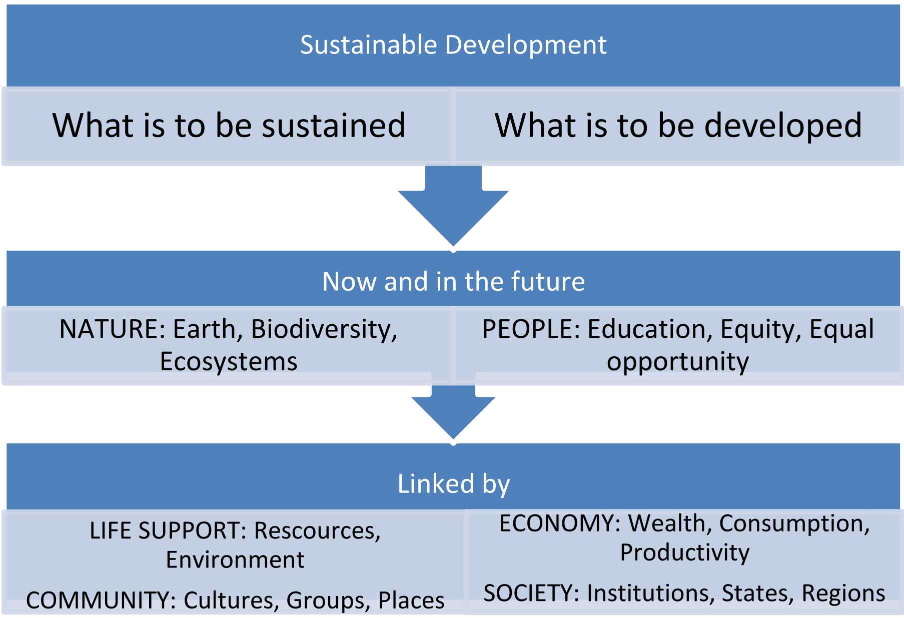
2.1 Sustainable Development: Co-Benefits

In the available guidelines, sustainable development is seen as an integrated part of the legal framework of the CDM and it is emphasised that contribution to achieving sustainable development is equally important as the reduction of GHG emissions. Generally, however, relatively little attention is paid to the assessment of sustainable development impacts of CDM projects (UNDP, 2000).

Considering that the concept of sustainable development has a lot of different meanings, I choose in this study to use one of the most widely accepted definitions: *"Humanity has the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Chichilinisky, 1997). In the last half of the twentieth century, four key themes emerged as important areas of discussion and debate: peace, freedom, development, and environment. In particular, the latter two themes became prominent issues and aspirations in the 1970's and 1980's. The conflicts between environment and development were first acknowledged in the 1972 Stockholm Conference on the Human Environment. Later, it was the Brundtland Commission who began its work, which focused on the unity of environment and development, with their report 'Our Common Future', published in 1987 (WCED, 1987). In the interim, sustainable development as a concept, as a goal, and as a movement spread rapidly. It is now central to the mission of countless international organizations, national institutions and corporate enterprises (Kates & Parris & Leiserowitz, 2005).

Although the definition of Chichilinisky does not explicitly mention the environment or development, the two themes are clearly incorporated in the concept. On development, it is clear: human needs are basic and essential; economic growth - but also equity to share resources with the poor - is required to sustain them; and that equity is encouraged by effective citizen participation. People, economy and society are aspects that need to be developed. The link with environment, as you can see in *Figure 1*, is also clear. Nature and the environment are key source of services, which provide life support for humankind. That is why nature needs to be safe guarded and it indicates how biodiversity, ecosystems and the Earth are key components of life support systems and community (US National Research Council, 1999).

Figure 1: Components of sustainable development



SOURCE: Figure based on the U.S. National Research Council, Policy Division, Board on Sustainable Development, Our Common Journey: A Transition toward Sustainability (Washington, DC: National Academy Press, 1999).

The concept of sustainable development can be interpreted in many different ways. Though, the phrase "three pillars of sustainable development" is well-known in the sustainable development literature. In this study I focus on these three pillars of sustainable development; economic development, social development and environmental protection, and I will assess these at local levels. Three major variants of social development are found, each of which seeks to compensate for elements missing from economic development's narrow focus. The first is simply a generic non-economic social designation that uses terms such as "social," "social development," and "social progress." The second emphasizes human development as opposed to economic development: "human development," "human well-being," or just "people." The third variant focuses on issues of justice and equity: "social justice,'' "equity," and "poverty alleviation" (The Johannesburg Declaration on Sustainable Development, 2002).

The basic principle of the CDM is that both developed and developing countries benefit from participating, because synergies between global carbon abatement goals and local sustainable development goals are explored. From the developing country perspective, the benefits arise both from the increased investment flows and from the requirement that these investments should advance host country sustainable development goals. More specifically, the CDM biogas project in this research may contribute to several developing country's sustainable development objectives. The following *co-benefits* are based on the three pillars of sustainable development:

Social benefits:

- Reduces drudgery to women who spend long hours and travel long distances in search of fuel wood.
- Increases women and children's overall health situation by reducing smoke in kitchen, thus eliminating health hazards from indoor air pollution.
- Energy supply security.
- Better management of dung and organic wastes.
- Improves education of children as women have more time and resources to nurture their children and send them to school.

Economic benefits:

- Higher productivity of workers as they have adequate cooking fuel supply.
- Will provide employment to local communities through construction and maintenance of biogas units.
- The project will reduce cooking time, thus providing women to take up other activities.

Environmental benefits:

- Improves the local environment by reducing uncontrolled deforestation in the project area.
- Avoids local environmental pollution through better waste management.
- Will lead to soil improvement by providing high quality manure.
- Avoided global and local environmental pollution and environmental degradation by switching from non-renewable biomass to renewable energy, leading to reduction of GHG emissions.
- Reduces deforestation, preservation of pasture land, reduced indoor pollution, and increased use of manure rather than chemical fertilizers.

In section three of this study I will come back to these three pillars in explaining the indicators that I have used to do research on the co-benefits of the CDM. In the explanation of these benefits, especially the environmental benefits, it is clear that the biogas program is an agricultural development program which involves people and their environment. That is why I believe it to be important to highlight the important aspects of agricultural development in relation to this research.

2.2 Agricultural Development

The southern part of rural India has a low agricultural productivity which has been largely attributed to severe shortages of manpower, recurrent droughts, and soil erosion. An increase in agricultural productivity is vital for stimulating growth in many parts of the economy. However, accelerated growth requires a sharp productivity increase in smallholder farming combined with more effective support to the millions coping as subsistence farmers, many of them living in remote areas. In the state of Andhra Pradesh, with rising land and water scarcity and the added pressures of a globalizing world, the future of agriculture is intrinsically tied to better stewardship of natural resources. With the right incentives and investments, agriculture's environmental footprint can be lightened and environmental services harnessed to protect watersheds and biodiversity. Today, rapidly expanding domestic and global markets; institutional innovations in markets, finance, and collective action; and revolutions in biotechnology and information technology all offer exciting opportunities to use agriculture to promote development. Nevertheless, seizing these opportunities will require the political will to move forward with reforms that improve the governance of agriculture (World Bank, 2008).

Agriculture is a vital development tool for achieving the Millennium Development Goal, which calls for halving the share of people suffering from extreme poverty and hunger by 2015. Therefore, agricultural development is needed. Agriculture has features that make it a unique instrument for development, both economic and social. Agricultural production is important for food security because it is a source of income for the majority of the rural poor. The lack of assets is great in the state of Andhra Pradesh, where farm sizes in many of the more densely populated areas are unsustainably small and falling. In addition, land is severely degraded, investment in irrigation is negligible and poor health and education limit productivity and access to better livelihood options. Improving the productivity, profitability, and sustainability of smallholder farming is the main pathway out of poverty, in short using agriculture for development (Malla Reddy, 1992).

The key to the success of any agricultural development program lies in the participation of the people in various stages of its implementation. Effective monitoring systems can reveal the level of participation by the farmers and provide some useful data. That is why the focus in this research lies on monitoring systems and the impact outcomes of agricultural development programs like CDM.

2.3 Clean Development Mechanism (CDM)

The CDM is an arrangement under the Kyoto Protocol allowing industrialized countries with a GHG reduction commitment to invest in projects that reduce emissions in developing countries, as an alternative to more expensive emission reductions in their own countries. The presence of a market for carbon reduction credits (known as 'certified emission reductions' or CER[1]) creates a value for emission reductions that stimulates investment (known as carbon financing) for low-carbon projects in developing countries. The CDM assists countries in achieving sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission targets. The most important factor of a carbon finance project is that it can demonstrate that it would not have occurred without the additional incentive provided by emission reductions credits (UNFCC, 1997, 2006).

Projects deemed acceptable for carbon financing under the CDM must demonstrate that they deliver real emissions savings which go beyond what would happen in a "business-as-usual" scenario. They are independently verified in that once a project achieves emission reduction, CER's are issued to the project. One CER is equal to 1 ton of CO2 equivalent (e). CER's can be traded and sold or used by industrialized countries to meet a part of their targets under the Protocol (UNFCC, 1997, 2006).

2.3.1 Biogas as a gold standard CDM project

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen (i.e. anaerobic conditions). *Figure 2* shows how organic waste, such as dead plant and animal material, animal dung, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. The substrates are collected into the inlet, where they are converted into gas to cook. The rest of the substrates are used on gardens or fields as digested slurry fertilizer (Autonopedia, 2007).

[1] Certified Emission Reductions (CERs) are a type of emissions unit (or carbon credits) issued by the CDM Executive Board for emission reductions achieved by CDM projects and verified by a DOE under the rules of the Kyoto Protocol.

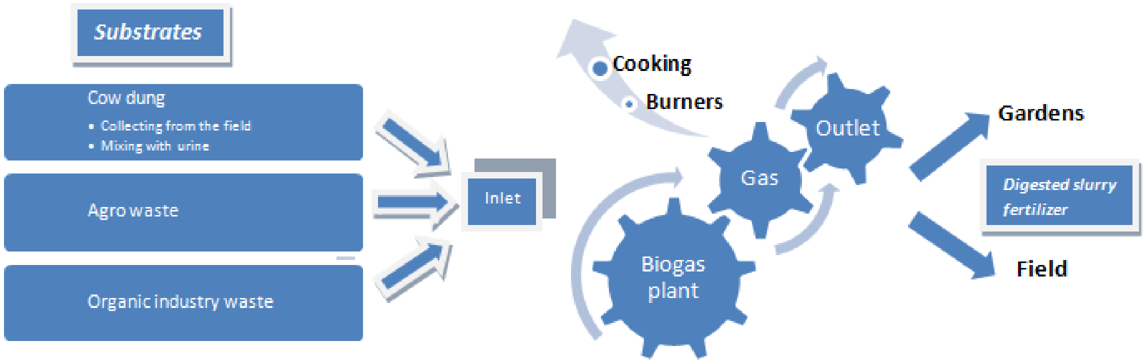
The processes are carried out by two sets of bacteria namely acid and methane forming bacteria. The Acidogenic Phase I consists of hydrolysis and acid formation stages in which organic wastes are converted primarily into acetate. Phase II is the Methanogenic Phase in which methane and carbon dioxide are formed (i.e. is it the hydrolysis of acid within the organic wastes which produces acetate). The better the three stages are interlinked, the shorter the digestion process. Users prepare batches of slurry (i.e. organic waste) in a mixing tank (i.e. Phase I), before allowing the contents to flow into a digester for methane formation phase (i.e. Phase II). After digestion, the remaining slurry can be re-used in the process. The recovered gas is combusted and used for cooking and water heating. The chosen methane recovery and combustion system utilised in India is the tested Deenabandhu Model biogas technology which is well-known in India (see 4.1.1.2) (PDD, 2006). In India, biogas produced from the anaerobic digestion of manure (e.g. organic cow dung) in small-scale digestion facilities is called gobar gas and chiefly comprises, as previously explained:

- methane (CH4): 40-70 vol.%
- carbon dioxide (CO2): 30-60 vol.%
- other gases: 1-5 vol.% including
- hydrogen (H2): 0-1 vol.%
- hydrogen sulfide (H2S): 0-3 vol.%

Like those of any pure gas, the characteristic properties of biogas are pressure and temperature-dependent as well as being affected by percentage moisture content. The main factors affecting biogas properties are:

1. Change in volume as a function of temperature and pressure;
2. Change in calorific value as a function of temperature, pressure and water-vapor content, and
3. Change in water-vapor content as a function of temperature and pressure.

Figure 2: A typical biogas system configuration



Source: Own composition of a biogas system.

An obvious obstacle to the large-scale introduction of biogas technology is the fact that the poorer strata of rural populations often cannot afford the investment cost for a biogas plant. Efforts have to be made to reduce construction costs but also to develop credit and other financing systems. A larger numbers of biogas operators ensure that as well as the private user, the society as a whole can benefit from biogas production (Autonopedia, 2007).

2.3.2 CER's and the Carbon Market in India

Ever since the mitigation strategy of carbon trading was conceptualized in the Kyoto Protocol, India seems to have been one of the most pro-active countries in terms of translating the concept into action.

Table 1: Overview of CDM projects in India (as on 16th of May 2011)

Project status *(including bilateral ones)*	**Number of projects**	**kCER's/annual**	**KCER's (2012)**	**[2]kCER's issued**
Validation	922	98224	182563	
Registered	645	50423	258286	93834
Registration request	36	958	3444	

[2] Certified Emission Reduction issued so far (Source: UNFCCC, 16th May 2011).

Total	**1603**	**149604**	**444293 (it will be 1516432 kCER's at 2020)**	**93834 (from 261 registered projects)**

Source: UNFCCC, 16th May 2011.

By the end of May, 2011, India had 645 CDM projects registered with the UNFCCC; 261 of which had already been issued a total of 93834 kCER's. Even more impressive is that at this point in time India had a total of 1,603 CDM projects, including the registered and CER-issued ones, with 922 at validation, and another 36 at various stages of registration (*Table 1*). Analysed together, the projects claim to offer a saving of 444,293 ktCO2 by 2012. The projected figures for 2020 therefore suggest a saving of 1,516,432 ktCO2, meaning that the projects will reduce GHG emission by approximately 1,520 million tonnes of GHG's by 2020 (Ghosh & Sahu, 2011).

Most CDM projects in India come under four sectors— wind, energy efficiency, biomass, and hydro. Other major sectors include fossil-fuel switch, biogas, cement, landfill gas, and HFC[3] (i.e. hydrofluorocarbons). After HFC, Energy Efficiency projects constitute the second highest contributing segment in issued-CER's. Biomass is the third highest CER-receiving sector in the country: projects in this sector have been issued 8,108 kCER's (8.72%), up to May 16th, 2011. The top three is followed by the wind sector, hydro, cement, landfill gas and fossil-fuel switch. In this research I will focus on the sector that has so far contributed the least: biogas. Up to now the biogas sector has generated a total 658 kCER's (0.7% of the country total) (Ghosh & Sahu, 2011).

Looking at India's CDM scenario in terms of corporate participation, it is clear that the energy sector is generating the maximum CER's. The unfortunate fact is that big corporations such as Tata, ITC, Reliance, Ambuja, Birla, Bajaj, GFL, HFL, NFIL, and many others, who keep on emitting millions of tons of carbon dioxide into the biosphere are earning handsome returns in the name of CDM (Ghosh & Sahu, 2011). Such an issue, as important as it is, will not be tackled within the scope of my research project; rather I will be concentrating more closely on the impact of biogas on smallholders. In this way, I try to tackle the issue on a bottom-up scale rather than the top-down view.

2.3.3 Gold standard for CDM Projects

Gold Standard to CER's is issued to CDM projects which achieve sustainable development goals within local communities and these are set by the Gold Standard Foundation. The Gold Standard

[3] HFCs have been included in the Kyoto Protocol because they are powerful global warming gases. HFCs have GWPs (global warming potentials) that are typically 1000-3000 times higher than that of CO2 (EC, 2013).

Foundation is a non-profit foundation, based in Basel, Switzerland. It offers a quality label to CDM/JI and voluntary offset projects, fetching premium prices. Gold Standard Carbon Credits are rewarded after an accredited third party determines that a project has fulfilled The Gold Standard criteria. The Gold Standard is an independently audited, globally applicable best practice methodology for project development that delivers high quality carbon credits of premium value along with sustainable development co-benefits associated with the projects. It is the worlds' only quality standard for carbon emission reduction projects with added sustainable development benefits and guaranteed environmental integrity. Initiated by WWF, SSN and HELIO International the Gold Standard for CDM projects was launched in 2003 after a wide-ranging stakeholder consultation among key actors of the carbon market as well as governments. Today, the label receives worldwide recognition and is officially supported by 59 charities, NGOs and environmental and development organizations. It is the most widely endorsed quality standard for designing and implementing carbon offset projects. The Gold Standard's main purpose is to ensure that CDM projects are both reducing carbon dioxide (CO2) emissions and fostering sustainable development *(*FCN, 2011).

Gold Standard project developers invite local stakeholders to make sure the project responds to local concerns regarding the environmental, social impacts, and the local economy. Using information from this consultation, and using information from the regular project development, Gold Standard project developers use a sustainable development matrix to calculate the impact of the project. Only projects with an overall positive impact on the environment, social networks, and local economy are Gold Standard Projects (WWF, 2006). Any project seeking to obtain the Gold Standard must demonstrate clear benefits in terms of sustainable development.

The contribution of the proposed project to the sustainable development of the country is measured on indicators that fall into three broad components:

- Local/global environment sustainability;
- Social sustainability and development;
- Economic and technological development.

The Gold Standard Foundation uses a Sustainable Development Assessment Matrix, based on these three components, to assess a projects eligibility for the Gold Standard. In this research I will be using similar components as to the Sustainable Development Assessment Matrix of the Gold Standard Foundation.

3 Literature review

The changing nature, as well as the role and function of states in a globalizing world are some of the major themes that are truly interdisciplinary and cross borders of the social sciences disciplines. In particular this is due to the in depth researchers that globalization scholars from political science, sociology, international relations, environmental economics, and other specialized areas, have conducted into various perspectives, theories, and analyses in order to help to understand the changing nature of the state and to understand politics including contemporary global environmental challenges. We live in a globalized world where networks and 'environmental flows' are considered to be categories of the broad modern architecture (Beyne, 2011). The CDM can be seen as an environmental flow, with social, economic as well as environmental consequences. In this section I present some of the main hypotheses centered around the social, economic and environmental improvements which ensue from biogas projects.

Rural areas of developing countries are very dependent on biomass fuels, such as firewood and dried dung, to sustain their energy consumption. This use of energy is often coupled with many problems such as deforestation, land degrade and various health and social problems as well as giving rise to GHG emissions. In many areas biogas can be used as a replacement for these fuels and can help to solve many of the common problems associated with energy production (Wargert, 2009).

3.1 Local and global environment

One estimate claims that the use of firewood for energy needs accounts for 54% of the world's deforestation in developing countries. One of the biggest problems in India is that energy resources are used in an inherently unsustainable way and moreover the demand for energy is far greater than its availability. This leads to many problems such as deforestation, soil degradation, environmental pollution, which ultimately accelerate the climate change process (Wargert, 2009).

3.1.1 Direct and indirect environmental effects

A study performed by the Government of India, which monitored biogas plants installed from April to December 2002 under the National Biogas Programme, indicated that the overall functioning of biogas units is 86% (i.e. 86% of the biogas units was working efficient) (MNES 2012). The use of these biogas plants results in the saving of 4.4 million tonnes of fuel wood and, in addition, produces 45 million tonnes of manure per year. Also the IPCC believes in the fact that biogas has the potential to reduce pressure on forests and thus conserve biodiversity (IPCC, 2002).

Biogas systems not only lead to direct benefits, such as reduced emissions of air pollutants when fossil fuels are replaced, but also indirect benefits from changed land use and handling of organic by-products. The indirect benefits include reduced nitrogen leaching[4], emissions of ammonia and methane which are achieved when manure, crop residues, and organic waste are utilized for biogas production. These indirect benefits are seldom considered when biogas is evaluated from an environmental point of view (Bhattacharya, 2005), whereas a shift to a biogas system does actually lead to global benefits, such as no net CO_2 emission (as sustainable biomass harvests are possible) and a reduction in CO_2 emissions (Ravindranath, 1992).

Many scientific articles only ever discuss the CO_2 reduction benefits; however, the production of animal dung for use within biogas units can also reduce methane gas emissions. When dung is naturally digested, methane gas is produced and released into the atmosphere. If instead these substrates are digested in a biogas plant the methane gas (biogas) can be contained. When the biogas is then combusted, most of it is converted into $CO_{2,}$ rather than methane. Methane gas is a 21 times more aggressive GHG than $CO_{2,}$ when considering a hundred year time frame. Therefore it can be concluded that biogas plants can be an effective means of mitigation. The net saving of GHG for an average sized biogas plant has been estimated to 4.6 tonnes of CO_2 equivalents per year (Bajgain & Shakya, 2005).

A shift to biogas from traditional biomass fuels results in less dependence on natural resources such as forests, placing a check on their indiscriminate and unsustainable exploitation. Since dung is collected systematically when used for biogas, the environment can be kept clean and hygienic. Better environmental conditions which relate to the use of biogas also include reduced indoor pollution, increased use of manure rather than chemical fertilisers, and reduced soil erosion and siltation in lakes (Bhattacharya, 2005).

Environmental benefits are clearly positive for anaerobic digestion systems even though they are not able to meet national standards. The NGO BEST, who is situated in the state of Karnataka, conducted research concerning the environmental benefits from biogas. They found three key areas of improvement namely the improvement of; soil fertility due to the use of organic fertilizer, water quality due to the treatment of wastes that would normally enter ground or surface water, and air

[4] Nitrogen is a common element in nature and an essential nutrient. Approximately 78% of Earth's atmosphere is nitrogen (N_2). The strong bond between the atoms of N_2 makes this gas quite inert and not directly usable by plants and animals. As nitrogen naturally cycles through the air, water and soil it undergoes various chemical and biological transformations. Nitrogen promotes plant root growth. Livestock then eat the crops producing manure, which is returned to the soil, adding organic and mineral forms of nitrogen. The cycle is complete when the next crop uses the amended soil.

quality due to the reduced combustion of wood (FCN, 2011). Another result from their research is that the improvement in health is directly correlated with the increased use of biogas. The burning of firewood, dung cakes, straw and agricultural residue creates many hazardous particles and since cooking is usually done indoors, this can lead to severe health problems. In the next section, I will present the health benefits from biogas (Bajgain & Shakya, 2005).

3.1.2 Health improvement

In 2004, the World Health Organization (WHO) issued a global statement calling for the world to wake up to the dangers of cooking with firewood leading to smoke in the kitchen. Indoor air pollution is one of the major causes of death and disease in the world's poorest countries. While the millions of deaths from well-known communicable diseases often make headlines, indoor air pollution remains a silent and unreported killer. The particles from the smoke can give rise to acute respiratory infections affecting the people who are in contact with the smoke. These people are mainly women, children and infants (Bajgain, Shakya, 2005).Thick acrid smoke rising from stoves and fires inside homes is associated with around 1.6 million deaths per year in developing countries. That is one life lost every 20 seconds to this ‘killer in the kitchen’. Despite this statistic, nearly half of the world continues to cook with solid fuels such as dung, wood, agricultural residues and coal. Smoke from burning these fuels gives off a poisonous cocktail of particles and chemicals that bypass the body's defences and more than doubles the risk of respiratory illnesses such as bronchitis and pneumonia (WHO, 2004).

Other studies have been undertaken to establish a connection between using biofuels and adverse health effects. In addition to the issue of indoor pollution, there are quite considerable injuries and disorders that occur during the collection and transportation of firewood. In Anantapur district where the climate is dry and heavy deforestation has taken place, the distance travelled to collect firewood can be more than 8 km. The task is very time consuming and often takes several hours per day. The labour is very hard and can lead to, amongst others; neck and spinal stress; headaches from carrying heavy loads; cuts, bruises and injuries caused by forests trekking and chopping of fuel wood; and snake and scorpion bites (Wikramsinghe, 2009).

A shift to a biogas system leads to local health benefits such as the elimination of a smoke-filled cooking environment, soot-free walls, prevention of eye infections, improvement in rural sanitation, etc. as well as reduced injuries from the physical labour associated with biofuel collection. Also, the cow dung, often an unexploited source of fuel, is recycled through the biogas unit and creates a positive impact on the health of the rural people. Furthermore there is no more breeding ground for flies and mosquitoes, causing additional public health problems (Miles, 2004).

3.2 Social Development

Poor people, woman in particular, devote a considerable amount of time collecting, processing and using traditional fuel for cooking. In India, one to eight hours each day can be devoted to the collection of fuel for cooking. This is time that could otherwise be spent on child care, education, agriculture related work, leisure, socializing, vocational work or income generation (UNDP, 2000).

When using biogas, people can do more additional activities, and social benefits such as village self-reliance, local employment and skill generation will occur (Ravindranath, 1992). Time can be saved from the collection of firewood and other biofuels carried out by children. The daily time spent in feeding a small biogas digester could be as little as 15 minutes compared to several hours with the collecting of biomass. Time consumed cleaning pots and other kitchen equipment can also be lowered since biogas produces less soot than biomass generally does. Most importantly, the more economical use of time, results in more time available for education. (Gautam et al, 2009)

3.3 Economic well-being

The lifespan of a biogas plant is estimated to be over 15 years. However, taking into account the utilization pattern, socio-economic aspects, and climatic factors, the average life of biogas plants may be estimated at about 10 years. Based on a life-cycle analysis, the cost for the generation of 1 m^3 biogas from a family type biogas plant is Rs 3. A comparison of cost with diesel and kerosene based on energy value shows that biogas is more cost-effective due to kerosene being expensive due to importation costs (MNES, 2012). At the same time, smallholders can use their saved money to buy other assets to improve their social and economic life.

Another very important economic benefit is the improvement of agriculture due to a better management of dung and organic wastes. Farmers have more time to do agriculture related work and use their biogas-slurry as fertilizer instead of expensive chemical fertilizer. Smallholders can save their money for the purchase of seeds, other organic fertilizers and pesticides. Therefore, in this sense, biogas is promoting economic self-sufficiency (Miles, 2004). The biogas program also generates employment in rural areas as experienced people are needed in the building of biogas digesters. The biogas sector often creates a multiplier effect within rural communities (Gautam et al, 2009 & Ilori et al, 2000).

4 Case Study

In this section I present the case-study used to help answer my research question: '*What is the social and economic impact of biogas on smallholders?*' I start with a description of NGO's in India, and the NGO involved within my case-study. In 4.2, I will describe the geographic location of the project area. Furthermore, I explain the functioning of the CDM Project used within the case-study. In 4.4, I define the methodology I have used as well as highlighting its problems and limitations.

4.1 NGO's in India

Although the term NGO only became popular in India in the 1980s, the voluntary sector has an older tradition. Since independence from the British in 1947, the voluntary sector had already again a lot of respect - first, because the father of the nation Mahatma Gandhi was an active participant; and secondly because India has always had the tradition of honoring those who have made some sacrifice to help others (Chatterjee, 2006).

In independent India, the initial role played by the voluntary organizations, started by Gandhi and his disciples, was to fill in the gaps left by the government in the development process. The volunteers organized handloom weavers in villages to form cooperatives, which allow them to market their products directly in the cities, and thus get a better price. Similar cooperatives were later set up in areas such as the marketing of dairy products and fish. In almost all these cases, the volunteers helped in other areas of development. In the 1980s, however, the groups who were now known as NGOs became more specialized, and the voluntary movement was fragmented into three major groups:

1. There were those considered the traditional development NGOs, who went into a village or a group of villages and ran literacy programs, encouraged farmers to experiment with new crops and livestock breeds that would bring more money, helped the weavers and other village artisans market their products (etc.) - in short these NGOs almost became part of the community in their chosen area (usually in rural India) and tried to fill all the gaps left in the development process by the government (Chatterjee, 2006).

2. The second group of NGOs consisted of those who researched a particular subject in depth, and then lobbied with the government or with industry or petitioned the courts for improvements in the lives of the citizens, as far as that particular subject was concerned (Chatterjee, 2006).

3. In the third group were those volunteers who saw themselves more as activists in comparison to other NGOs. Of course, all NGOs undertook a certain amount of activism to get their points across - they petitioned the bureaucrats, they alerted the media whenever they found something wrong (etc). However, this third group of NGOs saw activism as their primary means of reaching their goals, because they did not believe they could get the authorities to move in any other way (Chatterjee, 2006).

India is a representative rather than a participatory democracy. Once the elections are over, the politicians who run the federal and state governments do not really need to go back to the electorate for every major decision - there is no tradition of referendums in India, as there is in Switzerland or Denmark. Therefore, in the five years between elections, the NGOs - and parts of the media, to some extent - are often the only means available to citizens to voice their opinions on any decision taken by a government (Chatterjee, 2006).

In a large developing country like India, there are numerous gaps left by the government in relation to the development process - sometimes by intention, sometimes due to lack of funds, or even just due to lack of awareness. These are the gaps that many NGOs try to fill in modern India. Some of them may work in areas that the government does not want to get into - like fighting discrimination on the basis of caste. Most Indian politicians do not really want to upset the existing caste hierarchy[5] in his or her constituency, because the politician is dependent for votes on the dominant castes of that particular constituency (Chatterjee, 2006).

4.1.1 SEDS (Social Education and Development Society)

SEDS, the Social Education and Development Society, was founded in 1980 by Rajen Joshua and Manil Jayasena as a grassroots development NGO, motivated by the desire to help the poorest of the poor in the drought-prone area of Anantapur District in Andhra Pradesh. In the early days, the main focus of the work was on community development by way of non-formal education and small loans to target skilled communities like cobblers, basket weavers, blanket weavers and others. Initially small nurseries were started for homestead plantations and planting of avenue trees along village roads. In addition afforestation and more sustainable agricultural practices were introduced (SEDS, 2012).

[5] Caste hierarchy refers here to the division of India's Hindu society into rigid social groups, with roots in India's ancient history and persisting until today. Caste refers to a form of social stratification characterized by endogamy, hereditary transmission of a style of life which often includes an occupation, ritual status in a hierarchy, and customary social interaction and exclusion based on cultural notions of purity and pollution. The economic significance of the caste system in India has been declining as a result of urbanization and affirmative action programs, but it is still prominent in the rural areas.

From 1990, SEDS started using a more participatory approach, through the formation of Community Based Organizations. Involving the communities in their work to a greater extent made them actual stakeholders in the development process of the region, rather than just on-lookers. Throughout the years the scope and area of the work increased and the fruits of the sustained efforts became visible, such as the greener environment and the enthusiasm of the communities (SEDS, 2012).

Today, SEDS is working through an integrated rural development approach with an emphasis on women's empowerment, watersheds, afforestation and natural resource management. This is within five Mandals in the southern part of Anantapur District, in south western Andhra Pradesh namely, Penukonda, Roddam, Gorantla, Somandepalli and Chilamathur. In these 5 mandals SEDS currently supports 125 villages, which equates to approximately 12,000 women and their families, 980 Self Help Groups (SHGs), and 120 Village Organisations (VOs).

4.1.1.1 Agricultural development in SEDS: Biogas

In 2011, SEDS started with a biogas project after the successful validation and registration of the project as a CDM project. The project is financed by the investor EED[6] (project participant from Annex I countries) for the construction of 5000 biogas units. In the baseline scenario, 2.85 t/family/yr non renewable biomass and 31 litres kerosene resulted in carbon emission of 3.6 tCO_2 per annum per family. In the project scenario, 5,000 x 3.6 = 18000 tCO_2 is reduced, thus generating 18,000 CERs. Annual income from the sale of 18,000 CERs will, for the initial years, will return to the investor to meet the construction cost of the 5,000 biogas units and therefore enabling the carbon investor to recover their initial investment. After that, CER revenues will provide income for the rural woman (80%) and SEDS (20%) for overhead costs (SEDS, 2012).

Since the Kyoto Protocol and CDM, NGO's in India started with their own biogas-project, for the simple reason that agriculture and deforestation within this developing country are major sources of GHG emissions. They contribute an estimated 22 percent and up to 30 percent of total emissions worldwide, more than half of which is from deforestation largely caused by agricultural encroachment (13 million hectares of annual deforestation globally). Carbon-trading schemes—especially if their coverage is extended to provide financing to help reduce deforestation and soil carbon sequestration (for example, conservation tillage)—offer a significant untapped potential to reduce emissions from land-use changes in agriculture. Some improvements in land and livestock

[6] Church Development Service (Evangelischer Entwicklungsdienst - EED) is an association of the Protestant Churches in Germany. EED is active in The Climate Alliance, an association of organizations committed to promoting climate protection and global justice. They are the main investor of the biogas project in SEDS.

management practices often provide win-win situations, in that after the initial investments, they can result in more productive and sustainable farming systems.

In a broad sense, agricultural development has experienced an overall increase in the use of inputs and higher returns (income) from land, i.e., a concept roughly synonymous with that of the 'Green Revolution'. Therefore biogas in a sense is a great opportunity, but poses many challenges/problems. In developed countries, new opportunities for mitigating climate change and creating large new markets for agriculture have emerged through the production of biofuels, and these are stimulated further by high energy prices. Nevertheless, few of the current biofuels programs are economically viable, and many pose social (rising food prices) and environmental (deforestation) risks. To date, production in industrial countries has developed behind high protective tariffs on biofuels and with large subsidies. These policies hurt developing countries that currently are, or could become in the future, efficient producers in profitable new export markets (Bajgain, Shakya, 2005 & Sasse, 1988).

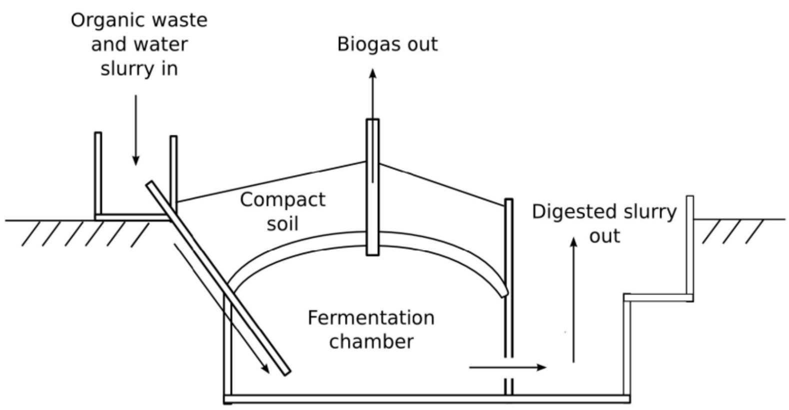
Few developing countries are likely to be efficient producers of biofuels with current technologies. Policy decisions on biofuels need to devise regulations or certification systems to mitigate the potentially large environmental footprint of biofuels production. At large-scales, increased public and private investment in research is important to develop more efficient and sustainable production processes based on feed stocks other than food staples. At small-scales, however, there are many opportunities. In India, a biogas project can be seen as a particular, smallholder based development process. The benefits of biogas I mentioned in 2.1 are mainly household benefits. The purpose of this case-study is to examine the project implementation methodologies used and the results obtained from the biogas project ran by SEDS in Andhra Pradesh, India. Much is already known about what NGO's want to do, what they say they do, and what others say they ought to do. This thesis provides an empirically-based community-level analysis of the biogas project and provides insight into what the NGO does in order to promote sustainable agricultural development in these marginal communities in the region of Anantapur through working with biogas (Bajgain, Shakya, 2005 & Sasse, 1988).

This CDM biogas project is only successful if three methodological principles are combined. First of all, the NGO has to consider not only the targets to build 5000 plants, but all the sustainable development issues as seen in the paragraphs above. Secondly, SEDS has to build participatory development with the smallholders, which must focus on the understanding of biogas procedures and the empowerment of woman who use the biogas unit. And finally, SEDS has to use modern management techniques and look at the biogas project as a project with wider impact. The biogas project will be successful if it isn't only considered as 'another' project, i.e. in isolation, but if it can move towards a larger ‘movement’. A movement of people who try a new technique that is sustainable, good for the environment as well as their social and economic life (SEDS, 2012).

4.1.1.2 Fixe- dome installations: Deenabandhu model

SEDS is working with fixed-dome installations. The fixed-dome plant (*Figure 3*) consists of a digester with a fixed, non-movable gas holder that sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank is altered. Advantages are the relatively low construction costs, the absence of moving parts and the rusting of steel parts. If well-constructed, fixed dome plants have a long life span. In addition, the digester of this type of installation is built underground, which saves space and protects the digester from temperature changes. The construction provides opportunities for skilled local employment. The main disadvantages are the frequent problems associated with the gas-tightness of the brickwork gas holder, in which gas pressures fluctuated substantially (a small crack in the upper brickwork can cause heavy losses of biogas). Fixed-dome plants are, therefore, recommended only where construction can be supervised by experienced biogas technicians (SEDS, 2012).

Figure 3: Fixed dome biogas plant



Source: *Typical household fixed dome biogas plant* (Gautam *et al* 2009)

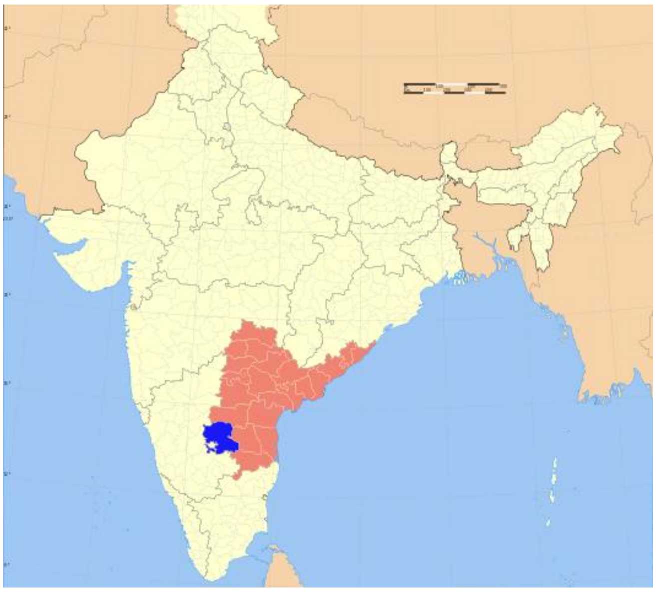
SEDS is building fixed dome biogas plants in the villages within the Anantapur region. Given that some households consist of more than eight members, the normal size of a biogas plant is too small to provide enough biogas for the whole family. Generally a household that has two cattle will operate a 4 m^3 digester (Bajgain, Shakya, 2005 & Sasse, 1988).

4.2 Geographic description of the project area

4.2.1 Andhra Pradesh Region

This thesis report compiles data for the southern Indian state Andhra Pradesh (*Figure 4*). More specifically this report includes research in the region of Anantapur. Andhra Pradesh is one of the 28 states of India, situated along the southeastern coast of India. It is India's fourth largest state by area and fifth largest by population. The overall level of development of Andhra Pradesh, measured in terms of agricultural development, infrastructure, and educational and health characteristics of the population is lower than the Indian average. The economy of Andhra Pradesh is mainly driven by agriculture with 60 percent of population being engaged directly in agriculture or related activities. Rice is the major food crop and staple food of the state, with other important crops consisting of groundnut, sorghum, pearl millet, maize (corn), small millets, pulses, tobacco, cotton and sugar cane. Agriculture is a way of life for the people of Andhra Pradesh, a tradition which has shaped the culture and economic life. Rapid growth of agriculture is essential not only to achieve self-reliance but also for food security and to bring about equity in distribution of income and wealth which would ultimately lead to a reduction in poverty levels (Ramachandran, 2008).

Figure 4: India, Andhra Pradesh



Source: Anantapur locator map, 2008

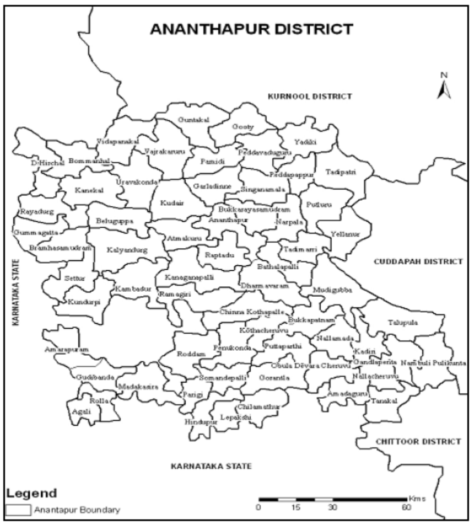
In addition, the share of agriculture in GSDP (Gross State Domestic Product) and employment are higher in Andhra Pradesh as compared to the rest of India due to significant changes in the structure and performance of the agrarian economy in the state. In recent years, the state has also been facing a crisis in agriculture with a high incidence of suicides by farmers (SER Division Planning Commission Government of India, 2008).

4.2.1.1 Anantapur District

Anantapur district is one of the 23 districts in Andhra Pradesh (*Figure 5*). It is its largest district, spanning an area of 19,130 square kilometers. As with the rest of Andhra Pradesh, the economy in the Anantapur district is principally agrarian with very few industries. Prominent agrarian practices include the cultivation of groundnut, sunflower, rice, cotton, maize, chilies, sesame, and sugarcane. Whereas industrial activities are limited to silk trade, limestone quarrying, iron and diamond mining. The district is historically known as the ‘stalking grounds of famine’ and this is partly due to the harsh climatic conditions. In 2006 the Indian government named Anantapur one of the country's 250 most backward districts (out of a total of 640). It is one of the thirteen districts in Andhra Pradesh currently receiving funds from the Backward Regions Grant Fund Program (BRGF) (Ministry of Panchayati Raj, 2009).

According to the 1991 census, Anantapur district has a population of 4,083,315 living in 866 villages. The district has a population density of 213 inhabitants per square kilometer and its population growth rate over the decade 2001-2011 was 12.16 %. Anantapur has a sex ratio of 977 females for every 1000 males, and a literacy rate of 64.28 %. The main religious groups are Hindus 3,225,156, Muslims 389,201, and Christians 20,770 (Anantapur Census, 1991).

Figure 5: Andhra Pradesh, Anantapur District

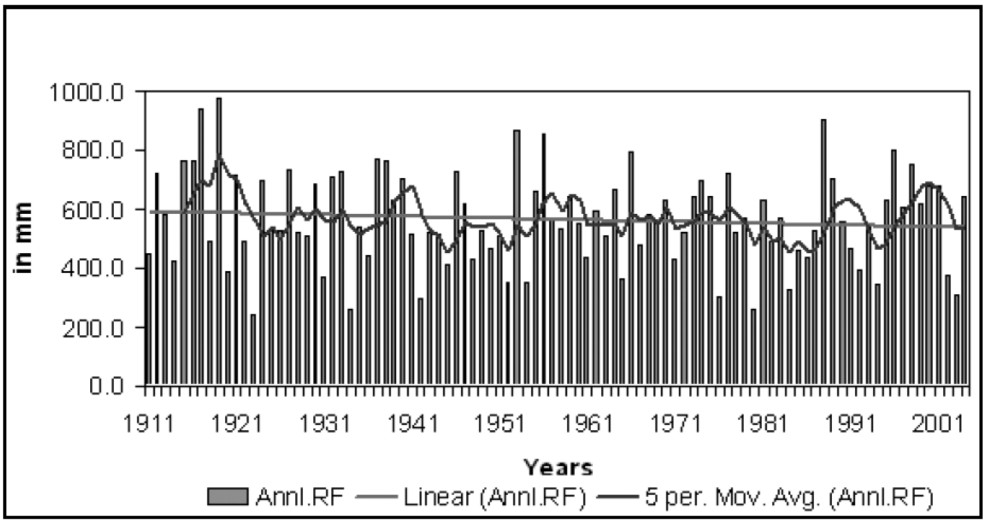


Source: Anantapur Census, 1991

The geographical location of Anantapur District is such that it does not get the full benefit of either of the two Indian monsoons. The south-west monsoon gets cut off by the Western Ghats, while the full benefit of the north-east monsoon is not felt, as the district lies far from the eastern coastline. The district is therefore situated within a rainshadow and the normal rainfall is 553 mm, making it the second most drought prone area in India (Srivastava & Dayawanti, 2010).

Eighteen out of the last ninety-four years are classified as drought years, as the annual actual rainfall in these years has been 75 percent below the annual mean rainfall of 568.5 mm.[7] Fourteen out of these eighteen years were moderate-drought years while four can be classified as severe-drought years (*Figure 6*).

Figure 6: Annual rainfall – Anantapur District



Source: *Data collected from IMD, Pune.*

4.2.1.2 Penukonda

Penukonda is a small town in the Anantapur district of Andhra Pradesh, India. It is 70 km away from Anantapur town. The area contains 96 villages covering an area of 677 square miles. The NGO SEDS started to work in 10 villages near Penukonda in 1980. As this region is the second most drought prone area in India and much of its natural resources are depleted, it soon became clear that

[7]According to the India Meteorological Department, meteorological drought occurs when the actual annual rainfall is less than or equal to 75% of the mean annual rainfall. Severe drought occurs when the actual annual rainfall is below 50% percent of the mean annual rainfall; moderate drought occurs when the actual annual rainfall is 50 to 75% of the mean annual rainfall (Indian Meteorological Department, 2001).

environmental problems would have to be tackled first if peoples' livelihoods were to be made sustainable. A pioneering scheme work was developed, which aimed to empower local communities and improve their environment (SEDS, 2012).

Like in the rest of Anantapur District, agriculture is the main occupation for the population. All therefore exerts a lot of pressure on the land resulting in decreasing forest/vegetation coverage, lowering water tables and soil erosion. There is a huge lack of irrigation facilities: only 13.3 % of the cultivated area enjoys irrigation in this district as compared to 18.9 % in Rayalaseema region, 33.6 % for Andhra and 27.66 % for India as a whole (Anantapur Census, 1991). The main irrigation sources are tanks and wells, which are rainfed and thus unreliable. Green Revolution techniques that were introduced after Independence in Anantapur are designed around irrigated farming and are thus ill-suited for the kind of rainfed agriculture practiced in Anantapur. Little effort has been done in the past to address the problems of rainfed farming. The spread of Green Revolution techniques and the increase of local knowledge due to this external oriented way of agriculture have further depleted resources over the years. Because of this background, yields and outputs vary greatly per year and are not always profitable, hence farmers rely on credit and are forced to borrow from different sources (SEDS, 2009).

Data indicates that the combination of limited natural resources and external input based farming result in agriculture being a non-profitable livelihood option. Little alternatives are available locally for illiterate farmers as no other sector provides employment for such a large number of people. This in turn results in high migration rates, farmer suicides due to debts, lands left fallow or sold to big farmers or real estate agencies (especially along the new highway Hyderabad-Bangalore where land prices have multiplied in recent years), high unemployment, loss of indigenous knowledge and sovereignty and further natural degradation. The only stakeholders benefiting from this are the suppliers of the inputs (i.e. crops, etc.), who keep farmers within this vicious circle of what one could call modern slavery. It is therefore not surprising that this District scores very badly on HDI (Human Development Indicators) indicators (SEDS, 2012).

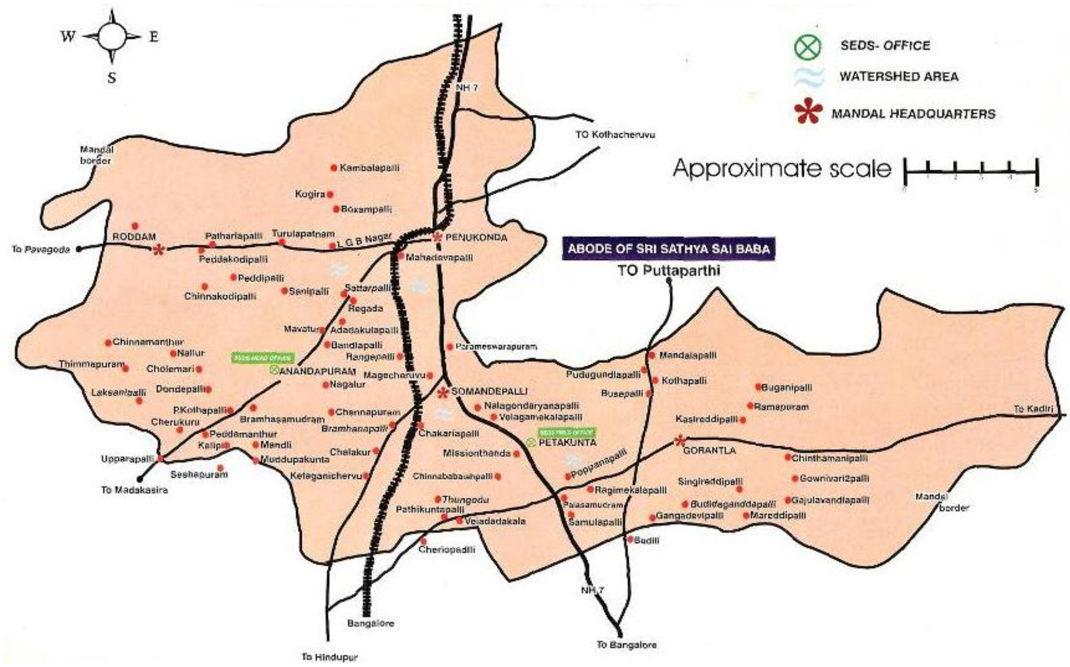
The SEDS biogas project is situated across the 5 Mandals of Roddam, Somandepalli, Penukonda, Chilamathur and Gorantla (*Figure 7*). The villages where the surveys were conducted are listed in *Table 2*.

Table 2: Super Report Biogas Project

District	Taluk/Mandal	Gram Panchayat	Village	Biogas users	Non-biogas users
Anantapur	Somandepalli	Somandepalli	Nalagondrayanapalli	12	7
		Gudipalli	Gudipalli	11	
		Thungodu	Thungodu	1	
		Magecheruvu	Magecheruvu	1	3
		Thungodu	Chinnababaihapalli	7	5
		Thungodu	Kolimipalli	2	
		Thungodu	Kavelinagepalli	1	
		Thungodu	Konthattupalli	1	5
		Thungodu	C.B. Palli	3	
		Edulabalapuram	Edulabalapuram		7
Anantapur	Gorantla	Mallapalli	Mallapalli	4	5
		Vadigepalli	B.N. Thanda	5	2
		Vadigepalli	Venkatapuram	1	
		Vadigepalli	Boyalapalli	1	4
		Kondapuram	Romapuram	1	
Anantapur	Penukonda	Rampuram	Kondampalli	8	2
		Mavaturu	Mavaturu		6
		Mavaturu	Sattarpalli		3
Anantapur	Roddam	Peddamanthur	P. Roppala	2	
		Sanepalli	Sanepalli	11	6
		Roddam	R. Kottala	2	
		Roddam	Patharlapalli	4	3
		Reddipalli	Reddipalli		4
		M. Kothapalli	Gorajpalli	4	
Anantapur	Chillamathur	Kodur	Kotlapalli	3	
		Kodur	Kambalapalli		5
		Chillamathur	Adepalli		5
			TOTAL	**85**	**72**
			Total questionnaires	**157**	

Source: Primary data collected from the research project.

Figure 7: *SEDS working area*



Source: SEDS, SEDS area of work, 2011.

4.3 CDM Project description

Before starting with a CDM project, the initiator (e.g. SEDS) has to make a Project Design Document (PDD) for the UNFCCC. This document needs a general description of the small scale project, an outline of the baseline and monitoring methodology, information about the duration of the project activity and the crediting period, environmental impacts, and stakeholders' comments. After the initial adoption of the PDD in 2003 and after going through the whole administrative and logistic necessities, the board agreed to revise the CDM PDD for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM (New Baseline). The effective project start was in January 2011. In 4.3, I will present the most important facets of the PDD by SEDS; a description of the renewable biomass calculations for the project area, the socio-economic survey, and a description of the monitoring plan.

4.3.1 Description of the renewable biomass calculations for the project area

Table 3: Project Participants

Name of Party involved (*) ((host) indicates a host Party)	**Private and/or/public entity(ies) Project participants (*) (as applicable)**	**Kindly indicate if the Party involved wishes to be considered as a project participant (Yes/No)**
India (host)	Social Education and Development Society (SEDS)	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

Source: PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD) - Version 03, SEDS, 2006

The description of the small-scale project (*Table 3*) activity presents the purpose of the biogas CDM project together with the benefits mentioned in earlier. The aim of the project is to replace the commonly used inefficient wood fired mud stove technology with clean, sustainable and efficient biogas and in this way replace Non-Renewable Biomass with biogas for cooking and for the heating of water. By utilizing cattle dung in a controlled anaerobic digestion and combustion system, biogas will be available for cooking and heating water. The biogas will be used on a two-ring gas stove with a flame temperature of 870°C, which is supplied as part of the project remit. Households having cattle or willing to collect cattle dung will participate in the project. In the PDD submitted for the project a list of 5,337 interested beneficiaries were identified. In reality only 5,000 will be built under the project as some drop outs will be expected due to technical or other feasibility issues. The project would be implemented following its registration as a new CDM project activity, as the project will be financed completely from carbon revenues. The project provides social, environmental, economic and technological benefits which contribute to sustainable development within the local environment and country as a whole (PDD, 2006).

To understand the impact and benefits of the project on the environment, it is essential to understand the baseline emissions of the project. The baseline of the project is the usage of fuel wood and kerosene, i.e. a comparison between the old method and the biogas method. The project activity will replace the usage of non-renewable biomass. Using the methodology given by the UNFCCC, the CO_2 emissions are calculated as follows:

$$ER_y = B_y * f_{NRB,y} * NCV_{Biomass} * EF_{projected\_fossilfuel}$$

Where:

- ER_y= Emission reductions during the year y in tCO_2e
- B_y = Quantity of biomass that is substituted or displaced in tonnes
- $f_{NRB,y}$ = Fraction of biomass used in the absence of the project activity in year y that can be established as non-renewable biomass using survey methods
- $NCV_{Biomass}$ = Net calorific value of the non-renewable biomass that is substituted (IPCC default for wood fuel, 0.015 TJ/tonne)
- $EF_{projected\_fossilfuel}$ = Emission factor for the projected fossil fuel consumption in the baseline. The fossil fuel likely to be used by similar consumers is taken: 71.5 tCO_2 /TJ for Kerosene.

There is no published data on the fuelwood consumption in the project area, i.e. at the mandals where SEDS is working. However, an exhaustive study was conducted in the neighbouring district of Kolar, Karnataka, 30 km away from Penukonda, which has a comparable agro-ecological situation. To understand the baseline usage, I will briefly explain this study conducted by Ramachandra et al., 2005. The most important outputs of this study are presented in *table 4*. The survey shows that each family uses 5.1 t of fuelwood/family/yr and 49 litres of kerosene for cooking and hot water for an average family size of 5 members. This translates into a per capita usage of 0.85 t fuelwood/capita/yr and 0.68 litres/capita/month. The main source of fuel wood is the local forests and to lesser extent, wasteland and farm-land (Ramachandra et al., 2005).

Table 4: Baseline Emissions from the use of Fuelwood and Kerosene

Data	Value
Emissions from use of fuelwood in the baseline	
Quantity of biomass used in baseline (t/yr)	5.1
Fraction of NRB	75.6%
NCV Biomass (TJ/t)	0.015
Emission factor (tCO_2/TJ)	71.5
Emission from Fuelwood (tCO_2/yr/family)	**4.1**
Emission from use of Kerosene in the baseline	
Family kerosene consumption reduction (l/yr)	49
Density of kerosene (kg/l)	0.75
NCV of kerosene (TJ/Gg)	43.8
Emission factor Kerosene (tCO_2/TJ)	71.9
CO_2 emission from kerosene/yr (tCO_2/yr)	**0.12**
Total Emission of a family in the baseline (tCO_2/family/yr)	***4.22***

Source: Ramachandra et al., 2005.

This study shows that 75.6% of the fuelwood used is non-renewable. This implies that the biomass productivity of the region is able to replace only 24.4% of the fuelwood which is used and hence only this small percentage can be regarded as renewable biomass. Thus, 75.6% of the fuelwood used for burning is non-renewable and unsustainable, contributing to GHG emissions. In *Table 4* it can be seen that the emissions from fuelwood is much larger than the emissions from kerosene and unfortunately families use less kerosene than biomass for cooking. This is due to the fact that availability of kerosene is limited to just 2 litres in the PDS system and they are not able to procure from the open market at higher prices due to fiscal constraints. The beneficiaries are from the lower economic strata and are therefore unable to purchase kerosene from the open market (at the price of Rs.30/lt) which means the only alternative is to collect biomass with no costs. This is highlighted by the fact that the per capita income of families is far less than 1$/day. Taken together the total emission of a typical family used in the baseline calculation is 4.22 (tCO_2/family/yr) (Ramachandra et al., 2005 & PDD, 2006).

As you can see B_y is estimated using a survey method by Ramachandra et al. Another way to derive the quantity of biomass that is substituted or displaced in tonnes (tonnes/year) is from historical data or the following calculation (PDD, 2006):

$$B_y = HG_{p,y} / (NCV_{biomass} \cdot \eta_{old})$$

Where:

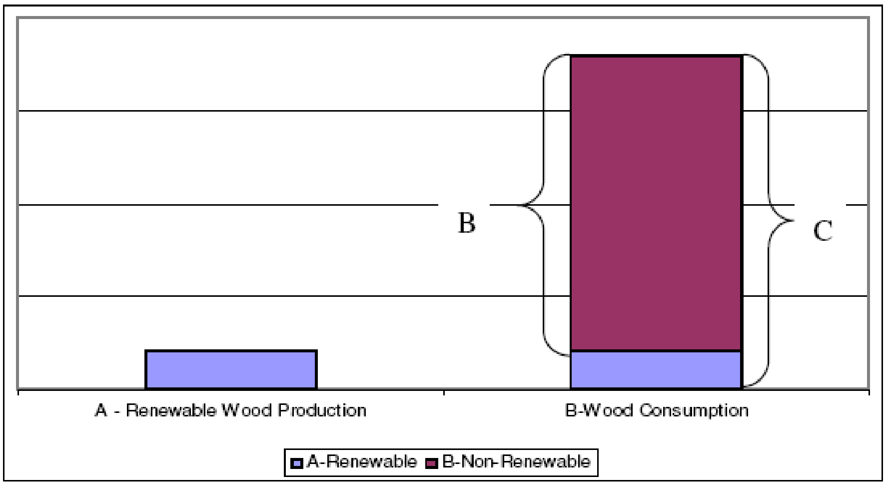
- $HG_{p,y}$ = Quantity of thermal energy generated by the new renewable energy technology in the project in year y (TJ).
- η_{old} = Efficiency of the system being replaced measured using representative sampling methods or based on referenced literature values.

A survey conducted by the Government of India showed that rural households belonging to the lower Monthly Per Capita Expenditure (MPCE) classes used more firewood than any other fuel type (NSSO, 2007). Among different household occupational types in rural India, the percentage of households using firewood was highest for agricultural labour households (NSSO, 2007). Off course, it is important that we take the fuelwood use of 5.1 t/family/yr as conservative. This number will be different for the various families living in different regions within India. Nevertheless it is clear that, the emissions produced by the use of firewood (tCO_2/yr/family) are high and as long as people belonging to the MPCE class use firewood, the emissions will stay high.

The determination of $f_{NRB,y}$ (fraction of biomass used in the absence of the project activity in year y that can be established as non-renewable biomass using survey methods) is the second important factor in determining Emission Reductions during the year y in tCO_2e. The 75.6% calculated in the survey is taken as fuelwood consumption that contributes to deforestation or degradation. The critical factor is whether the consumption is greater than the increase in sustainable biomass growth. Biomass would be reduced in absolute terms beginning at the point where the consumption exceeds the rate of growth, as shown below:

- $G_b / D_b < 1$; where G_b = growth in biomass; D_b=use of biomass

Figure 8: Concept of renewable and non-renewable wood

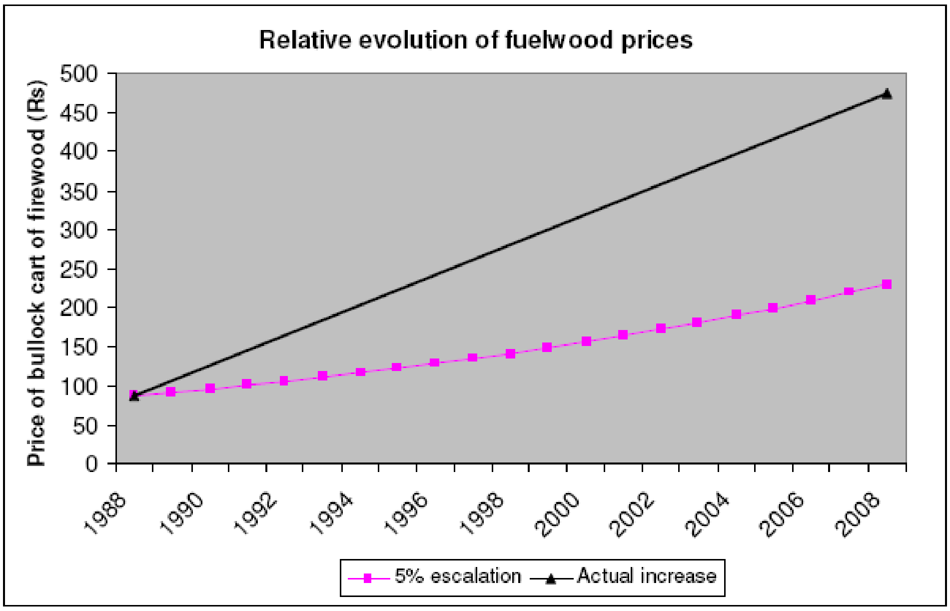


As shown in *Figure 8*, non-renewable fuel wood consumption (B) is defined as any wood consumption (C) beyond the level of renewable wood production (A). The household fuelwood consumption in India is a driver for forest deforestation / degradation and at present household fuelwood consumption is far greater than the annual increment of wood in forests and on non-forest land (PDD, 2006).

4.3.2 Socio-economic survey

Beside the renewable biomass calculations for the project area, another important facet of the PDD is the socio-economic survey, which was conducted by SEDS in the project area to assess the trends in time spent and distance travelled in the collection of biofuels and trends in fuel wood prices over the past 20 years. As previously mentioned, the project area is currently facing a fuelwood crisis and has been for many years due to deforestation. Due to this, all the respondents in the survey are experiencing greater distances to travel and more time spent on fuel-wood collection over the years. The fuel wood prices over the 20 year period have increased more than 5 times (*Figure 9*). Of course these trends are not due to any enforcement of national or local regulations but more due to local environmental conditions (PDD, 2006).

Figure 9: Relative escalation of the fuelwood prices (5% per year corresponds to the average inflation rate in India since 1990).



In this research I will go deeper into the socio-economic study conducted by SEDS. I will also study the trends in time spent, distance travelled (etc.), but my focus lies on the improvement of social and economic well-being which comes with the using of biogas. In order to achieve this I used different indicators and worked with a control group to study the differences between biogas users and non-biogas users.

4.4 Indicators for monitoring and assessment

After gathering background information about NGO's, India, biogas, the case description, I developed my indicators for this research on the basis of the methodological principles previously discussed in chapter 2 and 3. Indicators are tools that measure change and describe impact trends. They can help to identify objective outcomes (e.g. whether smallholders noticed benefits from CDM). They describe the intensity of the impact while simultaneously recognizing its multidimensional aspects. They can also be used for identifying areas in which performance is weak. Good indicators measure the effectiveness, efficiency, impact and sustainability in evaluation and help to clarify the objectives of a project (e.g. CDM). Indicators can help to find out what happened or changed as a result of the organization's work and other factors, and can help to ask further questions about how these changes happened (Stephen & Hebbare, 1998).

Indicators can be developed in many ways. There is not a single methodology that exists but rather many which all have both their advantages and disadvantages. What is important, however, is that they must be developed with keeping in mind of the goals and objectives of the project. Otherwise, they will result in chaos and confusion. The simplest way of developing indicators is by identifying desired outcomes, necessary inputs and outputs and finally, keeping in view the goals and objectives. More importantly still project participants (i.e. stakeholders) should be fully involved in the process of identifying indicators (Stephen & Hebbare, 1998).

During this research I used a logical framework to collect and analyze data. A logical framework brings together the goal and objectives of the CDM project. This, in turn, helps develop indicators suitable for analyzing the three main aspects of the study (social, economic and environmental improvement), as well as the means of verification and assumptions. It helps in developing questions for monitoring and assessing the impact. To achieve clear results/outcomes these goals, objectives, and processes, should be as simple as possible. A logical framework is shown in table 5, 6 and 7.

Table 5: Logical framework for the social indicator.

Project Structure	Indicators	Means of Verification
Goal	Social improvement	Social status
Objectives:	- Empowerment	- Feeling involved in a project
	- Time management	- Less time spending on cooking/search for firewood
	- Social interactions	- Membership/holding positions
	- Community organization	- Village level organization

Table 6: Logical framework for the economical indicator.

Project Structure	Indicators	Means of Verification
Goal	Economical well-being	Standard of living
Objectives:	- Annual income	- More income/ more savings
	- Creation of jobs	- Biogas sector often creates spinoff jobs
	- Asset ownership	- Utility and productive assets
	- Adult literacy	- More educated

Table 7: Logical framework for the environmental indicator.

Project Structure	Indicators	Means of Verification
Goal	Environmental improvement	Save the climate
Objectives:	- Health improvement - Water quantity - Protecting forests - Air quality - Soil condition	- Improving hygienic conditions - Reducing water quantity - No cutting of trees - Reducing air pollution - Biogas slurry instead of chemical fertilizer

Indicators can be either quantitative or qualitative. Quantitative indicators help to answer questions about things that are inherently expressed in numbers (e.g. amount, age, income, etc.), whereas the qualitative indicators help to demonstrate or illustrate that something has happened. These indicators are more difficult to measure. A distinction can also be made between output indicators and the outcome indicators. Output indicators measure what and how much is produced, which in turn may be considered as the immediate objectives of a project or activity. Outcome indicators measure the consequences of the project's outcome in terms of the project's goal and objectives (Stephen & Hebbare, 1998).

A major aspect in the implementation of CDM is the involvement of the NGO SEDS in a supervisory and motivational role in order to encourage the community to participate, manage, maintain and have ownership over the resources developed and assets created. The envisaged benefits of the proposed program are not only aimed to provide immediate and direct benefits to the local people by increasing the availability of natural resources and improving their infrastructural capabilities but also indirectly benefits the local environment, which is a combination of the natural and physical surroundings and their relationship/interaction with people. This relationship covers economic as well as social values. In this study I try to illustrate how changes have occurred due to the implementation of a biogas project, therefore have chosen to use qualitative indicators. Outcome indicators make more sense because I am not only interested in the direct goal of the biogas project, but also in the long-term objectives as presented in tables 5, 6 and 7.

I consider the most important long-term objectives of the project to be:

- ✓ Community organization
- ✓ Human resource development for socio-economic improvement
- ✓ Afforestation
- ✓ Livestock development
- ✓ Energy conservation
- ✓ Economic well-being

The logical framework (e.g. means of verification and assumptions) helped me to formulate the most important indicators. I devised the questions for my questionnaire based on the following social, economic, and environmental indicators:

- ➢ *Social indicators*

- Enhancement of woman's role in decision-making and asset holding
- Increase in the age at marriage
- Number of members involved in an organization
- Number of training activities undertaken
- Individual and group activities
- Initiatives in planning and implementing program by themselves (i.e. the local community)
- Improved time management

- ➢ *Economic indicators*

- Equitable distribution of common resources
- Increased savings
- Increase in adult education
- Increase in per capita income
- Optimum utilization of energy
- More assets available
- Creation of jobs

- ➢ *Environmental indicators*

- Reduction in use of chemical fertilizers and pesticides
- Biodiversity
- Sustainability
- Water quantity
- Air quality
- Soil condition
- Health conditions

4.4.1 Problems and limitations

There are several important factors which can explain why some biogas programs are more successful than others. Financing can be an important key factor, for example, subsidies can be very important in the dissemination of biogas. It is almost impossible for a small farmer to be able to invest in a biogas plant without some form of financial help. In that sense it is clear that NGO's and Government Organisations (GOs) can serve an important role. Moreover, as previously explained discussions about climate change are forever growing and it is clear that a mechanism such as the CDM has a big role to play now and in the future.[8] The CDM helps to finance biogas projects and its flexibility makes it possible for Annex 1 (developed) countries to displace emission reductions to developing countries. The reduced GHG emissions from the CDM projects generate ER's that can be bought by Annex 1 countries. Furthermore these can help finance further biogas growth in developing countries (Bajgain & Shakya, 2005).

The Annex 1 investor helping to finance the SEDS biogas project is German. They have a contract with SEDS to build 5,000 biogas plants in a time period of four years (2011-2014). As we can see in *table 8*, the starting date for the project was January 1st 2011 and 2,000 biogas plants were programmed to be commissioned by February 5th 2012, which would result in approximately 4,991 emission reductions (ER's) 5 months later. The second stage of the project started on February 5th 2012 and ended December 1st 2012. During this period another 2000 biogas plants had to be commissioned. Again, these 2,000 plants will result in 4,991 ER's which can be added to the 5,347 ER's from the first 2,000 plants giving a total of 10,338 ER's generated by the end of the second phase. The last period started in December 1st 2012 and ended on the 26nd of March 2014. This period only 1,000 biogas plants will be commissioned. With the 4,000 biogas plants from earlier dates, the total ER's will be 28,515 (SEDS, 2012).

Table 8: Calculation of commissioned plants and their ER's.

Start Date		Plastered by		Commissioned by		Suggested Verification Dates			
1-Jan-11	2,000	11-Apr-11	667	20-Jul-11	667	3-Aug-12	2,258		
		20-Jul-11	667	28-Oct-11	667		1,664		
		28-Oct-11	667	5-Feb-12	667		1,069	4,991	ER's

[8] Not discussed in this report are the ongoing negotiations about climate change adaptation funds and other flexible mechanism such as REDD (Reducing Emissions from Deforestation and Degradation) that could possibly help finance biogas projects in the future (to be decided in Copenhagen, Dec. 2009)

5-Feb-12	2,000	5-Feb-12	667	15-May-12	667	30-May-13	2,258		
		15-May-12	667	23-Aug-12	667		1,664		
		23-Aug-12	667	1-Dec-12	667		1,069		
							5,347	10,338	
1-Dec-12	1,000	1-Dec-12	333	11-Mar-13	333	26-Mar-14	1,129		
		11-Mar-13	333	19-Jun-13	333		832		
		19-Jun-13	333	27-Sep-13	333		535		
							10,694	13,189	
	5,000				5,000		28,518	28,518	ER's

Source: Own calculation by SEDS (2012).

These 28,518 ER's need to be converted into CERs. At that moment the emission reductions are worth money and the average price of a CER is € 13.68 at the moment of calculation (February 2012). One biogas plant saves 3.2528 ton carbon/yr (this equals 3.2528 ER's). 3.2528 ER's times 5000 (biogas plants) equals 16,264 ER's per year. Calculated in *table 9*, in March 2019 there will be 109,838 ER's. The 5000 plants will produce than € 1,502,583.84 (109,838 times € 13.68), which equated to enough for SEDS to pay back the German investor. From that date on, all the ER's are for SEDS and farmers will get a 75% share of the ER's they produce with their biogas plant. So, after a period of seven years the biogas project will produce important economic benefits for the smallholders (SEDS, 2012).

Table 9: ER's produced after seven years.

	28,518	**ER's**
Mar-15	16,264	ER's
Mar-16	16,264	
Mar-17	16,264	
Mar-18	16,264	
Mar-19	16,264	
	109,838	

Source: Own calculation by SEDS (2012).

A problem, however, is that several technical problems can arise. If there are heavy rains, biogas digesters that are below ground can get flooded and as a result have to be drained which adds to the maintenance time and costs. This can easily be avoided with better site design during the construction stage of the biogas plant. Other technical issues are mostly related to poor maintenance of the plants, for example a common problem is that pipes get blocked due to lack of service. Leakage is also a problem that is not unusual with fixed dome biogas plants. Precaution and frequent checks of the pipe, stove and unit can help to overcome these major problems (Woods et al, 2006 & Bajgain, Shakya, 2005 & Han et al, 2005).

A further limitation that many people overlook is an information barrier. A lot of attention goes to the construction of the biogas plants and to finish the targets on time, but at the same time there is no information on CDM assistance available. A lack of understanding of CDM procedures remains a challenge for women and energy developers and this could be attributed to a number of reasons. One of the reasons is that there is no specific training on CDM. The development of a regional assistance body for provision of advice, recommendations and assistance can help to overcome this information barrier. This could include activities such as the establishment of sustainable development criteria, the provision of recommendations regarding individual project approval (how to use a biogas installation properly), and other technical assistance. For this, it is important to develop the capacity of project developers so that they are able to put together projects and to monitor and report on these projects self-sufficiently. Other challenges can be that operational costs are high due to the often isolated and remote locations of the projects. Furthermore, there are many technical difficulties which include finding enough JCB's to dig the pits for biogas units and difficulties to find masons who are capable (SEDS, 2012).

5 Results

As discussed in part 2 of this thesis, the CDM is designed with the dual aim of assisting developing countries in achieving sustainable development and of assisting industrialised countries in achieving compliance with their GHG emission reduction commitments. For this research the contribution of the biogas-CDM project to the sustainable development is assessed based on three, previously stated, broad categories:

- Social development
- Economic development
- Environmental development

Several indicators under each of the categories have been selected to assess the impact of the project and these are elaborated in the sections below.

5.1 Global overview

5.1.1 Objectives and criteria of selection

The main methodological issue of this study arises from the fact that it is very difficult to prove with certainly the existence of causal relationships between agricultural development (CDM/biogas) and any element of social-economic impact on smallholders. Therefore the significant correlations found in any of the models below cannot be interpreted as being causal (as many important factors are not captured in these models). The first thing was to find variables influencing positively or negatively change in the social and economic life of smallholders. The indicators mentioned in chapter 4.4 were used to find out if agricultural development might change the social and economic life of smallholders through influencing some of these chosen variables. There will definitely be a time-lag before some of the variables exhibit changes and there might be interaction between these variables. There is also the complicating factor of interaction with external factors like urban influence and various government programs.

The identification of the variables (called the *process variables* in this study), their interactions and the way they influence any particular aspect of social-economic change – all these together describe the process through which the CDM project might influence a particular *end* variable; the social and economic impact on smallholders. The objectives of this study should be both to understand the process and to quantify the changes in the end variables as a result of the implementation of the biogas project.

The most suitable and direct method of conducting such a study would be to take up a *longitudinal* survey of the areas, which have witnessed varying types and magnitudes of agricultural development in the past. This method was however not possible in the absence of a bench-mark study giving information on various aspects of relevance (i.e., process variables and end variables). The *alternative, cross-sectional* method is probably the best alternative available way to study the social and economic impact of agricultural development on smallholders. This methodology uses two groups, called the *experimental* and *control* groups, on a comparative basis. The logic behind this approach is that much of the observed change in the process and end variables between experimental and control groups can be attributed to the external stimulus of agricultural development. The underlying assumption is that these two groups were similar before the introduction of CDM, which is suggested to have led to agricultural development. It is not necessary, however, that similarity is maintained in all aspects.

5.1.1.1 Objectives:

- ➔ The objective was to develop a measurement of some of the processes and end variables so as to find out whether they are significantly different between experimental and control villages (i.e. groups).
- ➔ The study should give an indication of the crucial elements or variables driving the process.
- ➔ Some of the information can be collected at the village level and some at the household level. For example, information on community organization, economic organization and agricultural practices (etc.) can be collected at the village level. At the household level, information such as land, crops grown, education of all family members, social participation and family labour, can be collected. This study focuses on the household level.
- ➔ Finally, the variables describing the process should lead to a scientific design for further study, particularly in forming important hypotheses and suggesting the approach to tackle conceptual and measurement problems.

5.1.1.2 Criteria of selection

Experimental and control villages were selected after a preliminary study consisting of data compilation from SEDS and studies conducted coupled with field visits. Such a study was required so as to select more or less homogeneous sets of (experimental) villages fulfilling criteria such as whether biogas is the predominant form of cooking and ensures biogas supply to the households of the area. Other selection criteria were introduced to reduce the influence of confounding factors, such as predominant industrial or commercial activities in the villages, major government programmes, and the village is at least 15 km away from any major urban centre.

Control households are selected as to share the same regional features (i.e., population type, land type, distance from urban centre) as well as basic socio-economic structure (i.e., caste composition, primarily an agrarian society) of the experimental villages but different from the latter in terms of biogas use with CDM practices. There is no control on educational or other amenities in the village, or community organization as it was believed that they could be a part of the development process.

5.1.2 Questionnaire method

The questionnaire method is a quick and efficient way to obtain information for large samples. A semi-structured questionnaire was developed for this study. There are many advantages to this questionnaire method.

- It is quick and easy to administer,
- it can obtain large amount of information in a short time,
- it allows for participation of the interviewee, and
- it is relatively cost effective (when compared to a more labour intensive questionnaire such as a census).

The goal of this investigation is to answer the research question by testing the stated hypotheses from chapter 3. An example of the questionnaire can be found in the Annex.

The surveys were performed face-to-face, predominantly on a one-on-one basis. An interview took approximately 30 minutes per person. The biggest issue with this method was the lack of literacy skills of most of the participants. In five villages this problem was solved through village meetings with an English/Telugu speaker. Although, as the village (group) meetings were organised as part of the CDM and LCF (Low Carbon Farming) awareness tours, the discussion with the village people about the social and economic impact of biogas, their experiences and expectations (etc.) may contain some bias and unreliable information. For example, many farmers often wrote similar answers to their neighbour's by looking to each other's sheet. For this reason in some cases I tried to do group interviews with help of a staff member who was able to explain the questions in the participant's native language. In the end, minor translation problems, mistakes or misunderstandings may have occurred however these are considered to have been sufficiently reduced thanks to the assistant's excellent command of English.

The SEDS database was utilised to locate the villages in which biogas is used and in this database 2,192 families are currently listed. The data from the questionnaires was entered by myself and through data cleaning and coding the final file was prepared. Errors in the preliminary spreadsheet prepared for the data analysis should be negligible.

5.2 Descriptive analysis and multiple regression models

All data from the questionnaires was entered into STATA. STATA is a statistical software package that offers a large number of statistical and econometric estimation functions. With STATA I can easily manage the data and apply standard statistical and econometric methods, such as regression analysis.

As mentioned in 5.1, I made a cross-sectional study that involves observations of a representative subset in the Anantapur district, at one specific point in time. For each category of indicators (social , economic, and environmental) I made a descriptive analysis with means, frequencies, t-tests and percentages to test the hypotheses developed in the previous chapters and the graphs presented show some significant results. Secondly, theory often suggests that the behaviour of a certain variable is influenced not only by a single variable, but by a multitude of factors. For example, the time to cook depends not only on the presence of a biogas-unit, but also on family size, and additional activities. Therefore, I will discuss three multiple regression models relating to the results of the descriptive analysis, for the dependent variable biogas use, cooking time and biogas slurry as field manure.

157 heads of households between 20 and 67 years old were asked to respond to the questionnaire and these household heads were mostly female; 117 females and 40 males. The mean family size of all respondents is 4.87 and 147 of the 157 households were involved with agriculture. 10 other respondents have another occupation. As mentioned before, these people were randomly interviewed in 27 villages, in 5 different Taluks (village-groups) and 17 different Gram Panchayats (small provinces).

5.2.1 Social Development: Model 1

In what follows I will examine the significance of certain independent variables in the first multiple regression model:

$$\textbf{Biogas} = \beta_0 + \gamma X + e_i$$

In the above equation owning a biogas-unit or not is the dependent variable, β_0 and γ represents the unknown parameters (constant and gradients), and X is a vector of the independent (explanatory) variables. I will investigate here how the variable *biogas* is influenced by the independent variables. A binary probit or logit model would be appropriate in this case (as the latter takes into account the possibility of using biogas must be situated between 0 and 1). However, I inspected and recoded some variables before I performed different regressions with the OLS (Ordinary Least Squares) estimator (with heteroskedasticity - robust standard errors), the so called 'linear probability model'[9]. The output from this model is presented in *table 1*.

From the 157 households, 72 interviewed families do not have a biogas-unit in comparison to 85 people who are in a possession. First I turned the yes/no biogas variable into a 0/1 biogas dummy taking on a value of 1 if the household uses biogas and 0 otherwise. Secondly, I prepared the independent variables; for example I generated the variable *annual income/family size* (gen anincome = anincomedummy / familymembers). I will now investigate how the variable *biogas* is influenced by these independent variables.

If I just include *family size* in the model, I can see a slight positive correlation with *biogas use* (coefficient = .0875797). I can conclude that having a larger household increases the chances of biogas adoption; on average, one more household member implies an increase of almost 9 percentage points in the chance of using biogas. Next, if I also add *age* (of the household head) to the model, I find a very small positive coefficient (.0053948).

In addition, I used the P value to look whether we have statistically significant partial correlations between *biogas use* on the one hand and *family size* and *age* on the other hand. If I focus on these two independent variables, I can see that the p-value for the *family size* coefficient is 0.001, which is below 0.05 and therefore statistically significant. The correlation with the second variable *age* however, is not significant in this model (p = 0.222).

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[9] A linear probability model is a special case of a binomial regression model. Here the observed variable for each observation takes values which are either 0 or 1. The probability of observing a 0 or 1 in any one case is treated as depending on one or more explanatory variables. For the "linear probability model", this relationship is a particularly simple one, and allows the model to be fitted by simple linear regression.

If I add the variable *annual income/familymembers* into the model, I see a positive correlation with *biogas use* (coefficient = .616207), however this is not significantly different from zero. Therefore I cannot deduce from this whether *annual income/familymembers* has a significant effect on the possession of a biogas-unit; i.e. when households have a higher annual income, they wouldn't necessary take the step to own a biogas-unit.

Finally, I add dummy variables for the different *taluks* and *grampanchayats* to see if the location of households is significantly correlated with *biogas use*. Here, chances of owning a biogas unit are relatively higher in taluks 2 and 4 (Gorantla and Roddam), compared to the reference taluk (i.e. Somandepalli). Also, chances of owning a biogas unit are relatively higher in grampanchayat 3, 5, 6, 8, 10, 11 (Thungodu, Edulabalapuram, Mallapalli, Kondapuram, Mavaturu, and Peddamanthur), compared to the reference grampanchayat (i.e. Somandepalli). By interviewing households in these areas it became clear that less people were able to have a biogas-unit, because of the distance of the biogas-unit from their house, water availability, and wood availability. Also, these significant location effects are by construction, since I selected experimental and control villages purposively on their use (or not) of biogas.

Table 10[10]: MODEL 1 – Owning a biogas-unit

	BiogasOLS1	**BiogasOLS2**	**BiogasOLS3**	**BiogasOLS4**
	b/se	b/se	b/se	b/se
familymembers	0.0876***	0.1026**	0.0934*	0.0487
	[0.0209]	[0.0465]	[0.0496]	[0.0531]
age		0.0052	0.0034	0.0058
		[0.0044]	[0.0047]	[0.0046]
anincome		0.6162	0.4729	0.3357
		[1.1192]	[1.1878]	[1.0955]
Gorantla			0.3725**	
			[0.1662]	
Penukonda			0.179	
			[0.1628]	
Roddam			0.3144**	
			[0.1433]	

[10] Heteroskedasticity-robust standard errors are reported in brackets. *, **, *** indicates significance at the 10%, 5% and 1% significance levels, respectively.

Chillamathur			0.2727*	
			[0.1380]	
Gudipalli				-0.0692
				[0.0481]
Thungodu				0.8826***
				[0.0566]
Magecheruvu				0.3719*
				[0.1937]
Edulabalapuram				0.9327***
				[0.0992]
Mallapalli				0.9174***
				[0.1049]
Vadigepalli				0.4718
				[0.3594]
Kondapuram				0.9184***
				[0.0597]
Rampuram				-0.0318
				[0.0444]
Mavaturu				0.8835***
				[0.0778]
Peddamanthur				0.7800***
				[0.1322]
Sanepalli				-0.0364
				[0.0564]
Roddam				0.5574***
				[0.1772]
Reddipalli				0.5319***
				[0.1462]
M. Kothapalli				0.4450***
				[0.1463]
Kodur				0.5156***
				[0.1134]
Chillamathur				0.4705***

				[0.1610]
_cons	0.1312	-0.3019	-0.408	-0.4836
	[0.1174]	[0.4830]	[0.5115]	[0.4602]
N	147	140	140	140
r2	0.0691	0.0772	0.1134	0.389
r2_a	0.0627	0.0568	0.0664	0.2922

It is important to remember the difference between a coefficient and a *t*-statistic. Coefficients are the estimated effects of variables but are not very useful without knowledge of the variance. Each coefficient is assigned a *t*-statistic. Further, I use the P value to assess whether the coefficients are significantly different from zero. If I focus on the most important variables, I can see that the significance level for biogas is 0.000 (p = 0.000), which is below 0.05 and therefore, there is a statistically significant difference.

I can also interpret the R^2 value, which helps with the interpretation of the goodness of fit of the model. In the first block, I see that the model declares 6.91 % of the variation in the dependent variable, which is an outcome or predicted by the independent variable (and the constant). The more independent variables I add to the model, the higher R^2 becomes. This can be misleading, as the model may contain several redundant variables which have little explanatory power. That is why also the adjusted R^2[11] is reported.

The main results that are produced by this model, is that age and family size does not have a great impact on owning a biogas-unit when considering the grampanchayat where the household resides. It can be suggested that this results from the fact that SEDS and their co-workers are in contact with all age-groups and households within the area regardless of the age of the family head and the family size. They have a clear policy about not making any exceptions for larger families or older people. Moreover, I can see from the results that younger as well as older people are using biogas. Next, it cannot be concluded that there is an effect of *annual income/familymembers* on the possession of a biogas-unit. When households have a higher annual income, they wouldn't necessary take the step to own a biogas-unit. Further, it can be suggested that the province and place (*taluk* and *grampanchayat)* does have some impact on the use of biogas. From interviewing households, I can

[11] The explanation of this statistic is almost the same as R-squared but it penalizes the statistic as extra variables are included in the model. The conclusion that R-squared increases with extra variables no longer holds, but downward variations are usually small.

conclude that areas with a higher availability of wood and water will not intend to have a biogas-unit at the same time as areas with less wood and water.

As can be seen from *Graph 1*, households without biogas devote a considerable amount of time to collecting, processing and using firewood for cooking. In all the villages without biogas, one to eight hours per day can be devoted to the collection of fuel for cooking. This is time that could be spent on child care, education, agriculture related work, leisure, socializing, vocational work or income generation. In villages where biogas-units are installed, people spend less time on cooking and all associated activities and therefore have more time available for all the aforementioned activities (e.g. childcare and education).

When using biogas, people can engage in a greater number of additional activities such as agriculture related work, vocational work, looking after children, and more leisure activities. In comparison with non-biogas users, these people have more time for themselves which benefits their social development. From interviews it appeared that children had more time for education, reading a book, and schoolwork, which can result in social benefits in the longer-term. *Graph 2* compares the percentage of biogas users and non-biogas users partaking in a number of additional activities. Note that these categories of activities are not mutually exclusive.

Figure 10: Cooking hours - cooktime (percentages of interviewees)

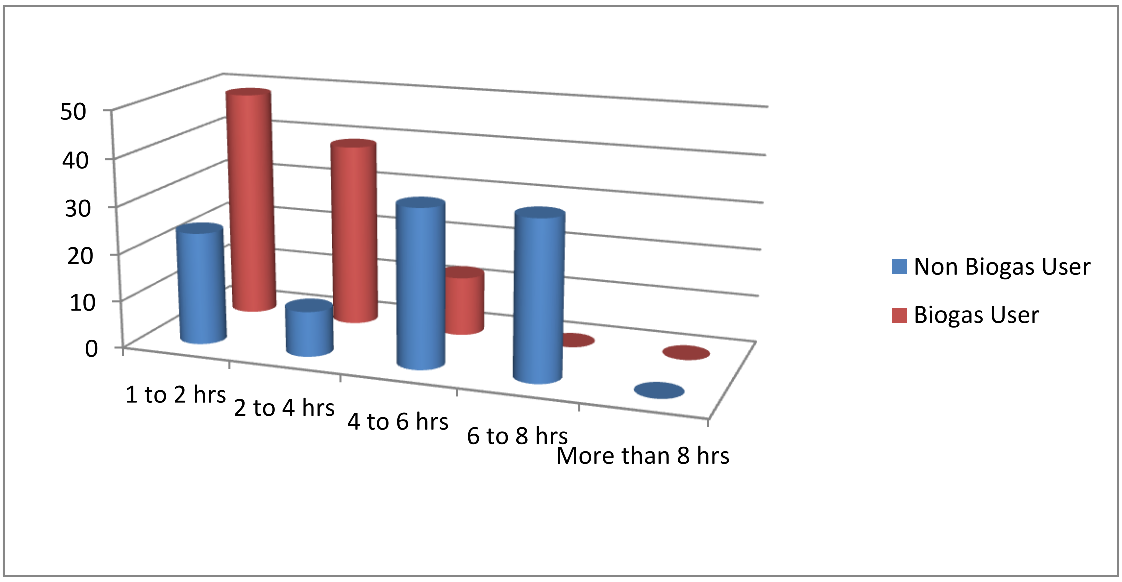
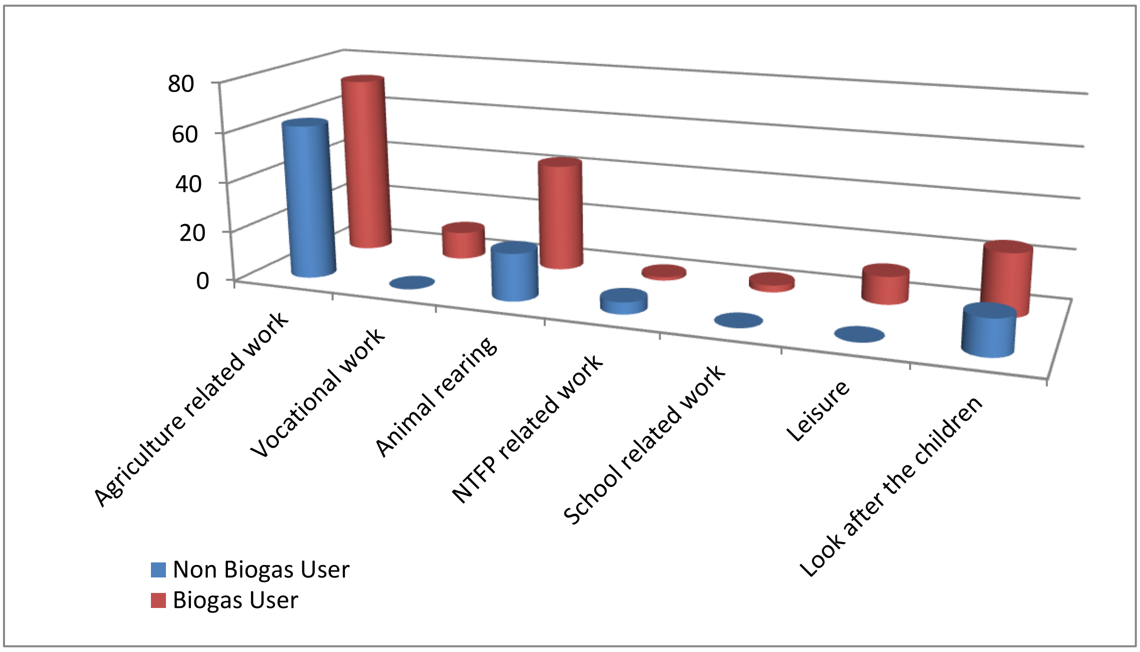


Figure 11: Additional Activities - addact (percentages of interviewees)



5.2.1.1 T-tests

I compared two sample means. I measured the impact of support for biogas from smallholders on the use of biogas. In the questionnaire I asked the following question: *Do you support the idea of biogas-installations for every household?* Asking this question would reveal the thought of smallholders on the concept of biogas.

If P>|t| is smaller than 0.05, the null-hypothesis of equal sample means can be rejected at the 5% significance level. Here, there is a very significant and large correlation (coefficient = .9345) between support for biogas and its actual use. It seems that people supporting the use of biogas would like to possess a biogas-unit as well.

Table 11: Support

	supportOLS1
	b/se
supportdummy	0.9345***
	[0.0288]
_cons	0.0533**

	[0.0261]
N	157
r2	0.8775
r2_a	0.8767

Next, I compared two sample means by groups. I wanted to see whether males and females differ in their opinions regarding biogas. If P>|t| or P>t are lower than 0.05 then the opinions around biogas-use differs between males and females. By interviewing both males and females, it appeared that males are much more interested in the know-how of biogas and CDM, CER's and the carbon and environment aspects, in comparison to females who are only interested in efficient cooking techniques. This is consistent with the statistical results in the following table, where we can see that female's interests in biogas are lower than men's.

Table 12: Opinion Females

	femaleOLS1
	b/se
femaledummy	-0.4812***
	[0.0662]
_cons	0.9000***
	[0.0477]
N	157
r2	0.1771
r2_a	0.1718

5.2.2 Health Improvement

As previously explained, non-biogas users are more exposed to the dangers of cooking with firewood and smoke in the kitchen, than biogas-users. Non-biogas users complain about the indoor air pollution and particles from smoke. Exposure to indoor pollution can have very serious health consequences most predominantly a higher risk of respiratory illnesses such as bronchitis and pneumonia.

In this research I see that people who use biogas for cooking complain less about their health. By interviewing the respondents it becomes clear this is not only the consequence of a healthier environment in the kitchen, but also a reduction in the amount of time spent searching for firewood. The distance travelled to collect firewood for non-biogas users is up to 8 km and this task is very time-consuming, often taking several hours per day. The labour is very hard and can lead to neck and spinal stress, headaches from carrying heavy loads, cuts, bruises and injuries from going to forests and chopping fuel wood.

As the graphs below seem to suggest, a shift to a biogas system can lead to local health benefits such as the elimination of a smoke-filled cooking environment, soot-free walls, prevention of eye infections, improvement in rural sanitation, etc.

Figure 12: Current Health Status - healthprob (percentages of interviewees)

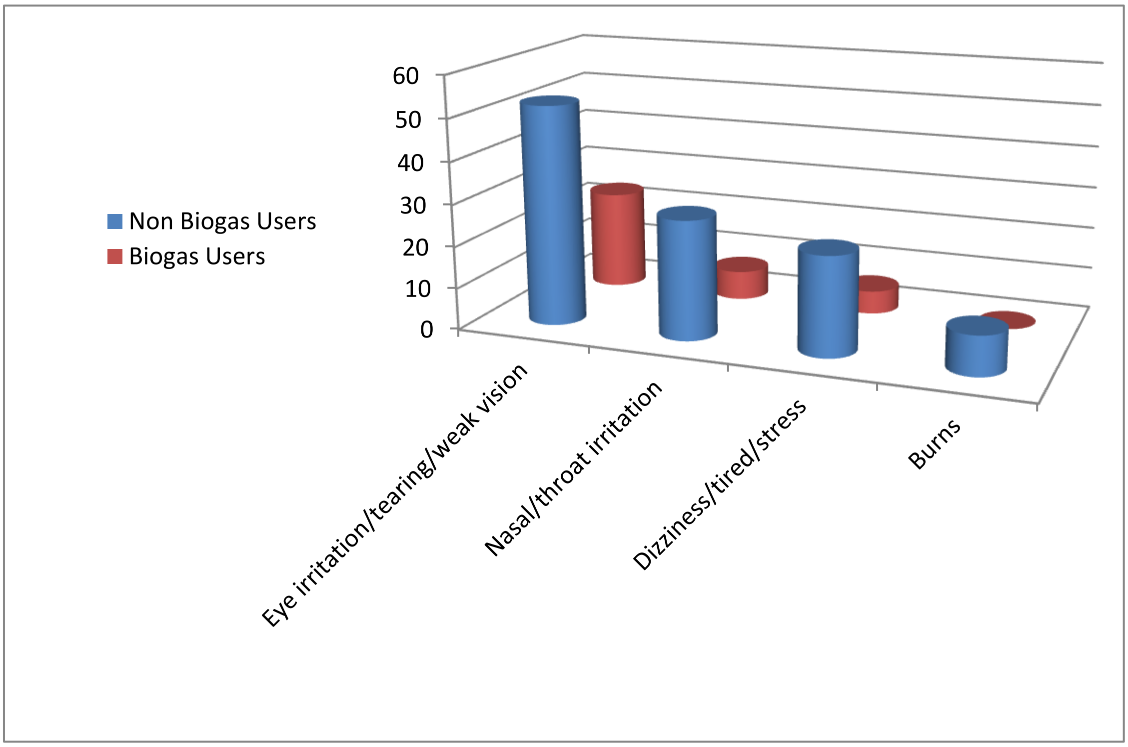
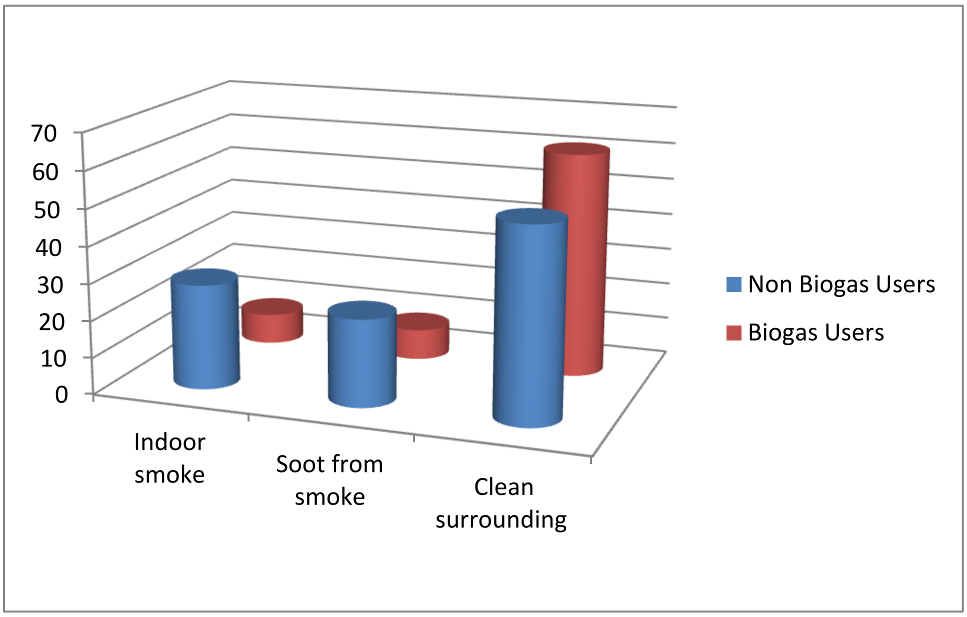


Figure 13: *Hygiene and pollution - qualityair (percentages of interviewees)*



5.2.3 Economic development

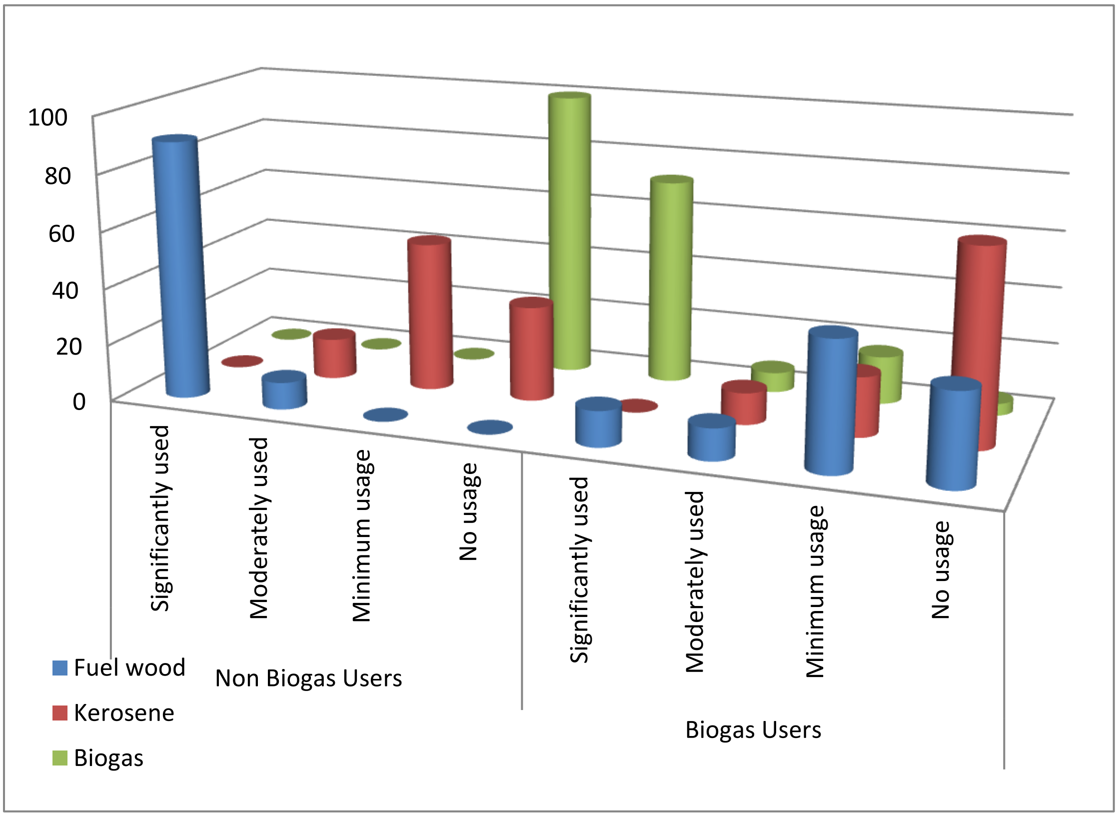
First, I looked at the respondents preferred choice of energy. I could see biogas-users use more biogas as type of energy for cooking than other sources (i.e. wood and kerosene). However, there were some exceptions to the rule which could be explained by the malfunctioning of some biogas-units. It is surprising to see that biogas-users still use fuel wood and kerosene as a second or third energy type. This can be attributed to the tradition of using fuel wood and kerosene as a source of energy. Moreover, there seems to be a lack of trust in biogas as an important energy type and perhaps this is due to habit i.e. energy use may shift only gradually over time when they become a viable alternative to traditional energy types.

In the questionnaire I asked directly about the annual income of the household (Rs/year). During the research it became clear many households were unsure on their annual income. This was often deduced by locals conferring with others and estimating an average annual income.

Another very important economic benefit is the improvement of agriculture due to a better management of dung and organic wastes. Farmers have more time to spend on agricultural related work and can use their biogas-slurry as fertilizer. Despite this, the results show that 75.80% of the respondents use farmyard manure (FYM) as fertilizer instead of biogas-slurry and 67.52% of the biogas-users still use an expensive chemical fertilizer. From discussions held with the respondents it appeared that there is a lack of trust in the slurry of produced by a biogas-unit and its use as a good fertilizer.

24.84% of the respondents declared that they know someone who directly/indirectly works for the biogas-project. In addition, the hypothesis stated in section 4, about the fact that experienced people are needed in the building of biogas digesters, seems correct. The biogas sector also often creates spinoff jobs rooted in the rural communities.

Figure 14: Energy type usage (users in percentage)



5.2.4 Social-Economic Development: Model 2

In what follows I will assess the significance levels when I input certain independent variables into the below multiple regression model.

$$\mathbf{Th = \beta_0 + \beta_1\, biogas + \gamma\, X + e_i}$$

Here, I will investigate how the variable COOKTIME (Th) (i.e. signifies the amount of time a household will spend on cooking) is influenced by the independent variables. Again, I chose for a simple linear model estimated with OLS. First of all, I have to recode some of the variables before calculating different regressions with OLS estimator (with heteroskedasticity - robust standard errors). I transform the COOKTIME variables into one CookTime_n variable with values 1-5. The output from this is presented in *table 2*.

I see that there are 157 observations used in the regression. The most important of these numbers are the coefficients and their p values. The coefficients tell us the effect of each X on Y (dy/dx). In this case none of the variables are in log form so the interpretation is considered to be straightforward. The coefficients tell me how Y changes if X changes by one unit. When I include only the binary variable *biogas use* in the model (CookOLS1), I can see that *biogas use* is negatively correlated with *cooking time* (coefficient = -.8805556). Moreover, the coefficient is significant at the 1% level. Therefore it can be suggested that when people use biogas for cooking, it goes faster and they need less time to prepare their meals.

In the second block, I add *family size.* Now I see that *biogas use* is still negatively correlated with *cooking time* and *family size* is positively (and significantly) correlated, as expected. *Biogas use* has an even larger coefficient = -.9338609, because of the fact that the more family members there are in one household, the more time they need to cook, even with biogas.

After making dummies for the variable ADDITIONAL ACTIVITIES (AddAct1 = Agriculture, AddAct2 = Vocational work, AddAct3 = Animal rearing, AddAct4 = NTFP, AddAct5 = School related, AddAct6 = Leisure, AddAct7 = Children, AddAct8 = No time) and adding them to the model, *biogas use* is still negatively correlated with *cooking time* and *family size* is still positively correlated. I also see that *leisure* (coefficient = -.2467311) is the only variable besides *biogas use* that is negatively correlated with *cooking time*. Although the addact6 coefficient is not significantly different from zero, I might assume that if family members have more time for leisure, they need less time for cooking. From talking with the interviewees, leisure seems to be the most valuable/desired additional activity. When people have time to read a book or watch television, they are considered to have a better work-life balance. The interviewed households start to prioritize between "work" (career and ambition) and "lifestyle" (health, pleasure, leisure, family and spiritual development/meditation).

In the next block, in addition to *family size* and dummies for *additional activities,* I also add *Taluk* dummies. Again, I see that *biogas use* is negatively (B = -.8401727) correlated with *cooking time* and *family size* is still positively correlated. Significance of both coefficients is also maintained.

Following on from this, I look at the effect if I include *Gram Panchayat* dummies. If I, after the addition and thus control of all the independent variables, look at the effects of all independent variables on the dependent variable *"How many hours do you cook?"* I note that biogas users score on *cooking time* is 0.67 points lower when compared to non-users. The difference is clear: the more variables we use in the model, the less *biogas use* is negatively correlated with *cooking time*. Other variables will account for some of the effect of biogas use on the dependent variable *cooking time*.

Table 13: MODEL 2 – Cooking time

	CookOLS1	CookOLS2	CookOLS3	CookOLS4
	b/se	b/se	b/se	b/se
biogasdummy	-0.8806***	-0.8383***	-0.8402***	-0.6654***
	[0.1370]	[0.1622]	[0.1652]	[0.1808]
familymembers		0.1346***	0.1241***	0.0885*
		[0.0480]	[0.0469]	[0.0493]
addact1		0.3080*	0.3026*	0.2114
		[0.1785]	[0.1720]	[0.1692]
addact2		0.0117	-0.0108	0.0791
		[0.2002]	[0.1880]	[0.2026]
addact3		0.0552	0.1112	0.052
		[0.1676]	[0.1735]	[0.1820]
addact4		0.0872	0.277	0.9399***
		[0.2629]	[0.2687]	[0.2638]
addact5		0.0027	-0.036	-0.3106
		[0.2687]	[0.2546]	[0.2395]
addact6		-0.2467	-0.2795	-0.347
		[0.2760]	[0.3012]	[0.2809]
addact7		0.2207	0.3084	0.2192
		[0.2092]	[0.2219]	[0.1994]
addact8		0.6451**	0.6201**	0.4676
		[0.2966]	[0.2902]	[0.3073]
Gorantla			0.1284	
			[0.3158]	

Penukonda			0.043	
			[0.3010]	
Roddam			-0.2653	
			[0.2854]	
Chillamathur			0.2137	
			[0.2581]	
Gudipalli				0.3411
				[0.6288]
Thungodu				0.1802
				[0.4827]
Magecheruvu				-0.1397
				[0.5443]
Edulabalapuram				-1.1392**
				[0.4966]
Mallapalli				-0.2236
				[0.6121]
Vadigepalli				-0.8354
				[0.7611]
Kondapuram				0.0417
				[0.4831]
Rampuram				0.2433
				[0.5562]
Mavaturu				-0.2638
				[0.8201]
Peddamanthur				-0.3494
				[0.5043]
Sanepalli				0.3355
				[0.6298]
Roddam				-1.0328**
				[0.4755]
Reddipalli				-0.2957
				[0.5045]
M. Kothapalli				0.6009

				[0.4838]
Kodur				-0.2605
				[0.4956]
Chillamathur				0.0516
				[0.5253]
_cons	2.6806***	1.6290***	1.6098***	1.9216***
	[0.1061]	[0.3253]	[0.3789]	[0.5591]
N	157	147	147	147
r2	0.2136	0.294	0.3335	0.4632
r2_a	0.2086	0.2421	0.2628	0.3469

I can also interpret the R^2 value, which as previously explained illustrate the goodness of fit of the model. In the first block, I see that 21.36 % of the variation in our dependent variable is accounted for (or predicted by) our independent variable biogas use (and a constant). The more independent variables I add to the model, the higher R^2 becomes. This can be misleading, as the model may contain several redundant variables which have little explanatory power. In this case, *taluk* seems to be a variable with little explanatory power. The *grampanchayat* dummies, however, seem to have some explanatory power as the adjusted R^2 increases from 0.2086 to 0.3469.

The main conclusions that can be made from this model are; that when people use biogas for cooking the cooking process seems to occur faster and the more family members there are in one household, the more time they spend on cooking, even with biogas. Furthermore, I can assume that if family members have more time for leisure, they need less time for cooking and consequently they have a better work-life balance. Finally, the place (*taluk)* does not have a significant effect on the cooking process whereas the coefficients of the grampanchayat 5 and 13 dummies (Edulabalapuram and Roddam) are significant at the 5% level.

5.2.5 Environmental development: Model 3

The various indicators assessed to study the impact on the environment are:

- Water quantity
- Air quality
- Soil conditions
- Biodiversity (species and habitat conservation)

The results show indirectly that biogas systems not only lead to direct benefits such as reduced emissions of air pollutants when fossil fuels are replaced, but also indirect benefits from changed land use and handling of organic by-products. A shift to biogas from traditional biomass fuels result in less dependence on natural resources such as forests, and helps to tackle unsustainable exploitation. Effective communication with the farmers is essential to keep biogas-users aware of how they can keep the environment clean and hygienic. As mentioned before, biogas includes reduced indoor pollution, as well as reduced soil erosion and the process of siltation in lakes.

Water quality will improve from the treatment of wastes that would normally enter ground or surface water, in areas where gas replaces wood or other bio-fuels for cooking. Another result from the research on water quantity shows that there is no reduction on water quantity with the use of biogas. In villages where there is a lack of water, the interviewed people will rather not use biogas-units because of the greater amount of water that is needed for the mixture of the cow dung. People in the rural district of Anantapur said they need all the water they have, and they don't want to 'waste' it on biogas-units.

In model 3, I will investigate how the field manure is influenced by a number of independent variables:

$$\textbf{Fieldman1} = \beta_0 + \gamma\, X + e_i$$

In the above equation field manure (slurry from the biogas-unit) is the dependent variable, β_0 and γ represent the unknown parameters (constant and gradients), and X is a vector of independent (explanatory) variables. Again, I have to recode some variables before I can calculate different regressions with the OLS estimator (with heteroskedasticity - robust standard errors). Using this equation, I will investigate which variables influence most strongly the use of biogas slurry as manure on the fields. By interviewing different households it became clear that not so many people believed in biogas slurry as a good replacement of chemical fertilizers, cow dung, or farm yard manure. The output is presented in *table 3*.

If I add *age* to the model (FieldOLS1), I can see that this independent variable is slightly positively correlated with *fieldman1* (B = .0117308). Although this is a very small correlation, I can conclude that older people tend to use more biogas slurry on their fields. They might be better educated in the use of biogas slurry therefore understanding that the organic composition of biogas slurry is a high quality field manure.

In the second block (FieldOLS2), I add *annual income/family members.* I see that this variable is negatively correlated with *fieldman1* (B = -.3296828), as expected. After adding *fieldman2* (use of chemical fertilizer for field manure) and *fieldman3* (other types of field manure), *annual income/family members* is still negatively correlated with *fieldman1,* but not significant. At the same time *fieldman2* (B = -0.0689) and *fieldman3* (B = -0.4627) are negatively correlated. Therefore, as expected, the greater number of other types of field manure farmers use on their fields, the less likely biogas slurry is used.

After adding *taluk* and *grampanchayat* (FieldOLS4 and 5, respectively), I see that taluk 3 (Penukonda) and grampanchayat 11 (Peddamanthur) have a significant effect on the dependent variable *fieldman1*. This might be the result of better communication and awareness in this area between SEDS co-workers and the farmers on the fact that biogas-slurry is a high quality and productive field manure.

Table 14: MODEL 3 – Field manure

	FieldOLS1	**FieldOLS2**	**FieldOLS3**	**FieldOLS4**	**FieldOLS5**
	b/se	b/se	b/se	b/se	b/se
age	0.0117***	0.0111***	0.0052	0.0046	0.0023
	[0.0040]	[0.0042]	[0.0039]	[0.0041]	[0.0037]
anincome		-0.3297	-0.4842	-0.5759	-0.6179
		[0.5613]	[0.4283]	[0.4334]	[0.4834]
fieldman2			-0.0689	-0.1238*	-0.1773**
			[0.0714]	[0.0726]	[0.0883]
fieldman3			-0.4627***	-0.5245***	-0.5395***
			[0.0823]	[0.0852]	[0.0881]
Gorantla				0.1548	
				[0.1031]	
Penukonda				0.4630***	
				[0.1291]	
Roddam				0.117	
				[0.1002]	
Chillamathur				0.133	
				[0.0959]	
Gudipalli					-0.1822
					[0.1484]
Thungodu					0.3586**
					[0.1633]
Magecheruvu					0.0424
					[0.1274]
Edulabalapuram					-0.0898
					[0.0801]

Mallapalli					0.0782
					[0.2948]
Vadigepalli					-0.1647
					[0.2222]
Kondapuram					0.2129
					[0.2063]
Rampuram					0.0458
					[0.0739]
Mavaturu					-0.0212
					[0.0913]
Peddamanthur					0.9272***
					[0.1594]
Sanepalli					0.1537
					[0.1019]
Roddam					0.1578
					[0.2049]
Reddipalli					0.1812
					[0.1351]
M. Kothapalli					0.2553*
					[0.1538]
Kodur					0.1254
					[0.0875]
Chillamathur					0.2089
					[0.1326]
_cons	-0.1213	-0.0207	0.5966**	0.5483**	0.6539***
	[0.1581]	[0.2285]	[0.2337]	[0.2254]	[0.2219]
N	148	140	140	140	140
r2	0.0591	0.0607	0.2523	0.3147	0.4796
r2_a	0.0526	0.047	0.2302	0.2728	0.3921

If households do not own a biogas unit it logically follows that they will not use biogas slurry as manure. Therefore I draw the attention to the fact that these non-biogas users can lead to a bias in the model results. Further, I can also interpret the R^2 value, which as previously explained illustrates the goodness of fit of the model. In the first block, I see that the model declares 5.91 % of the variation in our dependent variable that is accounted for (or predicted by) our independent variable (and the constant). The more independent variables I add to the model, the higher R^2 becomes (R^2 in FieldOLS5 = 47.96%).

The main conclusions I can make from model 3, are that older people seem to use more biogas slurry on their fields than younger people, when excluding the use of other types of manure and the location. They may be better informed or educated in the organic composition of biogas slurry and its properties as a high quality field manure. Although the effect seems non-significant, I can assume from interviews with households that the more income a household has, the more they are going to invest in other (more costly) types of field manure, such as chemical fertilizers. In addition, the use of chemical fertilizers, cow dung, or farm-yard manure, reduces the use of biogas slurry. This is not good for the environment in the sense that biogas slurry is a lot less harmless when compared to chemical fertilizers. Finally, I could see that taluk Penukonda and grampanchayat Peddamanthur have a significant effect on the use of biogas slurry and this could be a result of good communication and awareness in this area between SEDS co-workers and the farmers on the fact that biogas-slurry is a high quality and productive field manure.

6 Conclusion

It is clear that the increase in GHGs leading to global warming has become a real threat to our livelihood. Today's fragmented world demands creative institutional arrangements to allow governments, international organizations, and civil society actors to join forces in addressing global environmental problems. This thesis described the CDM, as established under Article 12 of the Kyoto Protocol, as an innovative mechanism that can help industrialized countries meet their obligations under the Kyoto Protocol in a cost-efficient manner while promoting sustainable development in non–Annex I countries. As an economic mechanism, the CDM seeks to draw on markets to provide the economic incentives and financial structures to promote sustainable development. Ever since this mitigation strategy of carbon trading was conceptualized in the Kyoto Protocol, India seems to have been one of the most pro-active countries in terms of translating the concept into action.

In this research project I tackled the research question: "***What is the social and economic impact of biogas on the smallholders in the Anantapur district, India?"*** I studied the contribution of CDM to the sustainable development of single households, which is measured on indicators that fall into three broad categories: local/global environment sustainability, social sustainability and development, economic and technological development. By conducting an in-depth, cross-sectional research study, I have seen that the biogas technology can be an important contribution to achieving these goals in many different ways.

First, while using biogas for cooking, social benefits, such as time saving, village self-reliance, and skill generation, can occur. Households will engage in more additional activities, such as education and agriculture, and family members will have more time for leisure. Due to these social benefits, the improved work-life balance of Indian households with biogas-units has a positive effect on their everyday life. Secondly, I can conclude that biogas is promoting economic self-sufficiency. Biogas is very cost-effective and therefore, smallholders can use saved money to buy other assets to improve their social and economic lifestyles. Furthermore, the cost of a biogas plant is minimal thanks to the investments of SEDS and their partners. Another very important economic benefit is the improvement of agriculture due to a better management of dung and organic wastes and moreover, this relative small biogas sector often creates spinoff jobs rooted in the rural communities. Thirdly, it is clear from this study that biogas systems not only lead to direct environmental benefits, such as reduced emissions, but also indirect environmental benefits. For example, many smallholders use organic waste and crop residues for biogas production. Households use less wood to cook, which leads to many advantages, with the most important improvement being regarded as the reduced indoor pollution and fewer particles from smoke.

The variables describing the process can lead to a scientific design for a larger study, particularly in forming important hypotheses and constructing/designing approaches to tackle conceptual and measurement problems. The analysis I made is limited in the sense that the identification of the variables, their interactions and the way they influence any particular aspect of social-economic change have been constrained into three models. More conclusions could be made by extending the analysis to different models and subsequent comparing and contrasting of the various outputs.

An important issue arising from this research is the fact that there is some inertia at work. People's traditions with respect to energy use may only shift gradually over time. Therefore, a strong case needs to be made for effective communication with the farmers in order to keep biogas-users aware of how they can keep the environment clean and hygienic. Through roots in the local community, NGOs can mobilize stakeholders' participation. They can gather important primary data through initial surveys of the present situation, predict trends related to climate change issues, and create favorable conditions for project implementation through dialogue and increased awareness. They also have specific knowledge that helps to prioritize CDM mitigation options, capacity building activities, and policy measures.

In a large developing country like India, NGOs need to fill in the voids left by the government during the development process. This can lead to a modern India, where the very poor can grow closer to the rich. The main constraint of this research lies in the participation of the people in the various stages of CDM implementation. When it comes to project implementation, the participation of NGOs is critical in helping to ensure that; (a) the dual objectives of achieving sustainable development in non–Annex I countries and additional emission reductions are achieved; and (b) non–Annex I countries have the capacity to request technology and projects that help them achieve their sustainable development goals. NGOs can tap into local knowledge and enhance benefits flowing to local communities by enabling project developers to better recognize community needs. In conclusion, an effective and active involvement of local NGOs and stakeholders in project design and implementation can reduce the financial risks of a project by achieving local public support and avoiding costly political opposition, legal action and local unrest.

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8 ANNEX

8.1 Annex 1: Description of the monitoring plan

This biogas CDM project is implemented for 5000 members of the SEDS village organisational network made up of 121 individual village organisations. A Standard Operation Procedure Manual is prepared for implementation and monitoring of the project activity, which will be followed by the CDM Team. The project implementation and monitoring team comprise of the following:

- CDM coordinator: appointed by the SEDS board of trustees. He manages the project on a full time basis.
- Project Staff: 1 database manager, 10 biogas field workers. These are appointed by the CDM coordinator.
- Masons: 50 individuals are selected through the village organisations to partake in an apprenticeship programme through which they were fully trained as biogas masons.
- Village level volunteers (VLV): Each village organisation selected a village level volunteer on an annual basis. This volunteer will maintain a daily usage register for each unit built in their village and enter them into the digitized monitoring system on a monthly basis.
- A maintenance team is appointed post implementation to ensure that all units are fully operational for the lifetime of the project.

8.1.1 Monitoring database

An online digitized system, custom built for monitoring this biogas-CDM Project, is used to enter data on an everyday basis and generate real-time online progress reports. Inputting data into this intranet solution is permission driven – i.e. each biogas field worker can record construction progress of only those villages entrusted to her/him; volunteers can record daily usage only for their respective village; etc. Progress and analytical reports are totally transparent, open for one and all. These reports are perused by:

- Village organisation functionaries who meet regularly to discuss the progress made in their respective villages. All of these meetings are also be attended by the respective biogas field worker of the area. Any problems identified are discussed.

- Project staff who meet every week to ensure the smooth supply of material and timely construction of the biogas units.
- After the construction and satisfactory functioning of each biogas plant for a minimum of 2 weeks, an end user agreement on legal paper is signed with the respective beneficiary, and this date is taken as the day of commissioning of that particular biogas unit. Thus from day 1 of the commissioning of the biogas plant, full account of emission reduction can be considered.
- All data is archived and stored throughout the crediting period and an additional two years.

8.1.2 Stakeholders' comments

The local stakeholders identified for this project are:

- Village communities (Self Help Group members, Village level volunteers)
- Elected members of the Village organisations
- Gram Panchayat members
- SEDS staff
- Members of the district forestry division
- Members of the district NEDCAP division
- Local NGO's
- NGO's affiliated with the Gold Standard (REDS)

The stakeholders meeting was held on the 16th July 2008 at the SEDS vocational training centre situated in Penukonda, Anantapur district, Andhra Pradesh. A personal invitation along with a copy of the non technical PDD was sent in an appropriate language (Telugu, English) to the stakeholders identified above. The SEDS field staff also spread word of the meeting to all village members they encountered in the weeks preceding the meeting. An open invitation to the meeting was posted on the SEDS web-blog and was also published in a local newspaper daily on Sunday the 13th July 2008. The meeting comprised of village members, village level volunteers, VO members, SEDS staff, Panchayat members, members of district NEDCAP division and members of Local NGO's. All the stakeholders were supportive of the SEDS initiative to undertake such a pro poor CDM project and promised to support the project in any way possible. No adverse comments were received by any of the local stakeholders (PDD & SEDS, 2006).

Comments:

- **Village people (SHG members, VLV's, VO members):** The village people were very happy about the introduction of the project.
- **Local Panchayats:** The local Panchayat members offered their support for the project. They asked whether any similar CDM initiative could be taken up to benefit the people residing in the town areas.
- **NEDCAP:** The district level NEDCAP officer Mr. Kondanda Ramaiah, Executive Engineer, offered his encouragement for the project. He praised the initiative of the organisation in making the merits of clean cooking technologies available to all segments of society.
- **Local NGO's:** The local NGO's said it was an excellent initiative to help the most vulnerable sector-the rural women and wished SEDS all the best in implementing the program. They saw no negative environmental or social impact.

8.2 Annex 2: Questionnaire – Internship CDM research:

DATE of survey: ….. - ….. - ……….	
District	
Taluk	
Gram Panchayat	
Village	

Biogas = YES/NO

NAME (Head of household)			
Qualification			
Occupation			
Age (Years)		Sex (M/F)	
How many family members:			

1. Why did you start with CDM?

2. How does your biogas-unit work?
    a. Very good
    b. Good
    c. Neutral
    d. Bad
    e. Very Bad

3. Are you happy with the CDM project? Why? Happy = YES/NO

Hreason1 = easy cooking
Hreason2 = clean house
Hreason3 = save time
Hreason4 = better for health

4. Which aspects of the CDM project would you like to be improved?
    a. Communication
    b. Public awareness
    c. Construction process
    d. Excavation process
    e. Maintenance process of the biogas-unit
    f. Material
    g. Other

Improve1 = Communication
Improve2 = Public awareness
Improve3 = Construction process
Improve4 = Excavation process
Improve5 = Maintenance process of the biogas-unit
Improve6 = Material
Improve7 = Other

5. Do you support the idea of biogas-installations for every household? Why?

Support = YES/NO

SOCIAL IMPROVEMENT – LIVELIHOOD OF THE POOR

1. Collection of firewood:
○ 1 to 4 hrs/day
○ 4 to 6 hrs/day
○ 6 to 8 hrs/day
○ Weekly once
○ Monthly twice
○ Monthly once
○ Purchasing
○ Not collecting

ColFirewood1 = 1 to 4 hrs/day
ColFirewood2 = 4 to 6 hrs/day
ColFirewood3 = 6 to 8 hrs/day
ColFirewood4 = Weekly once
ColFirewood5 = Monthly twice
ColFirewood6 = Monthly once
ColFirewood7 = Purchasing
ColFirewood8 = Not collecting

2. Distance travelled for firewood collection
○ Up to 2 km
○ 2 to 4 km
○ 4 to 6 km
○ 6 to 8 km
○ More than 8 km
○ Not going

DistFirewood1 = up to 2 km
DistFirewood2 = 2 to 4
DistFirewood3 = 4 to 6
DistFirewood4 = 6 to 8
DistFirewood5 = More than 8 km
DistFirewood6 = Not going

3. Cooking time

Cooktime1 = 1 to 2 *Cooktime2 = 2 to 4* *Cooktime3 = 4 to 6* *Cooktime4 = 6 to 8* *Cooktime5 = More than 8*	○ 1 to 2 hrs ○ 2 to 4 hrs ○ 4 to 6 hrs ○ 6 to 8 hrs ○ More than 8 hrs

4. Additional activity carried out in extra time available

AddAct1 = Agriculture *AddAct2 = Vocational work* *AddAct3 = Animal rearing* *AddAct4 = NTFP* *AddAct5 = School related* *AddAct6 = Leisure* *AddAct7 = Children* *AddAct8 = No time*	○ Agriculture related work ○ Vocational work (tailoring, sericulture, running petty shop, etc.) ○ Animal rearing (selling milk of cows – milk business) ○ NTFP related work (Non-Timber Forest Produce related work: collection of seeds, deseeding fruits, etc.) ○ School related work (cooking for students, teacher, etc.) ○ Leisure: watching television, reading a book, studying ○ Look after the children: helping with schoolwork ○ No time for additional activities

ACCESS TO ENERGY SERVICES

Energy type	Significantly used	Moderately used	Minimum usage	No usage
Fuel wood	*Fuel1*	*Fuel2*	*Fuel3*	*Fuel4*
Kerosene	*Kerosene1*	*Kerosene2*	*Kerosene3*	*Kerosene4*
Biogas	*Biogasuse1*	*Biogasuse2*	*Biogasuse3*	*Biogasuse4*

EMPOWERMENT

Is it possible for you to make coffee/tea/snacks for unexpected guests who come for a quick visit to your house in a **very short time**?	*ServeCof*	YES/NO
Do you discuss about projects/work with other people?	*Discuss*	YES/NO
Are you feeling involved in a project (for example the LCF or CDM-project)?	*FeelInv*	YES/NO
Are you able to provide food for your children in a **short time**? *Example: Giving enough time for children to get ready and go to school.*	*ProvideFood*	YES/NO
Do you take part in a village level organisation?	*Participating*	YES/NO

ECONOMIC WELL-BEING

1. What is you annual income (Rs/family/year)

- Rs. 1000-5000
- Rs. 5000-10000
- Rs. 10000-15000
- Rs. 15000-20000
- Rs. 20000-25000
- Rs. 25000-30000
- Rs. 30000 or more

AnIncome1= 1000-5000

AnIncome2 = 5000-10000

AnIncome3= 10000-15000

AnIncome4 = 15000-20000

AnIncome5= 20000-25000

MONETARY SAVINGS THROUGH BIOGAS USAGE

Do you purchase kerosene?	*PurchKero*	YES/NO
Do you purchase firewood?	*PurchFire*	YES/NO
Do you know someone who direct/indirect works for the biogas-project?	*ProjectWork*	YES/NO
Do you use FYM (farmyard manure) as fertilizer instead of biogas-slurry?	*FYM*	YES/NO
Do you still spend money on chemical fertilizer?	*Chemical*	YES/NO

Circle the assets that you possess:

Oil engine or electric motor	Tractor	Thresher/ Winnower	Tube well	Sprayers	Bullock carts

Circle the assets that you possess:

Bicycle	Television	Radio	Fan	Motorcycle	Car

Circle the basic amenities you have in the house:

Toilet	Protected drinking water	Bathing room	Electricity connection	Kitchen

LOCAL/REGIONAL/GLOBAL ENVIRONMENT – WATER QUANTITY

1. What is the change you see in the quantity of water which you use for washing, cleaning, cooking, etc.
   - Increase in water used
   - Decrease in water used
   - No change

ChangeWat1= increase

ChangeWat2 = decrease

ChangeWat3 = no change

1.1 Reasons for increase/decrease?
   - More/less washing vessels
   - More/less washing clothes
   - More/less cleaning house

CWreason1 = washing vessels

CWreason2 = washing clothes

CWreason3 = cleaning house

CWreason4 = water for biogas

LOCAL/REGIONAL/GLOBAL ENVIRONMENT – AIR QUALITY

2. How is the air quality?
   - Indoor smoke
   - Suspended particles in the air
   - Clean surrounding
   - Soot from smoke

QualityAir1 = indoor smoke

QualityAir2 = suspended particles

QualityAir3 = clean

QualityAir4 = soot from smoke

LOCAL/REGIONAL/GLOBAL ENVIRONMENT – HEALTH

3. Do you have health problems?

HealthProb1 = eye	○ Eye irritation/tearing/headache/weak vision
HealthProb2 = nasal	○ Nasal irritation/throat irritation/flu/cold
HealthProb3 = heart	○ Heart/rapid pulse/chest/breathing problems
HealthProb4 = dizziness	○ Dizziness/tired/stress
	○ Burns
	○ No problems

LOCAL/REGIONAL/GLOBAL ENVIRONMENT – SOIL CONDITION

4. What do you use as manure on the fields?

FieldMan1 = slurry biogas	○ Slurry from the biogas-unit
FieldMan2 = chemical	○ Chemical fertilizer
FieldMan3 = other	○ Other (Cow dung, FYM)
FieldMan4 = nothing	○ Nothing
	Why?

4.1 Do you think the slurry will increase your manure production and help you to reduce the use of chemical fertilizer? Extent of improvement:

ExtImprov1 = great extent	○ Great extent
ExtImprov2 = some extent	○ Some extent
ExtImprov3 = no difference	○ No difference
ExtImprov4 = negative impact	○ Negative impact

Thank you for your time!

8.3 Annex 3: CDM Super Report

Table 15: Interviews males and females

District	Taluk/Mandal	Gram Panchayat	Village	Male headed	Female headed	Main Occupation
Anantapur	Somandepalli	Somandepalli	Nalagondrayanapalli	11	9	Agriculture
		Gudipalli	Gudipalli	9	2	Agriculture
		Thungodu	Thungodu		1	Agriculture/Daily labour
		Magecheruvu	Magecheruvu		4	Agriculture/Daily labour
		Thungodu	Chinnababaihapalli	5	7	Agriculture
		Thungodu	Kolimipalli		2	Agriculture
		Thungodu	Kavelinagepalli		1	Agriculture
		Thungodu	Konthattupalli		6	Agriculture/Daily labour
		Thungodu	C.B. Palli	2	1	Agriculture
		Edulabalapuram	Edulabalapuram	4	3	Agriculture
Anantapur	Gorantla	Mallapalli	Mallapalli	5	4	Agriculture
		Vadigepalli	B.N. Thanda	1	6	Agriculture
		Vadigepalli	Venkatapuram		1	Agriculture/Daily labour
		Vadigepalli	Boyalapalli		5	Agriculture
		Kondapuram	Romapuram		1	Agriculture
Anantapur	Penukonda	Rampuram	Kondampalli	4	6	Agriculture
		Mavaturu	Mavaturu		6	Agriculture
		Mavaturu	Sattarpalli		3	Agriculture
Anantapur	Roddam	Peddamanthur	P. Roppala		2	Agriculture/Daily labour
		Sanepalli	Sanepalli	6	10	Agriculture
		Roddam	R. Kottala		2	Agriculture
		Roddam	Patharlapalli	5	2	Agriculture
		Reddipalli	Reddipalli		4	Agriculture
		M. Kothapalli	Gorajpalli		4	Agriculture/Daily labour
Anantapur	Chillamathur	Kodur	Kotlapalli	2	1	Agriculture
		Kodur	Kambalapalli		5	Agriculture
		Chillamathur	Adepalli		5	
			TOTAL	**54**	**103**	
			Total questionnaires	**157**		