Improving sustainability of rural livelihoods in Son La province, Northwest Vietnam: Potential of use of biogas digesters

Thesis

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Abstract

This thesis is based on a research conducted in 2007 in Son La province, Northwest Vietnam, during a transitional phase of the Vietnam Biogas Programme. After its initial success among relatively better-off farmers in peri-urban areas of plateau provinces, an extension of the programme was planned, with focus on reaching more poorer population. Therefore, Son La province was chosen among several others for the transitional phase, being one of the poorest provinces of Vietnam.

The research studied impacts of use of biogas digesters on livelihoods of their new users in specific conditions of remote, mountainous province of Son La, in order to see if this technology can contribute to higher degree of their sustainability. The potential for further dissemination within the province was also investigated.

The results of the research showed positive impacts that did not varied significantly from other provinces. After switching to biogas, households experienced monetary savings on cooking fuels and/or savings in time for their collection and for food preparation, reduced indoor air pollution and cleaner farmyard. Bioslurry was not yet replacing chemical fertilizers, thus resulting in no additional monetary savings. There is potential for further dissemination of the biogas technology in Son La, however limitations exist especially in more remote parts of the province.

keywords: Biogas, Energy, Poverty reduction, Son La, Vietnam, Sustainable livelihoods

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Abbreviations

AEC	Agricultural Extension Centre
BPD	Biogas Programme Division
BUS	Biogas User Survey
CCRD	Center for Community Research and Development
GHGs	Green-house gases
hh(s)	Household(s)
KfW	Kreditanstalt für Wiederaufbau (German Development Bank)
LPG	Liquefied petroleum gas
NGO	non-governmental organisation
PBPD	Provincial Biogas Programme Division
RETs	Renewable Energy Technologies
SNV	SNV Netherlands Development Organisation
TX Son La	Son La Town
VACVINA	Vietnam Gardening Association
VBARD	Vietnam Bank for Agriculture and Rural Development
VBSP	Vietnam Bank of Social Policy
VND	Vietnamese Dong[1]
VWU	Vietnam Women's Union

1 At the time of the research (2007) the exchange rate was about 1 USD = 16,000 VND.

1 Introduction

Worldwide, biogas technology has become a well established solution for energy needs of rural people and recently it has been gaining success also in Vietnam. An improved small-scale domestic biogas technology is being disseminated under Vietnam Biogas Programme which was initiated in 2003 with support of the Netherlands Government, and is implemented by the Vietnam Ministry of Agriculture and Rural Development (MARD) and SNV Netherlands Development Organisation.

In recent past, two surveys on impacts of domestic biogas installations have been conducted in Vietnam, both of them in more peri-urban areas of plateau provinces where the programme had been developed in its initial phase. The surveys showed positive results among the first users, who were however predominately better-off households. Based on this, a decision on extending the programme was made, with the intention to focus on reaching and including more poor population.

For the transitional phase, Son La province was chosen among several other provinces, representing one of the poorest regions of Vietnam. Although Vietnam as a whole has been experiencing fast developments following so-called doi moi reforms, the impacts of the changes vary across the country. Benefits of agricultural growth were far more stronger in plateau and delta regions than in more remote mountainous areas. Provinces in mountainous Northwest, such as Son La, still belong to the poorest in Vietnam and development opportunities have been limited over the past years.

Vietnam Biogas Programme entered Son La province in 2006 and the first biogas plants were finished in January and February 2007. The request from the Vietnam Biogas Programme, that lies behind the topic of this research, was to investigate whether the impacts of biogas technology on livelihoods in a mountainous province like Son La are similar to the impacts in plateau provinces, or whether there are any differences. The programme was also interested in an assessment of perspectives and obstacles for further dissemination.

The thesis resulting from the research is structured as follows: In this first section, an introduction to the problem is made, including a theoretical framework as a background for the research, and a socio-economic context on national and local level. The section concludes with formulating a research question and outlining a conceptual model that tied together the concepts and theories and served as a guide for the research. In the next section, a research methodology is explained. Results of the survey in Son La are presented in the third section: first, an overview is provided on livelihoods of surveyed farmers, followed by findings on the impacts of biogas. The forth section discusses the results, confronting them with theories and with available past results from other parts of Vietnam. The thesis concludes with a final section that also includes several recommendations for further extension of the technology.

1.1 Theoretical framework

This chapter provides an overview of concepts and theories relevant for the research. The stating point are the concepts of sustainability and human development that see poverty and development not merely in terms of income but as a more complex phenomenons with multiple dimensions. Next, the position and role of energy is discussed among these multiple dimensions, with assistance of livelihood framework, and with special attention to remote rural areas and the challenges they pose.

1.1.1 Sustainability and human development

A new paradigm entered development thinking in the beginning of 1990s, shifting it towards more complex concept of 'human development'. Large influence behind this shift was that of the Indian philosopher and economist Amartya Sen, who has for long time promoted softer understanding of poverty and development. Sen stressed capability and positive freedom of an individual; from his point of view, well-being means the things people can do rather than things people have. If their set of capabilities grows larger, people can do more of the things they would like to do. Goal of development is therefore to enhance people's potential to be and to do (Sen 1993).

The work of Sen and others contributed strongly to establishing of annual Human Development Reports by UNDP that rank countries on variety of economic and social indicators. *Human Development Report 1997* introduced the term 'human poverty' that goes beyond lack of material wealth and understands impoverishment as multidimensional, as a 'denial of choices and opportunities for a tolerable life' (UNDP 1997).

Sustainability is one of pillars of human development. The concepts of sustainability and sustainable development became gradually mainstreamed after the publication of the report *Our Common Future* by Brundtland Commission. According to the well-known definition coined by the report, development is sustainable when it 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). Sustainable development has three equally important dimensions: economic, but also social and environmental.

1.1.2 Link between energy and development and poverty reduction

The debate on sustainability went hand in hand with debates on the role of energy in development. In the past, the link between energy and development was problematized with various intensity. While in the dawn of 20th century energy was understood as an engine for economic and social development, in the following period the role of energy as an important factor for development was rather forgotten (Barnett, 2000). Energy slowly returned back into the foreground since the World Summit on Sustainable Development in 2002.

The link between energy and poverty reduction was discussed with a new intensity on World Summit on Sustainable Development in Johannesburg in 2007. In the action plan, the necessity to integrate energy improvements into the national policies for meeting Millennium Development Goals (MDGs) was pointed out. Although energy is not mentioned explicitly in any of the MDGs, it

has been agreed that it is necessary for meeting all of them. The links between energy and poverty reduction through looking at the MDGs were elaborated for example by DFID (DFID 2002).

1.1.3 Sustainable livelihood approach and energy

When we look at the poverty as a multidimensional phenomenon, through the lenses of human development, energy can be seen as one of important factors which affects in various ways people's capabilities to live better lives. To capture these various ways in their complexity, sustainable livelihood approach can be a valuable tool. The idea behind sustainable livelihood approach is to help stakeholders with different perspectives engage with the many factors that affect livelihoods. People, who are in the centre of the framework, are seen as operating in the context of vulnerability: they have access to certain assets (natural, human, financial, physical and social) that gain their meaning and value through the existing social, institutional and organisational environment. This environment influences the livelihood strategies (i.e. ways of combining and using the assets) that are available to people in pursuit of livelihood outcomes that meet their own livelihood objectives (DFID 1999).

Livelihoods are regarded as sustainable when they can 'cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (DFID 1999). From the perspective of sustainable livelihood approach, poverty reduction needs focusing on enhancing capabilities of vulnerable households and individuals so that they can secure their livelihoods, either through production and income generating activities or by other means.

Clean and affordable energy is, according to the DFID's *Guidelines for sustainable livelihood approach*, one of components of infrastructure essential for sustainable livelihoods (DFID 1999). Using sustainable livelihood framework, linkages between all of its components and energy can be made (see the Conceptual model in 1.6).

1.1.4 Transition from traditional to modern energy sources

There are various types of energy sources that can be divided into traditional and modern ones. Traditional energy sources are biomass, firewood, crop residues or animal wastes. They are relatively inefficient, time- and workforce-demanding and hazardous for health: cooking with firewood, dung or crop residues is associated with a significantly higher healths risks comparing to other forms of cooking, due to indoor air pollution.

On the other hand, modern energy comes from variety of energy sources, including LPG, kerosene, petroleum and electricity, either grid or off-grid electricity (this also includes innovative sources such as solar, biomass, hydro or wind). It is more efficient, less hazardous for health and more convenient, saving time and costs for its users.

Today, around 1.5 billion of world population do not have access to electricity (IEA 2009), and despite many efforts to bring this modern energy to these people, the number has remained rather static over the last years, since the population grows fastest in those regions in highest need (Saghir 2005). There are 2.5 billion people that lack access to modern fuels for cooking and heating, and if the

situation remains the same as now, this number will increase to 2.6 billion in 2020. Theses people – more than one third of world's population – rely on traditional sources of energy such as biomass (primarily firewood, but also agricultural residue), animal waste or charcoal for heating and cooking (IEA 2009).

The process of substituting of traditional biomass fuels by modern energy sources of increasing efficiency is known as 'the energy transition' and is hindered by several barriers (Leach 1992). One of them is the cost of modern fuel devices: it is often too high for poor people who tend to avoid 'lumpy' investments even though the total sum would be lower over time. Even if the device is available and affordable, another constrain might arise – the price of the source itself. Yet another important barrier is the access to the fuels, i.e. the non-existent (or unreliable) infrastructure for their distribution (Leach 1992).

1.1.5 Development and energy in remote rural areas

Distance and terrain (or 'accessibility') therefore play a significant role in energy poverty and in the process of the energy transition in rural areas. Connecting remote villages to national electricity grid is an on-going task for governments of many developing countries. There is also little interest of private sector to enter remote rural areas where people cannot pay for the services. It is no surprise that worldwide four out of five people without access to electricity live in rural areas (Saghir 2005).

Remote rural areas are especially challenging for any development initiative. Together with very limited access to modern and reliable energy supply, the chances are very low for local people to improve their quality of life.

Decentralised small-scale renewable energy technologies (RETs) are promising solution for such rural or remote areas. Moreover, apart from providing cheap, quality and reliable energy necessary for development, they have positive 'side effects' on local natural resources that rural households heavily rely on, and eventually also on the situation on national and global level. This is why the energy transition to RETs is generally preferred over transition to fossil-based modern fuels by global community today.

However, as already mentioned, there are many challenges associated with the process of introduction of such new technologies in remote areas. Initial investment into modern RETs is often quite high (especially solar, wind), and therefore hardly affordable for the poor households living in remote areas with limited opportunities for income generation. Poor road conditions can increase costs of material, construction and after-sales service. As the potential consumers have often had few educational opportunities, they might also lack knowledge and skills required to operate and maintain the systems.

1.2 Biogas

In this chapter, biogas technology is presented, together with its various potential benefits and drawbacks, as one of the RETs for rural households. Consequently, it will become clear that the biogas plant is not only a source of energy but also a solution for waste treatment on rural farms, or

a source of valuable organic fertiliser.

1.2.1 Biogas technology

Small-scale domestic biogas is one of decentralised RETs advocated for rural people. It can substitute commercial sources of energy like LPG or kerosene as well as non-commercial fuels like firewood, dried cow dung or crop residues, which are the most common source of energy for cooking and lighting in rural areas.

The enthusiasm for biogas increased in the beginning of 1970s, during the energy crisis. In the 1970s and the first half of 1980s the biogas technology quickly became popular in rural areas of developing countries, where there is usually a lack of cooking fuels and in the same time an abundant source for biogas fermentation. Several millions of simple-designed, household-sized biogas digesters were installed in Asia, Latin America and Africa (Ni and Nyns 1996). Today, biogas technology is proven and established in many parts of the world. In China, over 40 million small biogas plants are reported to be installed, and over 4.2 million in India (SNV 2011).

There are various designs of domestic biogas plants used all over the world. Biogas technology disseminated by the Vietnam Biogas Programme is based on a fixed-dome design (see Figure 1). The main part of the plant is a brick and cement digester in which the organic inputs (animal dung and urine, human excreta and other organic waste) are collected and anaerobically converted into a combustible gas comprised primarily from methane (65-80%) and carbon dioxide (20-35%). Connected to the digester, there is an inlet tank in which these inputs need to be mixed with water prior to feeding into the digester; and a compensation tank where a by-product, so called bioslurry, gradually accumulates until it overflows to a composting pit.

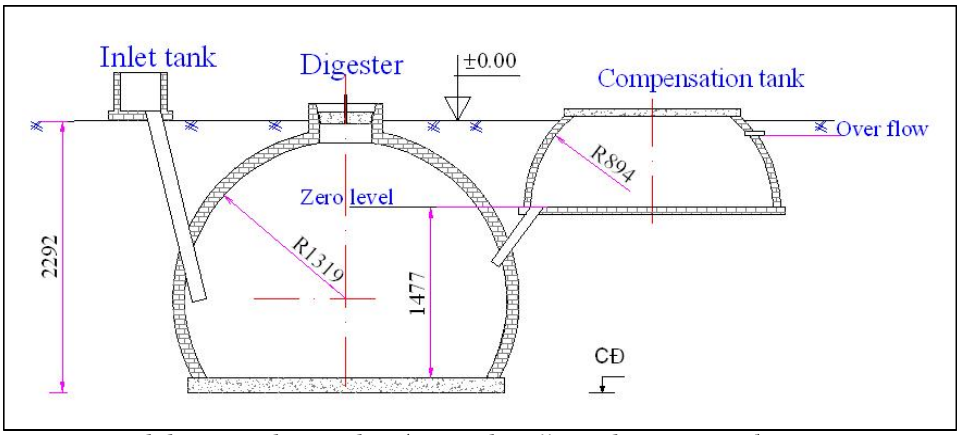

Figure 1: Fixed-dome type biogas plant (Source: http://www.biogas.org.vn/)

The amount of organic inputs to be fed into a digester depends on a size of the plant and also on ambient temperature. The bioslurry retains in the digester for about one month and then leaves through the compensation tank. The produced gas is led out from the digester by a gaspipe and combusted in gas cooking stoves, or in special gas lamps for lighting (Karki et al. 2005; various brochures of BPD).

1.2.2 Benefits

Various potential benefits of biogas are known: economic, as well as social and environmental. These benefits can be direct or indirect and can occur on all levels of society: international, national, local, household, or individual.

On household level, biogas reduces expanses on energy sources for cooking and lighting (electricity, LPG, charcoal, firewood purchased from middlemen etc.), because it is made from animal dung and other organic material readily available on a farm for free. More financial resources can be saved on chemical fertilizers when these are replaced by bioslurry (Karki 2006; Otten 2006).

Economic benefits:

- ✔ Savings on purchasing fuels and fertilizers
- ✔ Increase in crop yields through bioslurry use
- ✔ Income generation opportunities for local businesses
- ✔ Improved security of energy supply (both locally and nationally or regionally)

Biogas replaces dried dung cakes, which are commonly used as one of energy sources especially in rural areas. However, by burning the cow dung, farmers lose valuable fertiliser and instead they need to purchase fertiliser for their fields. On the contrary, when feeding a dung into the biogas digester, the resulting bioslurry contains more nutrients (especially nitrogen) than farmyard manure or compost. The humus contained in bioslurry improves soil and nutrients increase crop yields (Karki 2006; Eije 2007).

New opportunities open up around biogas projects for local companies and appliance manufacturing workshops. NGOs, consultants and entrepreneurs are involved in promotion and dissemination of the technology. With an increasing demand for biogas, the income generation opportunities for all of these subjects grow.

In general, using biogas instead of traditional biomass sources or fossil fuels also leads to improved security of energy supply (both on local and national/regional level) as the feedstock can mostly be acquired locally.

Health and social benefits:

- ✔ Reduced indoor air pollution
- ✔ Reduced workload and saved time especially for women and children
- ✔ Improved sanitation and comfort
- ✔ Income diversification opportunity for users in saved time

Burning biogas instead of traditional biomass fuels reduces an indoor air pollution significantly. Mostly women and children benefit from this as they spend lot of their time indoors cooking. Health problems related to long-term exposure to smoke can be prevented, in particular eye-diseases and problems of respiratory system (Bajgain and Shakya 2005) .

Cooking on biogas also means that pots and other kitchen equipment do not get stained with soot so much, and time is therefore saved on their cleaning. Cooking is more comfortable as there is no need for preparation of fire and fire does not require constant monitoring. Ash and dirt from firewood or charcoal can be avoided indoors and around house, and walls and clothes do not get black and dirty (Lauridsen 1998).

Most importantly, biogas means significant time and workload savings for those biogas users, who used to collect their firewood themselves in the past. All together, these time-savings can be used for other activities: taking care of family, studying, or gaining additional income.

Attaching a toilet to a biogas plant can reduce infestation of various water-borne diseases because around 90% of the parasitic eggs are destroyed in the digester (Karki at al. 2005). Also the house and farmyard are cleaner, and smell and the amount of flies can be reduced because manure handling is more controlled.

Treating manure in a biogas digester also reduces risks of contamination of soil and local resources of water. The process of substituting biogas for firewood also means less pressure on local forests and can contribute to slowing down deforestation and reduce erosion.

Environmental benefits:

- ✔ Reduced risk of soil and water contamination
- ✔ Reduced deforestation
- ✔ Reduction of GHGs

Reduction of green-house gases (GHGs) is one of the most visible benefits on global level. Utilizing biogas as an alternative to fossil-based fuels reduces the net amount of carbon dioxide emitted to the atmosphere. Moreover, the emissions of methane gas, which is more aggressive GHG than carbon dioxide, from otherwise naturally digested dung can be prevented. It has been estimated that one biogas plant in Nepal can save 4.6 tonnes of carbon dioxide equivalents per year (Bajgain and Shakya 2005).

1.2.3 Limitations and challenges

Limitations and disadvantages of biogas technology, although usually considered fewer then benefits, need to be mentioned here as well. Most of these can be avoided or overcome by careful planning and adjusting the technology, together with its promotion and after-sale services, to particular local situation.

One of the biggest challenges is still relatively high initial investment into biogas plant construction. Moreover, there is no direct income generated by biogas plant (only savings or indirect opportunities for additional income generation in saved time). Thus, especially poorer households hesitate greatly to invest loan money, because without any cash directly generated by the plant they are worried that they will not be able to pay it back.

There are technical limitation for biogas, for example low temperatures: the bacteria responsible for anaerobic digestion requires temperatures between 10°C and 35°C. In areas with colder climate (higher altitudes), thermal insulation and warm water feeding of the system is therefore necessary, rising the costs significantly (Bajgain and Shakya 2005).

Lacking or improper maintenance can lead to failures, e.g. blocked pipes or damaged digester, which adds extra costs. Possible resultant leakages of biogas are highly undesirable because biogas, comprising mostly of methane, is poisonous as well as it is an aggressive GHG.

One of the problems often mentioned is an increased presence of mosquitoes or other insect which was previously repelled by smoke from burning firewood. Some users also reported that mosquitoes were breeding in bioslurry outlet (Karki et al. 2005; Bajgain and Shakya 2005).

Considering time savings, biogas means switching one chore for another, as instead of spending time on collecting firewood users need to daily operate the plant, especially to collect water and mix it with manure. Thus local conditions, especially the distance to the nearest source of water, needs to be considered to maximize benefits (Karki et al. 2005). Another problem may arise when the digester depends on manure from grazing animals, as collecting it can be more time-consuming, especially if the animals graze on large area.

Social and cultural barriers may also hinder harnessing fully the benefits of the technology. In some cultures, resistance exists against using human excreta in biogas digester, as this is seen as making biogas 'unclean' for cooking (Karki et al. 2005).

1.3 National context: Vietnam

The Socialist Republic of Vietnam is situated in Southeast Asia and its area is about 331,210 km^2 (nearly 9 times of the Netherlands or over 4 times of the Czech Republic). The natural conditions and also socio-economic situation vary quite significantly throughout the country, especially between the northern and southern parts. With its population of 89 million (July 2010 est.), Vietnam is among the countries with the highest population density in the world. The majority ethnic group is Kinh (Viet) 86.2%, other ethnics are Tay 1.9%, Thai 1.7%, Muong 1.5%, Khome 1.4%, Hoa 1.1%, Nun 1.1%, Hmong 1%, and others 4.1% (1999 census) (CIA 2010).

1.3.1 Poverty

Following the launch of the political and economic renewal campaign (*doi moi*) in 1986, Vietnam has been impressively successful in economic and social development and in poverty reduction. Often cited is the fact that Vietnam has already achieved its MDG of halving poverty by 2015: the proportion of the population below the extreme poverty line fell from 58.1% in 1993 to 24.1% in 2004 (Viet Nam Fourth MDG Report, 2005). Due to relatively pro-poor orientation of public expenditures, social indicators show better results than in other countries with similar GDP, with relatively low growth of inequality (Minot et. al 2003).

Nonetheless, in recent years poverty is becoming increasingly concentrated in remote and mountainous areas. Although most of the poor live in the Red River Delta and in Mekong River Delta, which are the areas with the highest population density, poverty rate is greatest in the sparsely populated Northwest and Northeast, in the upland areas of the North Central Coast and in the northern part of the Central Highlands. Poverty in remote areas is connected with their low agricultural potential and poor access to markets: poverty is higher in districts with bare and sloping land and poor soils, located far from towns, whilst higher road density and flat land are associated with lower poverty (Minot et al. 2003).

It should be noted here, that poverty in Vietnam has increasingly evident poverty dimension: although in 2004 ethnic minorities accounted for only 14% of population, they represent 39% of all poor, and the gap between them and the Kinh majority continues to widen. Even in poor mountainous areas, Kinh households more often belong to richer (Swinkels andTurk 2006).

1.3.2 Agriculture and rural development

Since nearly three quarters of Vietnam's population, and nearly 90% of its poor, live in rural areas, rural development and agriculture are critical for poverty reduction. There has been strong progress in agricultural sector during recent years, partly due to policy reforms such as allocating land use rights to individuals, and also as a result of market-based incentives such as higher prices for crops (WB 2007).

Despite the advancements, many challenges still remain, such as slow investments in agricultural diversification, underdeveloped marketing channels, institutions and infrastructure; unsustainable and inequitable patterns of natural resource use, access and control, vulnerability to natural hazards, or limited capacity of public institutions and misalignment of public expenditures (WB 2007).

Rapid agricultural development has also aggravated the negative effects of agriculture on environment. For instance, intensification of pig husbandry has led to growing numbers of livestock and therefore to increased risks of pollution from poorly managed animal effluents. Intensification of agricultural production, which in case of Vietnam takes place on relatively small plots, has often resulted in common practice of overusing of chemical fertilizers, affecting negatively water resources and causing rapid deterioration of soil quality.

1.3.3 Energy in rural areas

With the Vietnam's booming population, growth of commercial sector and living standards, the demand for energy has been raising sharply in recent years: between 2000 and 2007, the annual growth rate of the consumption of electricity was 14%. Although Vietnam is currently a net energy exporter, the demand is expected to exceed domestic supply capabilities by 2015, even with promotion of energy conservation (APERC 2010). The country is now facing a challenge to meet this raising demand and provide secure energy in a way that minimizes adverse impacts on society and environment.

Vietnam has variety of energy resources: in the mountainous northern region and in central plains these are mainly hydropower and coal, in the southern region it is offshore natural gas and oil. The large share (30% in 2007) of the total primary energy supply in the country, however, is still represented by biomass, although this number used to be much higher in the past (70% in 1995) (APERC 2010).

The main reason behind these still relatively high numbers are large populations in rural areas where households continue to rely predominantly on non-commercial biomass energy sources such as wood and agricultural wastes (dung, rice husks). Vietnam's per capita commercial energy consumption still ranks among the lowest in Asia (EIA 2006).

Although the access to electricity grid has improved significantly during recent years (from 50% of households in 1996 to 88% in 2004), the service especially in rural areas is of low quality, with low voltage and poor reliability (EIA 2006). One problem is the limited generating capacity, which is now being up-scaled through construction of new power plants, but an important constrain for electrification is also the country's geographical complexity that makes the costs of grid extension significantly high in many remote or mountainous areas.

As a solution especially for communities living in such areas, various projects of alternative small-scale energy supply based on RETs are being promoted with support of international organizations and other countries. The RETs implemented so far are for instance windmills for water pumping, solar water heaters or mini-hydropower plants. Among waste-to-energy technologies, biogas digesters, which are closely connected to agriculture, are the most promising in large rural areas of Vietnam.

1.3.4 Vietnam Biogas programme

In Vietnam, first biogas stations appeared already in 1960s. Until 2003, however, the focus was mainly on research, development and pilots. First larger project was around 2,000 low-cost biogas digesters constructed since 1998 using technology developed by Center for Community Research and Development (CCRD) under the Vietnam Gardening Association (VACVINA)[2].

In 2003, The Support Project to the Biogas Programme for the Animal Husbandry Sector was set up in several provinces of Vietnam. It was funded from a 2.5 mil EUR grant from the Netherlands Government, and implemented by the Vietnam Ministry of Agriculture and Rural Development (MARD) and SNV Netherlands Development Organisation. During the first phase, 18,000 biogas plants were installed between 01/2003 and 01/2006 in 12 provinces: Lang Son, Hoa Binh, Hai Duong, Bac Ninh, Nghe An, Thua Thien Hue, Binh Dinh, Dac Lac, Dong Nai, Tien Giang, Thai Nguyen and Ha Noi.

In the time of this survey in Son La, in 2007, the Biogas Programme was entering a phase II (2007-2011), when the MARD and SNV decided to up-scale the programme after its successful first phase. The aim of this next, nation-wide phase, is to support construction of 140,000 domestic biogas plants in all provinces. The objectives of the programme are: (i) exploiting effectively biogas technology and developing a commercial viable biogas sector in Vietnam; and (ii) contributing to rural development and environmental protection via provision of clean and affordable energy to rural households, improvement of community's sanitation and rural people's health, creation of job for rural labour and reduction of greenhouse gas emission.[3]

For 2006 a bridging phase was developed, which aimed at building 9,455 biogas plants in 20 provinces and improving quality control system and trainings. In Son La, one of the provinces chosen for this transitional phase of the programme, the construction of small-scale biogas plants started in the second half of 2006 and about 200 biogas plants were finished by the beginning of 2007.

1.3.5 Previous biogas surveys in Vietnam

Recent information on specific impacts of biogas installation on users in Vietnam can be found in two studies which were done for the Biogas Programme: (i) Biogas User Survey 2005 (Nguyen 2005); and (ii) a survey by an external consultant in 2006 (Otten 2006). Relevant findings of these studies are summarized bellow:

2 The VACVINA biogas model combines the fixed-dome model that came from China and India (using a flat-top rectangular underground digester), with an external plastic bag made from nylon that serves as a reservoir for biogas.

3 Source: http://www.biogas.org.vn/

Biogas User Survey in 2005

Biogas User Survey (BUS) was conducted in 2005 in four provinces of Vietnam, namely Ha Noi, Hoa Binh, Nghe An, and Tien Giang. One hundred randomly chosen households using biogas participated in a questionnaire survey which aimed at evaluating the effect of domestic biogas plants built in the Phase I of the Vietnam Biogas Programme. The income/poverty levels of users were not surveyed, but from a common presence of valuable assets (motorbikes, TVs etc.) the authors concluded that the users did not belong to the poor or very poor (Nguyen, 2005).

The results include information on impacts in terms of time and money savings, and changes in usage of manure and fertilisers. On average, the users saved about 12 person-days per year on collecting firewood, or 75 minutes per day on cooking and cleaning. On buying fuel, households saved 120,000 VND per month on average. 40% of the users were applying bioslurry to fertilise their crops, and they replaced 30-40% of their former volume of chemical fertilisers, thus saving more money (Nguyen, 2005).

External consultant survey in 2006

In 2006 an expert mission was conducted by a KfW's consultant, including a small field survey in Ha Noi, Hoa Binh and Thai Nguyen provinces (Otten 2006). The aim was to complete information on the specific socio-economic conditions of the target group of the programme, to develop a proposal for a new subsidy scheme, and to recommend further measures regarding gender and poverty orientation of the programme.

In contrast with the BUS 2005, the survey was smaller (20 households), and included also biogas non-users (one half of the sample). When it comes to the impacts, those were very similar though: the households saved 20 person-days per year on average; women saved about 60 minutes per day on food preparation and 15 minutes on cleaning dishes. Also, households saved 100,000-120,000 VND per month on fuels. Two out of ten households mentioned savings on chemical fertilisers as a result of using bioslurry.

In comparison with the BUS 2005, the Otten's survey considered poverty levels of respondents: more poor and lower middle income households were included in the sample. The survey revealed, for instance, that 75% of the poor households had sufficient livestock for potential biogas production.

1.4 Regional context: Son La province

1.4.1 Geography

With its area of 14,055 km^2, Son La is the fifth largest province in Vietnam. It is located in the northwestern region; it borders with Laos to the south, with Yen Bai, Lao Cai, Lai Chau provinces to the north, Dien Bien province to the west and Phu Tho and Hoa Binh provinces to the east. The provincial capital is Son La Town, located approximately 300 km from Hanoi, and there are 10 rural districts: Quynh Nhai, Muong

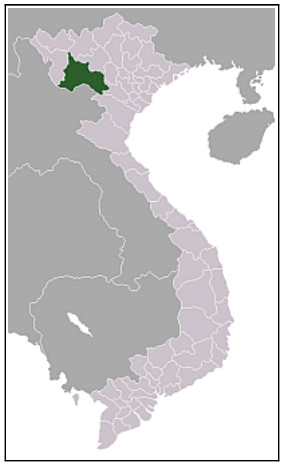

Figure 2: Son La province, Vietnam (Source: Wikimedia)

La, Thuan Chau, Phu Yen, Bac Yen, Mai Son, Song Ma, Yen Chau, Moc Chau, and Sop Cop.

Around 80% of the province is mountainous and the average elevation is 600-700m above sea level. There are two main rivers running through the province, Song Da (Black River) and Song Ma, both of irregular regime with maximum flow toward the end of summer. Together with numerous larger and smaller streams, distributed throughout the region, they create a system with good potential for irrigation and hydroelectric power. Son La climate has two seasons: dry winters from October to March, and hot and rainy summers from April to September. The average annual temperature is 21.4°C (highest 27°C, lowest 16°C). The average annual rainfall ranges between 1,200 and 1,600mm, and the average humidity is 81%.

1.4.2 Population

In the time of the survey, the population of Son La province was about 988,500 with the density of 70/km^2.[4] Similar to other Northwest provinces, the population comprises from the largest part of ethnic minorities: around 54% of people are Thai and 13% H'Mong, whereas Kinh (otherwise the majority ethnic group nationwide) account for only about 18% (SNV 2006). Other ethnics are Ma, Dao, Muong, Khmer, Tay, or Tai.

The demographic balance in the region altered dramatically in the second half of 20th century. Kinh families have been coming from plateau provinces since 1960s encouraged by government policies; Kinh believed that they had a mission to civilize ethnic minorities. Due to this migration and also the high rates of population growth among the ethnic minorities, population density and the pressure on natural resources increased rapidly, which had negative effect on local environment (Liljeström et al. 1998). Today, Kinh people mainly live in urban centres and along the arterial road of the province, the National Highway No. 6. The ethnic minority groups live mainly in the uplands: Thai live in and along valleys and H'Mong and other groups in higher located areas (SNV 2006).

1.4.3 Livelihoods of farmers

Son La province is one of the poorest in Vietnam; at the time of the survey the poverty rate in Son La was the third highest of all Vietnamese provinces (Minot et al. 2006). The economy of the province strongly relies on the agricultural sector: agriculture represents more than a half of the provincial GDP (compared to only 24% that agriculture represents on the national level). The main crops are rice, maize and cassava; in recent years a percentage of cropland planted with rice declined significantly in Son La, complemented with a strong increase in maize production. The reason for this has been a growing demand for animal fodder from livestock producers, which in turn has been stimulated by a growth of urban demand for poultry and pork (Minot et al. 2006).

The province has relatively poor accessibility (based on travel times to nearest district centres; Minot et al. 2006) and in large parts of the province an incorporation into market economy is therefore still limited. Majority of local farmers – especially ethnic minority groups – depends on low-input self-sufficiency agriculture. Cultural differences between the ethnic minorities and the Kinh are

4 Source: General Statistics Office of Vietnam, data from 2004 census. According to the latest census, the population of Son La province has risen to 1,080,641 in 2009.

expressed in traditional agricultural methods and food preferences: ethnic minority groups depend mostly on the upland agriculture with special local crop varieties of (sticky) rice, (sticky) maize, soybean and animal breeds (SNV 2006).

1.4.4 Biogas in Son La

The Vietnam Biogas Programme entered Son La province in 2006 and the first biogas plants were finished in January and February 2007. The biogas technology, however, was not completely new in the province; since 1990s biogas digesters of various designs had been built, as pilots or as a part of small projects, however there are no official and systematic records available on these installations.

A small scan was done by SNV in 2004 among Son La farmers, focusing on opportunities for better use of agricultural waste as a source of energy. According to the final report, biogas digesters were quite common on farms throughout the province, however about 80% were no longer active (Ervin-Ward and Le 2004). The reasons listed in the study were: broken digester, insufficient volume of manure, unpleasant smell of biogas, misconceptions about the technology, or too low volumes of biogas produced to make it worth the effort. Nevertheless, according to the study the respondents were optimistic about the concept of biogas, both in the villages that had some experience with biogas digesters and those that had not.

1.5 Research objective and questions

Before the Biogas Programme entered Son La province, it had already experienced substantial initial success among relatively better-off farmers in peri-urban areas of plateau provinces. Based on this success, a decision on extending the programme was made, with the intention to focus on reaching and including more poor population. Both the evaluation of the Programme's Phase I, and the findings of an expert's mission on preparation of the Phase II recommended to follow more pro-poor policies for the future (AITCV 2005, Otten 2006). Therefore, Son La province was chosen, among several others, for the transitional phase, being one of the poorest provinces in Vietnam.

From the first surveys and evaluations conducted on the implementation of the Vietnam Biogas Programme, there was already quite some information about the impacts of biogas in more peri-urban areas of Vietnam. However, there was not much known yet about the impacts in more remote areas, where the biogas programme's activities started only recently. The underlying hypothesis was that the impacts of biogas in Son La would be more or less different, since the geography and socio-economic situation in Son La were quite different from the provinces participating in the Programme's initial phase. It was assumed that, depending on the local situation in Son La province, another approach might be needed to promote and disseminate the biogas technology (provided that the impacts are predominantly positive and thus worth spreading) in specific conditions of Northwest Vietnam. The main **objective** of the research was therefore to:

> **investigate specific impacts of biogas digesters in Son La province, and thus contribute to better understanding of potential of biogas for poverty reduction in remote mountainous areas of Vietnam.**

In order to meet the objective of the research, following **research question** and **subquestions** were formulated:

> **RQ 1 What are the specific impacts of biogas digesters on its users in Son La province?**
>
> SQ 1.1 What are the characteristics of households using biogas digesters in Son La?
>
> SQ 1.2 What are the impacts of biogas digesters on livelihoods of their users?
>
> SQ 1.3 Do these impacts differ from impacts already known from more peri-urban parts of Vietnam? If yes, how?

1.6 Conceptual model

In order to capture a range of possible impacts, a sustainable livelihood framework was used as a starting point for the research design and also for the analysis of data. The model draws upon the most commonly used sustainable livelihoods framework designed for UK Department for International Development (DFID 1999). The linkages between biogas and various components of sustainable livelihoods framework are inspired by ideas of Barnett on the role of energy in rural livelihoods (Barnett 2001).

In the model (see Figure 3), a biogas plant is placed as a new asset among other assets of local households. Its potential linkages (to other livelihood assets, to livelihood strategies and to livelihood outcomes) are coloured white. These were also the lines along which potential impacts of biogas were primarily studied in this research.

Although the sustainable livelihoods framework can be used analytically on all levels (from individual to global), the focus of this research was on household level.

Livelihoods assets linkages

For biogas users, biogas plant becomes one of their livelihood assets (a part of their physical capital more particularly). It is closely linked to natural capitals (N): Manure from livestock is an important prerequisite for operating biogas plant which on the other hand provides a solution for storage and treating of this kind of farm waste. Fertility of household's land can be maintained and even improved by applying bioslurry, while risk of soil and water contamination from untreated manure can be reduced. Water is also needed for the plant operation (mixed with manure). Forests can be preserved by reducing demand for firewood, fruit trees can be fertilized with bioslurry. Bioslurry can be used as a fish feed in fishponds that are very common natural capital of households in mountainous Vietnam.

From physical capital (P), housing quality and facilities can alter after switching to biogas. A construction of a biogas plant is often connected with renovations (animal pens, kitchen, new toilet).

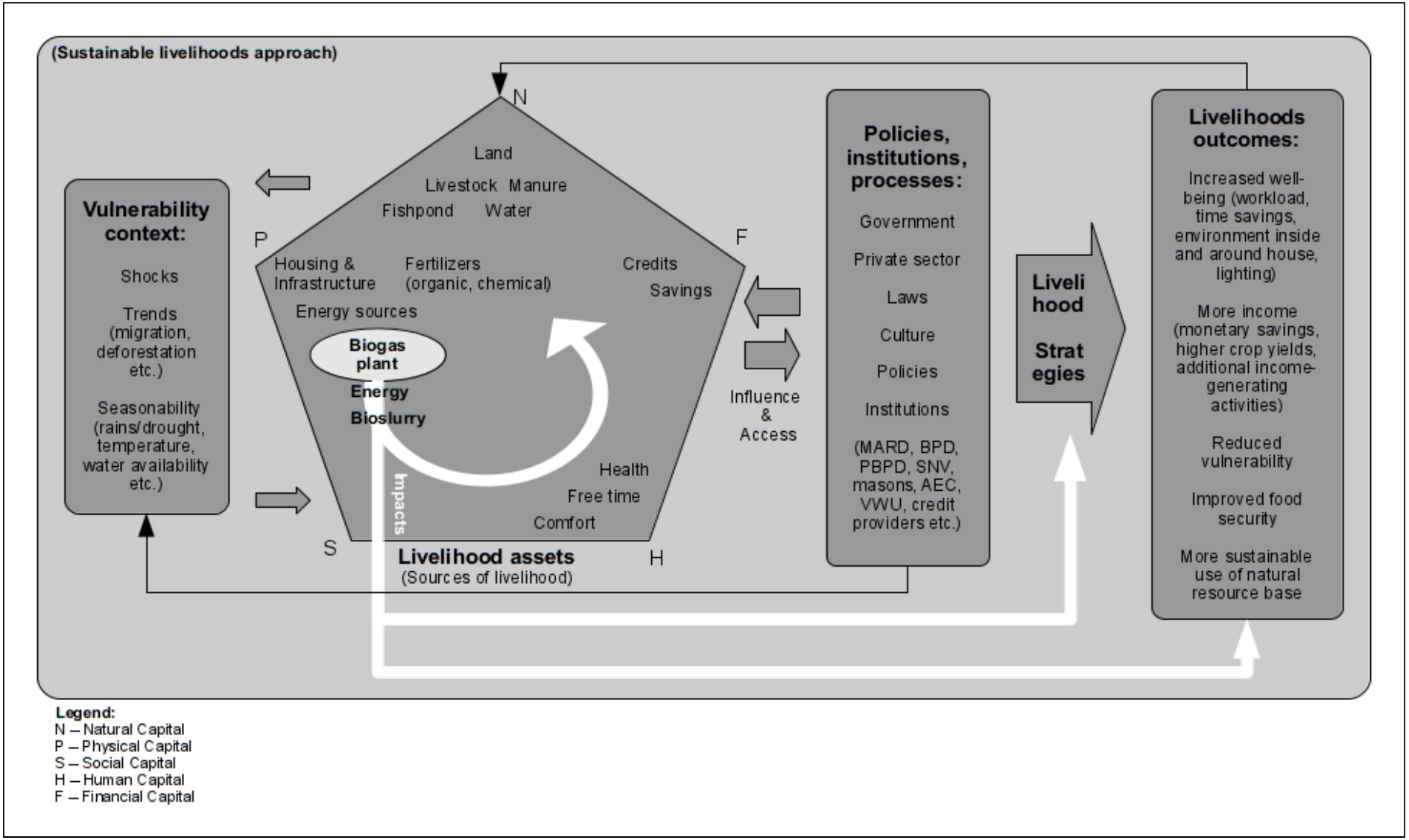

Figure 3: Conceptual model

Financial capital (F) is necessary for construction of a biogas plant. Although biogas recurrent costs are minimal, the initial investment is rather high. Together with the fact that biogas does not directly generate any income this discourages many poorer households.

In case of human capital (H), biogas has positive impacts on health by reducing an indoor air pollution from burning biomass, and by cleaner environment around house. Social contacts and relations (S) determine access to information on biogas technology, which influences very much its acceptance or rejection.

Vulnerability context linkages

Son La's mountainous geography, which makes it different from plateau provinces, was among the main concerns related to further up-scaling of the Biogas Programme. The research therefore studies how the local environment set conditions for biogas utilization and limits opportunities to enjoy its potential benefits. Difficult accessibility during a rainy season or seasonal fluctuations in temperature and availability of water might limit the use of biogas. And vice versa, it is important to find out whether biogas can positively influence vulnerability of local households face to face their external environment with its trends, shocks and seasonality.

Role of policies, institutions and processes

These shape an access to the biogas technology and determine possible livelihood outcomes related to it. They include for instance support from a national and a local government, or local policies and legislation. Local actors play a role in information spreading and facilitate dissemination of such innovative technology, including (a financial) support to poorer households. A private sector is important in making the technology self-sufficient in the future.

Use of biogas can be limited by culturally determined customs (a taboo of using gas produced from human excreta for cooking meals), and ethnicity and culture can also influence an access to the programme or to credits.

Livelihood strategies linkages

By switching to biogas, households are gaining an access to improved energy service and this can lead to livelihood diversification: energy as well as saved time can be used for additional income-generating activities. Some users can even try to gain additional income by selling surplus biogas or bioslurry.

Although the focus of this research in Son La was on biogas users, another important group benefiting from biogas are local masons, who also gain an opportunity to diversify their business by involving in construction of biogas plants.

Livelihood outcomes linkages

Outcomes from using biogas are savings on purchasing fuels (LPG, electricity, firewood from middlemen), saved time can be used for additional income-generating activities. Improved lighting can extend working day and lead again to higher income. Better crop yields can be achieved by using bioslurry as a fertiliser.

Going beyond a mere income increase, biogas can have a positive impact on well-being in general (reducing indoor air pollution, or a burden of firewood collection). It may reduce vulnerability (e.g. more secure fuel supply for example in rainy reason when finding dry firewood is more difficult), improve food quality (replacing chemical fertilizers with organic bioslurry, reducing pollution of water from untreated manure), or lead to more sustainable use of natural resources – all these link back to a capacity of local users to cope with their external environment.

2 Methodology

2.1 Operationalization

The findings came from analysis of data obtained from desk review of available documents including raw data on biogas users in Son La, from individual households interviews and focus group discussions, and from observations.

Operationalization of research subquestions, with corresponding methods for data collection and analysis necessary to answer them, can be found in Table 1:

Table 1: Operationalization and methods for data collection and analysis

SQ	Operationalization	Methods (Data collection/analysis)
(RQ 1 What are the specific impacts of biogas digesters on its users in Son La province?)		
1.1 What are the characteristics of hhs using biogas digester in Son La?	What are the general characteristics of current users in terms of ethnicity, size of hh, size of land for cultivation, livestock numbers, location. What are their sources of livelihood? What are the energy sources used? What are the ways of deposition and utilisation of animal manure? What is the usage of fertilisers?	Analysis of raw data from BP Database, and from list of hhs participating in the Biogas programme in Son La Semi-structured interviews with local informants Semi-structured interviews with farmers Observations
1.2 What are the impacts of biogas digesters on livelihoods of their users?	What are the impacts in terms of time-savings/workload? What are the impacts in terms of money savings? What are the impacts on environment, health benefits?	Semi-structured interviews in hhs Focus group discussions Observations
1.3 Do these impacts differ from impacts already known from more peri-urban parts of Vietnam? If yes, how?	What are the differences in terms of time-savings/workload? What are the differences in terms of money savings? What are the differences on environment, health benefits?	Review of reports from previous studies on biogas use in peri-urban areas and comparison with the findings from the survey in Son La

The research in Vietnam took place between March and July 2007. The research work schedule can be found in Table 2.

Table 2: Work schedule

Phase I	Preliminary design of the study	1 March – 16 March
	• Review of available literature (evaluation reports; Biogas User Survey 2005); • Interviews with informants in Hanoi (SNV Hanoi, BPD); • Short field visit to biogas users (Phuc Triu commune in Thai Nguyen town, Thai Nguyen province) for first observations • Preliminary design of the study	
Phase II	Field study in Son La province	19 March – 8 June
	• Basic data collection on situation of farmers in Son La and on biogas users (from local authorities and from statistics) • Finalising study design and preparation of interview guides • Semi-structured interviews with individual hhs and local informants • Focus group discussions	
Phase III	Analysing data, reporting	11 June – 16 July
	• Final analysis of data • Presentations at AEC TX Son La and BPD office in Hanoi • Final Report for BPD	

2.2 Data collection and sample

The main part of the survey comprised of semi-structured interviews in households, which involved 68 respondents in five district of Son La province, namely Thuan Chau, TX Son La, Mai Son, Yen Chau and Moc Chau. In the time of the survey, these were the only districts with biogas users. Both users (30 households participating in the Biogas Programme) and non-users (32 households) were interviewed; in addition, 6 former biogas users were interviewed who had or used to have a biogas plant constructed outside the current Biogas Programme.

From biogas users the information was sought about their livelihoods in general, and more specifically about households' energy sources, treatment of animal manure and use of fertilisers, before and after the installation of biogas plant.

Since the number of biogas users was limited in each surveyed area, non-users were also interviewed on the same topics to get more accurate picture about the situation in each place. In the end of each interview, non-users were also asked about their knowledge of biogas technology and their opinion on it.

Information obtained from households were discussed during formal or informal interviews with various local informants (agricultural extension officers, head of villages etc.), NGO experts or other researchers working in the area.

Interviews and focus group discussions were held by a team comprising of the authoress and Mr. Doan Duc Lan from the Faculty of Agriculture, Forestry and Economy, Tay Bac University. Mr Lan not only acted as a translator during interviews, but he was also of invaluable help when gaining access to communes.

2.2.1 Reducing potential biases

Similar to any other mountainous area, Son La is characterised by its high diversity. This poses a

problem when choosing a representative sample. During this survey, a quota sampling method together with so-called 'snowball sampling' were used for choosing respondents, which proved to be the best way with respect to the aim of the study, geographical dispersion of biogas users, and limited time and resources available.

Using aforementioned methods, however, the sample is not chosen randomly but according to the information obtained from local informants, respondents themselves, and depending on researcher's consideration; thus a risk remains that some groups of people are excluded from it; following are the ways which were used to reduce the potential biases:

Geographical aspect

Because the main focus of the research was on the impacts of biogas use, the survey itself was limited to the areas where the current biogas users live. However relevant information about other parts of Son La province were sought too where appropriate. These were obtained during discussions with informants and from previous surveys in the area done by others.

Ethnicity

It became clear after the first analysis of the existing data on biogas users in Son La that majority of the biogas users were Kinh, although Kinh ethnic group constitutes only a minor part of the population of Son La. This bias has partly been offset by including other ethnic groups (especially Thai) to the sample of biogas non-users.

Table 3: Ethnicity of respondents

	Kinh	Thai	Other
Users	24 (80%)	5 (17%)	1 (Muong)
Non-users	20 (63%)	10 (31%)	2 (H'Mong)

Gender balance

Interviews were conducted with heads of households, i.e. with men in most cases. Women were often busy with housework or did not take active part in the conversation from other reasons, although the team always tried to involved them in the conversation. To offset this bias, two focus groups with women were conducted towards the end of the survey, which also allowed to test some preliminary findings. Two different areas were chosen for this exercise: Thuan Chau district, where majority of users are Thai; and TX Son La, with majority of Kinh users.

3 Survey in Son La

This section presents an analysis of data collected during a field survey in Son La. First, the livelihoods of local farmers are explained with focus on particular components relevant for biogas utilization, than the impacts of biogas mainly on these components are presented.

3.1 Existing data on biogas users

The survey started with an analysis of existing raw data on *all* biogas users from Son La participating in the Vietnam Biogas Programme. These came from two sources: (a) Biogas Project Database (maintained by BPD in Hanoi) and (b) a list of users obtained from PBPD Son La. These included some basic raw data on households participating in the Biogas Programme in Son La.[5]

In the time of the survey, there were 200 households in Son La using biogas digesters which were built as part of the Biogas Programme. From these, 173 (86%) were Kinh, and 24 (12%) were Thai[6]. Average size of household was 4.5 persons.

Out of all households, 16.5% did not own any land for cultivation, 42.5% had less than 1,000 m^2, 28.5% had between 1,000 and 5,000 m^2, 8.5% between 5,000 and 10,000 m^2, and only 4% had more than 10,000 m^2. 12% of all households owned a fishpond (average size 430 m^2).

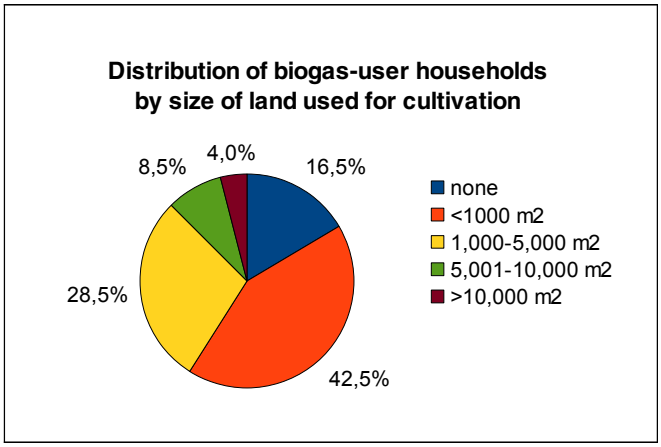

Figure 4: Distribution of biogas-user households by size of land used for cultivation

Out of all households using biogas, 92% had pigs (average number 30 per household); 11% had buffaloes (average 1.6 per household); 10% had cows (average 9 per household); 11% had goats (average 3.5 per household). Exact poultry numbers were not available.

5 The data were retrieved from the Biogas Project Database in the end of March 2007.
6 No other ethnic groups were indicated; in three cases the data were missing.

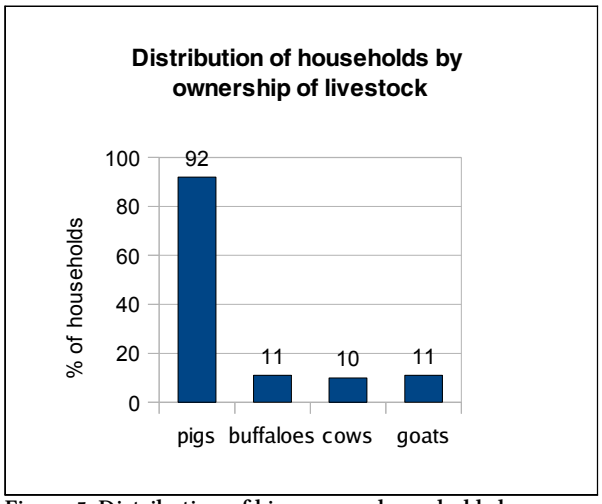

Figure 5: Distribution of biogas-user households by ownership of livestock

The data from the Biogas Project Database were complemented by the list of users obtained from the PBPD Son La, that included name of the household member who registered for the programme, district, commune and village, and the date when the construction of the biogas plant was finished. Geographical distribution of registered biogas plants in Son La can be found in Figure 6: the map shows how the first biogas users in the province were concentrated around the arterial road of the province, the National Highway No. 6.

Neither the database nor the list include any information on income or poverty level of biogas users.

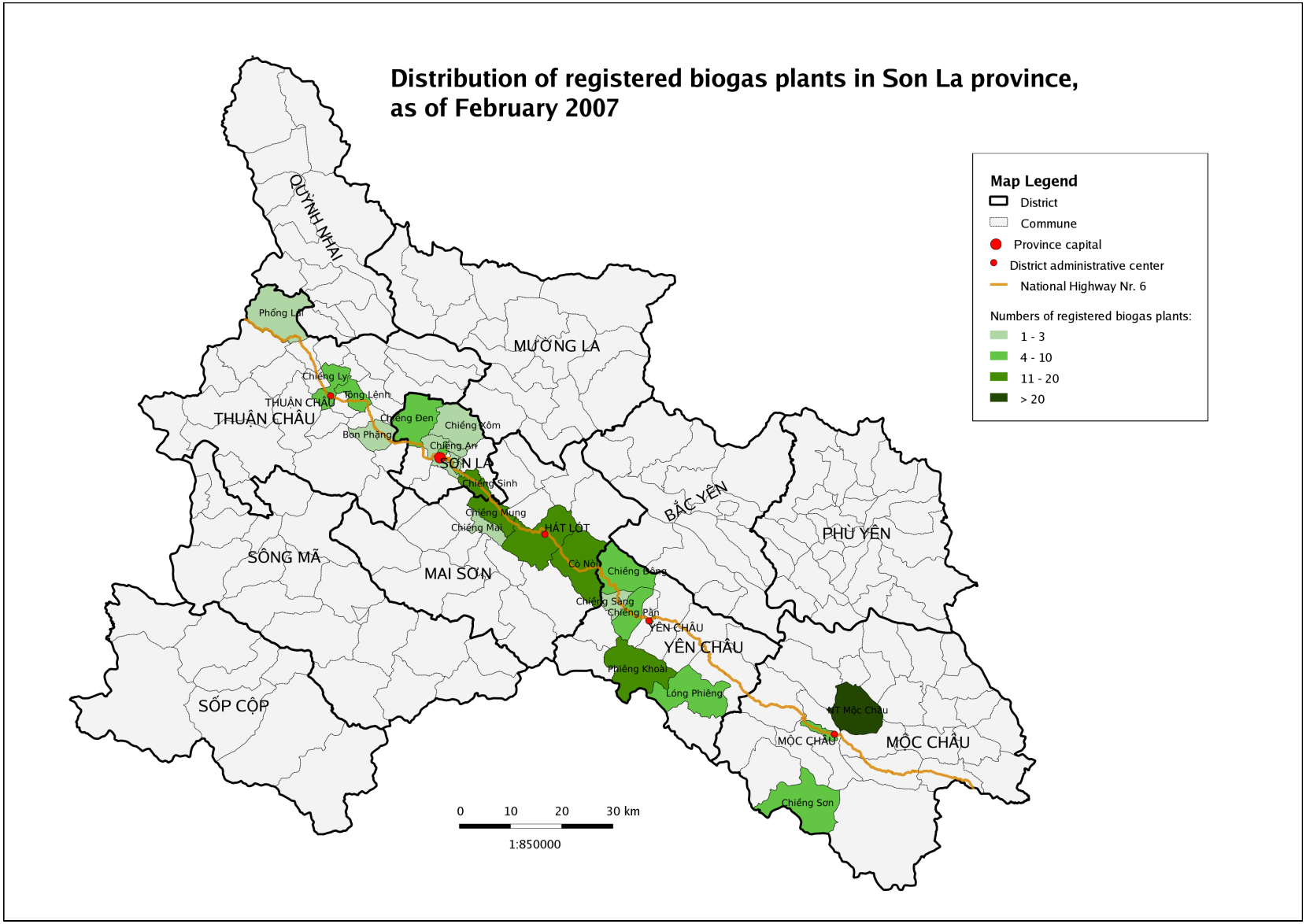

Figure 6: Map of distribution of registered biogas plants in Son La province as of February 2007

3.2 Livelihoods of farmers

To understand in more detail the livelihoods of the users and potential users in Son La, following data were obtained from semi-structured interviews with a sample of 30 hhs participating in the Biogas Programme, 32 hhs without biogas digesters, and 6 former users of biogas digesters which were built outside the Biogas Programme.

3.2.1 Sources of livelihood

Agricultural land

Although the research focused on biogas users or potential biogas users, i.e. those having livostock, agricultural land for cultivation was still an important natural capital for majority of these farmers; only 11 % of them did not own any (all of these were richer households, living in town). The main cash crop in the province is hybrid maize, grown predominantly on hill slopes. Most farmers get only one crop annually, in October. It is usually sold to traders (who come to farms with their own trucks), to be processed and used as an animal feed.

Paddy rice is grown on low-lying fields in valleys and the majority of interviewed households grew it for subsistence (if they grew any at all). In lower places with sufficient water for irrigation two harvests per year are possible, while in upper-lying plots there is only one harvest annually (in dry season, maize, soybean or peanuts might be grown instead of rice).

As growing maize leads to degradation of soil, increasing inputs of chemical fertilisers are needed over the time, thus lowering resulting profit. In the time of the survey, Son La Agricultural Extension Centre (AEC) was promoting project of fast-growing tree species as an alternative to maize, or various projects for intercropping: maize is sometimes intercropped with soybean, sweet potato, or other beans. Cassava was replacing hill rice on upper-lying plots where soil quality have deteriorated.

Several farmers interviewed cultivated tea in Phieng Khoai border commune in Yen Chau district and in Moc Chau district – both important areas of tea-cultivation in Son La. Average area for tea was around 5,000 m^2. Tea was usually sold fresh to local companies (e.g. Moc Chau Tea Company).

Coffee is another important cash crop in the province. It is grown mainly in Mai Son and Thuan Chau districts and in TX Son La where three farmers were interviewed (around 7,000m^2 each). Crop is sold to local companies (e.g. Son La Coffee and Fruit Company).

Home gardens provide vegetable and fruit for family's own need. For some farmers, fruit can be an important source of income too, as in case of mango in Yen Chau district. Other produce are for example plums, longan, or bananas. Fruit trees are also sources of firewood.

Animal husbandry

Livestock was an important source of livelihood for all surveyed households: 87% households had pigs and 61% had some cattle that was or could potentially be a source of manure for a biodigester.

Pigs are the most popular from large animals. Households with more developed husbandry raise exotic or cross breeds of pigs, rather than indigenous breeds (Ban or H'mong pigs[7]). These pigs are bred in semi-intensive way, grow faster, but they also require larger inputs. They are kept in closed pigpens. In Co Noi commune in Mai Son, pig raising is especially developed, and interviewed households had between 40 and 100 animals.

Pigs are usually fed ground maize powder mixed with water, sometimes mixed with cut leaves of various vegetable. To prepare this fodder, energy is needed to cook the mixture. Another option is to use concentrated fodder, which is more convenient, there is no need for energy for cooking, but it is more expensive to purchase. Several households fed their pigs on by-products of rice-wine production.

Several farmers mentioned that pig husbandry was not profitable anymore, because fodder was increasingly expensive while in the same time the price of pork meat was declining. For instance in Thuan Chau town, where Tay Bac University is located, some farmers were switching to more profitable livelihood strategies: renting rooms to students.

Farmers who own some land for cultivation usually have one or more buffaloes or cows for draught power. These are sold only if farmers need cash. They graze on farm or outside and they are usually brought back home every night. From the observations there was always some manure on the land around houses or under the shelters where the cattle stays over night, which could be collected for a biogas digester.

A specific case are dairy cows in Moc Chau district, raised in more intensive manner. Interviewed farmers had between 3 and 7 animals. Grazing is contracted to these smallholders by the Dairy Cattle Breeding Company of Moc Chau that provides extension and veterinary services and partly concentrate fodder, and purchases milk and breeding animals from them. The cows are stall-fed and occasionally grazed.

Chickens are the most common domestic animals throughout the province, other poultry is local variety of duck (ngan) or goose. Numbers of poultry are changing throughout the year, and in the time of the survey many farmers were reducing their numbers in response to the H5N1 threat. Poultry range free or is kept in hen coops (in towns).

One third of interviewed farmers had fishponds in a garden, on a maize field or on a former paddy field. The fishponds are source of fish and other by-products (like shrimps and molluscs) for consumption within household and for selling on local market. Fish are fed crop residues (maize, cassava leaves etc.) and grass.

Housing and infrastructure

A quality of housing encountered during the survey varied on a scale from large brick/stucco or wooden houses furnished with carved furniture to small and simple mud/straw houses, depending on a wealth status of households.

7 These local breeds are commonly raised by H'mong ethnics in extensive manner with limited inputs. Because they are not kept in closed pigpens, they are not considered as having strong potential for biogas.

Houses of Kinh farmers are made from bricks, poorer families live in mud houses, however these were less common among surveyed farmers. A kitchen is usually located inside, as one of the rooms, or outside in a separate, more open construction made either from bricks, wooden planks, bamboo, or mud.

Traditional stilt houses of Thai families are made from wood or bamboo, with thatched roof or tiled roof (richer households). A kitchen forms part of a large common space, serves as a meeting point of a family, and consists of an open fireplace in one of corners. In some larger houses of more richer households, the kitchen forms a separate room.

When it comes to a housing of animals, pigs are kept in pigpens built of bricks and/or wood. In Thai families, livestock traditionally used to stay in an area underneath a stilt house, but a growing number of households seem to be abandoning this tradition, giving sanitation concerns as a reason, and they use the space instead for storing various material, firewood, or machines.

A bad condition of roads was often mentioned by respondents as the main factor hindering development, especially in the communes located further from the arterial road of the province. Stability of an electricity supply was another serious problem often mentioned (see section on energy further below).

Sources of water in the province are mountain springs, local streams, common or private wells. Approximately one third of households were connected to common distribution system, others had their own wells, or used common wells in a village, or local streams. More than three quarters of respondents mentioned experiencing problems with water supply: some mountain springs are dry in dry season, and a level of ground water is constantly decreasing in many wells. In Chieng San in Yen Chau a common distribution system was broken and farmers had to transport water in barrels on carts. To lower the risk of running out of water, most households were collecting water in accumulation tanks.

In remote areas a sewerage system is non-existent. Some better-off households had toilets connected to septic tanks, but pit latrines were more common, or in more remote areas people simply used bushes around farm. Untreated waste-water, including water from cleaning animal pens, was discharged to gardens, ponds, and local streams (directly or through common drainage ditches).

Sources of income and household wealth status

The surveyed households were asked to classified themselves as rich, middle or poor, compared to other people living in their village. From all the households, 36% were rich, 50% middle and 14% were poor.[8]

8 Because of the focus of the survey on biogas users and potential biogas users, very poor households were not included in the sample, because they did not own animals necessary for the production of biogas.

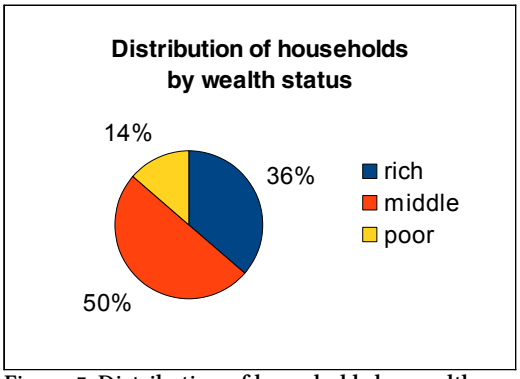

Figure 7: Distribution of households by wealth status

According to many respondents, participating in market is what makes people rich: having a small shop or other business, processing and/or trading agricultural products. Rich are those households that own a car, sell rice-wine etc. The poor have to work themselves on their own farm or as a hired labour on farms of others.

Selling cash crops (esp. maize or cassava) was the most important income source for all poor and most of the middle households. Animal husbandry was the main income source for about one half of all households: farmers focusing on pigs raising accounted for 28% of all respondents and were encountered in all visited districts. Selling milk to the local milk company was the main source of income for diary farmers interviewed in Moc Chau.

Non-farm sources of income were running a small business like making and selling rice wine or tofu, running a small shop (selling small goods, repairing, tailoring); all of them very common in towns. Trading maize, transporting, or processing in larger scale was characteristic for richer households.

Paid labour opportunities were working for state companies or as a state employee or working for other people (seasonal hired labour on farms, house cleaning, cooking). Former state employees or war veterans draw a pension.

3.2.2 Energy sources

The most common sources of energy according to the survey are presented below. The focus was on energy sources for cooking (both for family and domestic animals) and lighting, i.e. on those which can be most easily substituted by biogas:[9]

Firewood

Firewood (including bamboo) was used by majority of farmers; only few (<10%) answered they were not using it, either because it was too expensive, difficult to get, or not comfortable to use. Firewood can be bought from vendors for a price about 150,000 VND per m^3, but this price can grow significantly in areas where there is general lack of it. Several respondents from Nong truong, Moc Chau district, mentioned a price more than twice as high, explaining that firewood was getting

9 Both biogas users and non-users were interviewed on this topic. The users were asked to describe their situation *before* biogas.

scarce in their area and they had to pay to vendors to bring it from places further away. Nearly 30% of farmers said they bought their firewood from vendors, but more than two thirds of farmers collect firewood themselves in a forest[10] or from their gardens (e.g. cutting branches from fruit trees). Many farmers expressed their concerns about the future of this source of energy.

Corncob

Corn cob is easily available throughout the province and very cheap. Households with large maize farms have their own source, they store it under a shelter and sometimes sell to others (price about 3,000 VND per 3kg bag). Corn cob is used as a fuel when cooking pig food, making rice wine, and sometimes also when cooking meals for family. It ussually supplements firewood, but several households had replaced firewood with corn cob entirely, because the latter was cheaper and more available for them.

Coalbricks

Coal bricks were more common in towns; typically they can be seen in restaurants, while households use them as fuel for cooking pig food or in the production of rice wine. They can be bought for a price about 600 VND each, and they are usually burned in special clay stoves. Coal bricks were used by 10% of the surveyed households; several women mentioned they preferred firewood over coal bricks because the latter produce more smoke that they also considered as more harmful.

LPG

LPG was used by 30% of households. The price ranged between 200,000 and 230,000 VND per bottle, which normally lasts for 2-3 months.[11] LPG was very rare in Thai households (only one Thai family was using LPG); the Thai houses on stilts usually have a traditional fireplace in a corner of the main room or in a separate kitchen, and this fireplace is also used for drying meat or herbs.

Electricity

All the communes visited during the survey were connected to an electric grid, although its quality and reliability varied. In kitchens, electricity was used for cooking rice in electric cookers (nearly all households had such cooker) or to boil water in an electric kettle. Other appliances commonly seen were electric fans, TVs, VCD-players; a fridge was much more rare. Electricity was also used for lighting in majority of visited households.

Generally, the electric supply was very unstable though, and power cuts were frequent especially during dry season. In one village (Phu Luong in Chieng Luong commune, Mai Son) electricity was not available at all in the time of the survey and household were using kerosene lamps, accumulators or car batteries for lighting.

Average expanses on electricity were about 25,000 VND per month, but this figure was higher in households where electricity was used for income generation (e.g. 100,000 VND per month in a

10 This is a sensitive issue; when asked where they collect their firewood, respondents sometimes gave rather unclear answers. Local informants confirmed that poorer people often collect or cut firewood in protected areas, because they do not have any other choice.

11 This of course depends on how often the gas is used – in some households one bottle would last for a whole year.

household running a furniture workshop, or another household using an electric machine for making tofu). Gasoline generators, although very useful in cases of frequent power cuts, were not common in farmers' households due to their high price.

3.2.3 Deposition and utilisation of animal manure, fertilisers

Pigpens and cattle sheds are cleaned using water (if available) to flush manure into an open pit or directly into a drainage. Some farmers seemed to be concerned about various issues connected with this practice, especially in Moc Chau where there were larger volumes of manure produced by dairy livestock, and in Co Noi in Mai Son, where intensive pig husbandry was concentrated in town, with little space for storage and manipulation of manure.

Animal manure, fresh or composted, was commonly used as a fertiliser. Apart from simple cold composting, there was a technical assistance programme of AEC Son La providing training on making hot compost (mixture of manure and organic matter with enzymes that facilitate decomposition).

Manure or compost is transported to fields on shoulders or by a cart. Sometimes cattle is moved and kept for several days grazing on a plot which needs fertilising before e.g. transplanting rice, avoiding the necessity to transport manure.

Households who had limited land or did not want to use all manure from their animals, gave it for free to neighbours or poor farmers from uplands who did not have their own animals, or they were selling it. One older woman in Thuan Chau used to sell manure for 60,000VND per one tractor; this was also common practice in Xom Lom, an ethnic minority village in Phieng Luong, Moc Chau district.

Besides animal manure or compost, most farmers (90% of those with land for cash crops) were using chemical fertilisers. Average expenditures were around 6 mil. VND per year. Using chemical fertilisers on cash crops was very common especially for those who had larger land. Such farmers said that they were applying compost or manure too, but usually only on a small portion of their plots, since its amount was not sufficient for all their land.

Some farmers also used organic fertilisers produced locally. In Moc Chau, the local milk company made an utilization of its own organic fertilisers a condition for buying up milk from individual dairy farmers.

3.2.4 Typology of households and their livelihood strategies

Son La is a mountainous province, and as such it is less homogeneous than plateau provinces. This was confirmed during an initial review of available documents and during the first interviews . Livelihood strategies of local farmers differ in larger towns which serve as market centres, located along the arterial road of the province, and in more remote upland areas. Thus, the following very simple typology has been developed to describe specific local impacts of the biogas technology, using the remoteness (or accessibility) of the place where farmers live as a major differentiating factor.

Less remote

Households in more urbanized areas, like TX Son La or other district centres, has relatively good access to resources and markets, and they tend to develop commercially-oriented production systems. The mixed farming system is predominant, focusing mainly on rice; a significant crop area is irrigated (mainly rice paddies). Good and fast access to the local marketplace (located in district towns) is an advantage which enables generating profits from selling meat or vegetable. An important source for most farmers' livelihoods is livestock which provides meat, cash income, savings and draught power. Raising pigs is important especially for households that own a limited land. For many households, off-farm work is another important source of income.

More remote

In remote uplands villages, the access to resources and markets is much poorer. A mixed farming system is characterized by both permanent and shifting cultivation. Proportion of crop areas which are being irrigated is smaller, and there is high proportion of steep sloping land which is more fragile. Food security is still largely achieved through subsistence agriculture and households are less incorporated into the market economy. Typical cash crops are maize or fruit. Cattle is not so much raised for income, but it is rather a source of draught power, and it is being sold only in case of emergencies. Local varieties of pigs are raised, rather then exotic hybrids which require more expensive inputs and the price of their meat is lower. Opportunities for off-farm employment are very limited in these areas.

Poverty is higher in remote communes; the poorest are classified by authorities as being 'in difficult circumstances' and included in a special government's Programme 135 aimed at development of these areas. The remote communes are inhabited nearly exclusively by ethnic minorities.

The Table 4 shows districts, communes and villages visited during the survey and whether their accessibility was assessed by their inhabitants as good or poor. From the total of 68 households surveyed, 42 (62%) lived in areas with good access and 26 (38%) in areas with poorer access. It is worth noting that from 30 biogas users surveyed, 22 (73%) were from areas with good access and only 8 (27%) from areas with poorer access; this illustrates the fact that even in Son La the first households participating in the programme were from more peri-urban parts of the province.

Table 4: Remoteness / Accessibility of surveyed villages

District	Commune	Village	Accessibility good (+) or poor (–)	Number of hhs surveyed
TX Son La	Chieng Sinh	HTX3	+	6
	Chieng Den	Ban Pang	–	4
Thuan Chau	Tong Lenh	Cuong Muong	–	2
		Tieu Khu 2	+	1
	TT Thuan Chau	Tieu Khu 1	+	4
		Tieu Khu 2	+	2
	Chieng Ly	Na Cai	–	1
	Bon Phang	Nong San	+	1

Yen Chau	Cheing Sang	Chieng Kim	+	1
		Chieng Sang	+	7
		Ban Mai Ngap	+	1
	Phieng Khoai	Hang Mon I	–	8
	TT Yen Chau	Tieu Khu 5	+	2
Moc Chau	Nong Truong ('Farm town')	Tieu Khu 19/5	+	6
		Tieu Khu 67	+	4
		Tieu Khu Thao Nguyen	+	1
		Ban Pha Khen I	–	2
	Phieng Luong	Xom Lom	–	2
Mai Son	Xa Co Noi	Tieu Khu 3	+	1
		Tien Khu 39	+	1
		Tieu Khu 19/5	+	4
		Ban Me Lech	–	4
	Chieng Luong	Phu Luong	–	3

3.3 Impacts of biogas on users' livelihoods

This section presents findings of the survey on the impacts of biogas in Son La. In order to obtain results which could be compared with the finding of previous surveys in Vietnam, the impacts were sought primarily in the following three areas of farmers' livelihoods: time and workload, monetary savings, and environment.

3.3.1 Time savings and workload reduced

Firewood collecting

Biogas can save time needed for collecting firewood. In Son La, collecting firewood was much more common in more remote households: out of all households surveyed that lived in such areas nearly three quarters used firewood collected by themselves as their main source of energy for cooking, compared to only one third of households from areas with good accessibility.

Table 5: Main source of energy for cooking in Son La according to accessibility (both users and non-users):

	Firewood collected	Firewood bought	Corncob	LPG	Electricity
Hhs with good access (out of total 42 hhs)	13 (31%)	10 (24%)	3 (7%)	15 (36%)	1 (2%)
Hhs with poor access (out of total 26 hhs)	19 (73%)	3 (11%)	2 (8%)	2 (8%)	0 (0%)

LPG was much more common in less remote households, or these households were buying their

firewood from middlemen. In such households, biogas cannot (potentially) bring any time-savings in this respect.

Time savings are limited to those who used to collect their firewood in the past. In Son La, from all the new biogas users who used to collect their firewood before construction of biogas plant (16), 9 answered they no longer collect firewood now, however 7 households still collect some firewood, although less than in the past. This was due to several reasons: those households that raises pigs often said that the volume of biogas was not sufficient for cooking food for these animals. In Thai households, it was because fireplace is a traditional component of the house and it is important for preparation of traditional meals.

Cooking

Biogas can reduce time spent on cooking. All women who used to cook on firewood (interviewed directly or asked during observation at households) mentioned that with biogas they needed less time for cooking. Their estimated savings were around 1 h per day. It was because they did not need to monitor fire all the time. Also a biogas cooker can be used instantly, as opposed to firewood that takes some time to prepare and ignite, especially in rainy season.

None of the women who used to cook on LPG mentioned savings in time as a result of switching to biogas. These were mainly women in less remote households.

Using saved time for other activities

Estimating more precisely a total amount of time saved was not easy for users because biogas plants were still very new in the time of the survey.

It was even more difficult to find out how farmers use their saved time; only two women were able to say that they were using the extra time for various housework and caring for children/grandchildren. From a focus group discussion with women in Thuan Chau it has followed that thanks to biogas several women were able to go to a local market more often and sell more vegetable or handicraft products. In the same time, as they spent more time at the market, other family members (husband, children) had to involve in meals preparation more frequently.

Operating biogas plant

Time needed for operation of a biogas plant was minimal according to users. To feed a digester with manure, people used water to flush animal pens in more or less the same manner as they did before. Manure flows to an inlet of a biogas digester together with the water used for cleaning. Nobody mentioned any extra discomfort regarding this chore.

3.3.2 Monetary savings

Savings on fuel

With biogas there were direct savings on fuels, especially on fuels for cooking family meals. For example, households who used to utilise LPG for cooking saved about 70,000 - 100,000 VND per

month after installation of biogas (one bottle of LPG costs 200,000 – 230,000 VND and usually lasts about 2-3 months).

Savings on buying firewood were more difficult to count, mainly because biogas plants were still new, and their users could not say whether they will be able to substitute all of their previous source or whether they will have to continue buying some in future. If all the firewood is substituted by biogas, households could save between 50,000 and 100,000 VND per month. Not all households however, especially those in more remote areas, were buying their firewood, as already mentioned; in fact, from the 8 biogas users living in more remote areas, only one used to buy his cooking fuels before biogas. Therefore, when an average (an arithmetic mean) is made for all households in each group, estimated savings are much higher for the users living in less remote areas.

Table 6: Savings on fuels

	Cooking fuels were predominantly bought before biogas	Average estimated savings*) per month
Hhs with good access (total of 22 hhs)	15 (68%)	145,000 VND
Hhs with poor access (total of 8 hhs)	1 (12,5%)	31,000 VND

* arithmetic mean for all households in the group

According to all households that already had a biogas lamp for lighting, biogas reduced costs of electricity for them. Estimated savings were around 10,000 VND per month. This is less then in case of other sources of energy, because electricity is also used for other purposes than lighting, where it cannot easily be substituted by biogas (cooking rice in electric cookers etc.). Buying an electricity generator running on biogas would have been too expensive for most households.

Bioslurry and savings on chemical fertilisers

About one third of the interviewed biogas-user households were not using resulting bioslurry: the main reason given was that their biogas plant was too new and there was no bioslurry yet or only a few. However there were also 2 households among them that were disposing of the bioslurry although they had it and their biogas plant had been in the operation for the longest time. Both of them lived in an area with good accessibility and they owned only a little land.

From all the 8 remote biogas-user households, three did not utilize bioslurry because they did not have enough of it yet; all the others utilize it.

In total, two thirds of the owners of biogas digesters were already utilizing resulting bioslurry. They were using it for fertilising vegetable (81% of them), fruit trees (38%) and grassland (38%).

All those who used bioslurry for fertilising vegetable were satisfied with results, saying that vegetable grew better than with manure. Some also pointed out other advantages: elimination of unpleasant smell of manure on vegetable, and reduction in numbers of flies. In Moc Chau users reported positive outcomes after applying bioslurry to fertilize grass for their dairy cows.

Using bioslurry only on vegetable, fruit trees and grassland, however, means no savings on chemical

fertilisers, because home gardens and grassland are usually fertilised only by manure. Farmers explained that they did not use chemicals on vegetable, especially when they grew it for their own consumption. In fact, the farmers had merely substituted bioslurry for manure, which was now fed into biodigester.

In Son La, chemical fertilisers were used mainly for cash crops like maize, tea, or rice. Most of farmers, however, had not yet began to replace those chemicals with bioslurry, and they said they were still using the same amount of chemical fertilisers as before (only one user was expecting reduction in costs of fertilizers of about 50%).

According to the farmers, the reasons for not utilising bioslurry for fertilising crops were:

- insufficient volume of bioslurry;
- difficulties with transportation – it is easier to transport bags of chemicals than barrels of liquid bioslurry; according to the farmers a possible solution might be to install a pump and pipes for higher lying plots, which would however require an extra investment;
- scepticism regarding quality and capabilities of such organic fertiliser in comparison with chemical fertilisers.

3.3.3 Improved environment, health benefits

Cleaner air indoors

Households, and especially women who were the main cooks in the majority of households, benefited from reduction of smoke inside kitchens. Many respondents highlighted this aspect. Such improvement was limited only to the households where biogas has substituted firewood or other biomass sources of energy for cooking meals for family. The households who used to cook on LPG did not experience any improvements in this respect.

Sanitation

Most of the households with a biogas plant had a toilet, either new or renovated, connected to the biogas digester. In more remote households, completely new toilets were often built together with the construction of the digester. Households in towns and more richer households already had had a toilet before the construction of biogas digester, so they only renovated it and connected it to the digester.

Environment around house and animal pens

Here biogas clearly improved situation in all households as the manure was flushed to a biogas digester instead of being stored in an open air. However, the potential was not fully harnessed in most households. It was often the case that only part of the manure produced by animals could have been utilized in the digester, because this had been built too small as a result of owner's initial suspicions towards the new technology. The rest of the manure was therefore treated the same way as before, i.e. flushed away, stored in a pit, or sold.

Because a biogas plant needs to be fed regularly, cleaning of animal pens was carried out more frequently according to 12 (40%) biogas users, while the rest continued to perform the cleaning in the same manner as before. There was no difference between households in less remote and more remote areas.

3.4 Data on non-users

Households without biogas plant were asked about their knowledge of biogas and their interest in this technology. A majority of the non-users had already some knowledge of biogas; this knowledge came from their relatives or acquaintances from other provinces, neighbours, or from extension workers.

Advantages of biogas technology well known to the non-users were: a clean and convenient source of energy, saves money, reduces a pollution on a farm. Far less often the farmers mentioned savings in time, use of bioslurry for fertilizing crops, or use of biogas for lighting. One farmer said that he would like to use biogas for heating inside animal pens, and another farmer was interested in using bioslurry as a fodder for fish.

Reasons for not constructing a biogas plant were (see Figure 8 further below):

- An insufficient financial capital as the major reason. The lack of money was either temporary (money will be available after harvest; or when children finish their studies) or permanent (money is needed for purchase of seedlings or fertilizers, or family is generally poor or afraid of falling into poverty). This problem was more frequent in areas with poorer accessibility.
- An insufficient area for the construction of a plant. This problem was mentioned by two households living in a town.
- An insufficient number of livestock to produce enough manure for a biodigester. Several farmers mentioned their plan to reduce number of pigs since it is no longer a profitable business (the price of meat is declining while the price of pig fodder goes up), or because it requires too much work. There were also two farmers who did not keep their pigs in pigpens and therefore could not collect manure.
- People do not trust the technology or the Programme. Only one respondent gave this answer directly, but several farmers and local informants said this about others. The main reason for the distrust are bad reports about or direct negative experience with old-design biogas plants, as well as problems with new biogas plants built under the present Biogas Programme.
- A lack of information in general. Limited to places where there are no biogas plants yet. Two farmers interviewed did not have any knowledge, or had a very fragmentary picture about the technology and its use.[12]

12 An example of such lack of information could be an answer of one farmer who said that she would not build a biogas plant because she needed manure for fertilising flowers that she grew to sell on a local market. Although she knew

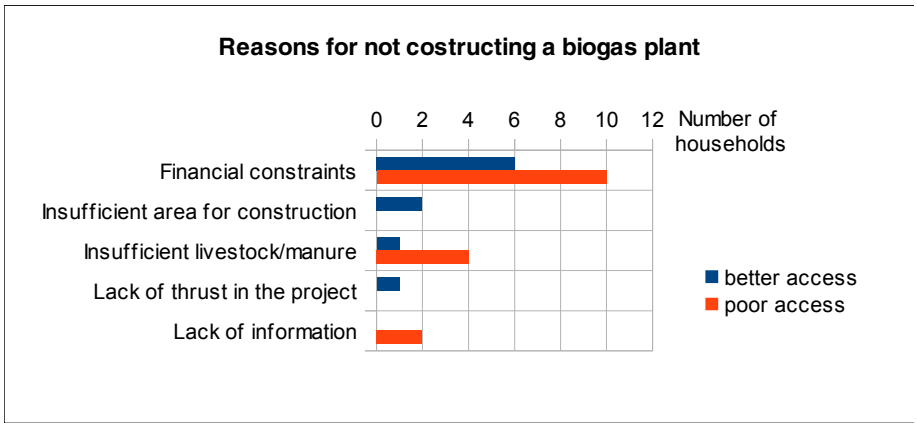

Figure 8: Reasons for not constructing a biogas plant

One third of the interviewed non-users were either planning to build a biogas plant in very near future (were already registered in the programme) or expressed their wish to build one in future.

During the survey, six former biogas users were also interviewed who did not participate in the current Vietnam Biogas Programme. Their biogas plants were of different design, built prior to the programme's launch in the province. They were all innovative people who decided to build a biogas plant on their own after they had seen it at their relatives or acquaintances in other provinces. Generally, these users spoke positively about advantages of biogas, although their biogas digesters had been out of operation for some time already due to defects in construction. All of them expressed their interest in the new design and in a subsidy and technical support being provided by the programme. However, they were also much more cautious and intended to wait to see first results in other households.

3.5 Credit possibilities

Since the financial aspect of the biogas plant construction was the main concern among the interviewed farmers, credit possibilities in the province were reviewed:

Constructing a biogas plant costed 3-5 mil. VND in Son La, and the Programme provided subsidy of 1 mil. VND on a flat-rate basis to all households. As for remaining costs, majority of interviewed users said that they did not take any loan to finance the construction (see Table 7); they explained that compared to other regular expenditures (purchase of seedlings, fertilizers etc.) the investment into a biogas plant were not so high for them and they could easily afford it.

about the possibility of using biogas as a source of energy, she was not informed about the fertilising qualities of bioslurry.

Table 7: Households with a loan taken for biogas construction

	No loan taken	Loan taken
Hhs with good access (total 22 hhs)	20 (91%)	2 (9%)
Hhs with poor access (total 8 hhs)	5 (63%)	3 (37%)
All biogas users (30)	25 (83%)	5 (17%)

For those households that are more or less dependent on income from selling maize (mainly the more remote households), money for investing into a biogas plant is generally available only after a harvest in October. Many of those households that expressed their intention to build a biogas plant in the near future mentioned that they will be able to do so only in autumn after selling their harvest.

Similarly to other provinces, main suppliers of financial services in Son La province are state-owned banks: the Vietnam Bank for Agriculture and Rural Development (VBARD) and the Vietnam Bank for Social Policies (VBSP). Another way to borrow money is via semi-formal financial institutions such as one of the mass organisations (Vietnam Women Union, Farmers' Association), or from private money lenders. From the five biogas users who financed the construction of their plant with help of a loan, two borrowed from VBARD, two from VBSP, and one from a private lender.

As for the other channels of financing, some of the interviewed households had experience with borrowing money via the Vietnam Women Union (VWU) on more favourable terms. Nobody however mentioned considering this possibility to finance the construction of a biogas plant. We spoke with heads of VWU in two different communes and also with several women who borrowed money through VWU in the past; they mentioned that Biogas programme was still very new and the VWU had not considered this area yet, but they admitted that this possibility could open up in the future. However, it became clear that women normally borrow only smaller sums (up to 1 mil. VND) through VWU, to purchase few chickens etc. More frequent instalments (a common set-up in the case of a loan through VWU) are also problematic when household's income relies on seasonal crops such as maize. In such cases, women regarded taking a conventional loan from a bank as more convenient.

4 Discussion

In this section, the data from the survey in Son La will be summarized and put into context to meet the aim of the research, which was to investigate specific impacts of biogas digesters in Son La province, and thus contribute to better understanding of potential of biogas for poverty reduction in remote mountainous areas of Vietnam.

First, the impacts in Son La are summarized and compared to the situation already documented in other provinces. Then the potential for biogas to contribute to poverty reduction in this mountainous province is assessed. Finally, some limitation of the research are presented which should a reader be aware of.

4.1 Impacts and comparison with other provinces

The main research question was on specific impacts of biogas digesters on livelihoods of their users in Son La province. An underlying hypothesis behind this research was that the impacts in Son La will be different from impacts in more peri-urban areas where the Biogas Programme initiated in its Phase I, since Son La has a different geography (mountainous) and is one of the poorest provinces in Vietnam. The survey showed only some minor differences.

Among the impacts of biogas most often quoted are savings on fuels, either monetary or in time for their collection. According to the previous surveys (BUS 2005, Otten 2006), average monthly savings on fuels were 100,000-120,000 VND per month per household. This is slightly more than savings of those Son La households which had been using mainly LPG before they constructed a biogas digester: 70,000-100,000 VND per month only on the LPG. Estimated savings on firewood in Son La were also slightly lower, between 50,000 and 100,000 VND per month.

The survey showed differences across Son La province itself. For instance, average estimated savings for all cooking fuels combined were 145,000 VND per month per household in areas with better accessibility, while in more remote areas it was only 31,000 VND per month per household. Only one out of 8 households used to pay for their fuels before biogas while all the others had not.

When it comes to time savings, according to the previous surveys women saved around 75 minutes per day on cooking and cleaning dishes. In Son La, this time was estimated by women themselves around 1 hour per day. Savings on firewood collection were yet too difficult to estimate for households in Son La; elsewhere in Vietnam, these were 12 person-days per year (BUS 2005), and 20 person-days per year in the survey of Otten (2006) which involved also poorer households. Higher savings in Otten's survey illustrated that more poorer households were included in the sample, that usually rely on more time-consuming energy sources.

Previous surveys showed that majority of men were using saved time for income generating activities, while majority of women for taking care of their families. In Son La, it was mainly women in more remote households who reported savings in time, using them for taking care of their family, but also for increasing their income generating activities.

In the time of the survey in Son La, bioslurry had not yet replaced chemical fertilisers and households were not experiencing any savings on purchasing them. Use of bioslurry was limited to a near vicinity of a biogas digester, applied on vegetable, fruit trees or grassland, replacing manure. Although the chemicals had not been replaced, still two thirds of biogas users used bioslurry, which is more than for example in the BUS 2005 where it was only 40%. Households in Son La however often mentioned problems with transportation and application of liquid bioslurry on sloping land, which was a significant difference from the previous surveys.

Similar to previous surveys in other provinces, users in Son La were experiencing cleaner air indoors, again especially in more remote households where biogas replaced firewood, or cleaner environment around animal pens, and reduction of smell and flies.

In conclusion, the survey showed that the general impacts on livelihoods were quite similar to peri-urban areas, however some differences could have been observed across the province itself. The more remote places experienced more time savings (on cooking, firewood collection), but not so significant monetary savings. The improvements in sanitary situation were more apparent (e.g. construction of toilets which were non-existent before). Such differences are important for further dissemination in remote areas, as for example the lack of direct monetary savings can make biogas less attractive for local households.

4.2 Potential of biogas to reduce poverty in Son La

The aim of the research was to contribute to better understanding of potential of biogas for poverty reduction in remote mountainous areas of Vietnam. Worldwide, the biogas technology has become a well established solution for the energy needs of rural people, and in Vietnam it was recently gaining success in many plateau provinces. It was therefore believed that biogas digesters can have positive impacts also on the livelihoods of rural farmers in mountainous Son La province. This was confirmed by the survey, although some limitations became evident too.

4.2.1 Biogas as a means of development

The research showed positive impacts of the biogas technlogy on livelihood assets of local farmers as described above. The assets are foundation stones for farmers' livelihood strategies on their pursuit of their livelihood outcomes. How have these changed and how this influenced vulnerability of farmers towards external environment?

Livelihood strategies and biogas

In sustainable livelihood framework, livelihood strategies are 'the range and combination of activities and choices that people make/undertake in order to achieve their livelihood goals (including productive activities, investment strategies, reproductive choices, etc.)' (DFID 1999). According to the sustainable livelihood approach, the more choices and flexibility people have, the greater is their ability to withstand – or adapt to – the shocks and stresses presented by their external environment (or 'vulnerability context'). Therefore (in poverty reduction and development interventions), to assist poorer households, instead on focusing on one strategy and how to get most of it, it is much better to

promote this freedom of choices.

For biogas users, constructing a biogas digester was a kind of an investment strategy into more convenient source of cheap energy that also solve their problems with waste from husbandry. By choosing biogas as a source of energy, households accept husbandry to continue being one their livelihood strategy becauase manure from livestock is necessary for operation; no fundamental change can be expected here. However, by using its advantages (time and monetary savings, fertilizer etc.), they can diversify and develop their livelihood strategies.

The survey in Son La indicated that this was indeed possible: One example were women from Thuan Chau district who were able to go more often to local market to sell their vegetable and handicrafts, thanks to the time they saved on collecting firewood and cooking. Although this was not a new activity per se, they could now focus more on developing it. Another example were two farmers in Yen Chau and Moc Chau districts who were considering using bioslurry for fertilizing their tea plants, and focusing rather on tea cultivation instead of pig raising. Because biogas plants were still quite new in most households, the changes were more in a stage of preliminary ideas, however the very fact that the farmers were thinking of them is important.

Livelihood outcomes

Livelihood outcomes are the outputs of livelihood strategies, goals that people pursue. Sustainable livelihood approach stresses their variety and richness, and that they cannot be narrowed down to a simple maximalization of income.

Measuring exact differences in outcomes would be impossible in these initial phases of the operation of biogas plants. Interviewed households made some estimations but only the future will show how exactly will the investment into biogas digester influence their outcomes. However, some picture can already be outlined.

Biogas brings no direct income and this is rather characteristic for energy services – they are usually only a means which enables to gain income through other productive activities. The only possible way of direct income would be to sell resulting energy, which in case of biogas is technically very complicated. Another option would be selling bioslurry but there was no such practice in Son La. Biogas therefore brought only savings, and only to those households that were buying their fuels in the past. Potential income increase could result indirectly from higher crops yields after applying bioslurry as fertilizer, based on findings from other provinces (Eije, 2007), or from additional income-generating activities. Both were still rare in Son La in the time of the survey.

However, there are more aspects other than increased income. In fact, many households indeed affirmed that when they decided for the biogas technology they were more interested in other advantages, mainly cleaner environment on farmyard and less smoke. Biogas positively affected well-being of especially those households who switched from firewood, by reducing indoor air pollution significantly, and alleviating or eliminating entirely the burden of firewood collection and preparation.

Food security of local farmers could be improved in longer term by reducing soil degradation and contamination. In a short-term perspective, there were first signs also of improved agricultural

outputs – some households confirmed that vegetable grew better after application of bioslurry.

Vulnerability context

One of the possible livelihood outcomes is reduced vulnerability. Sustainable livelihood approach points out an important role of trends, stresses and seasonality for livelihoods of people. These represent an external environment, over which people have limited or no control, but which strongly influences their livelihoods. Any improvement in ability to cope with these factors always means an improvement in their situation (DFID 1999). It is therefore interesting to see whether biogas has a potential to reduce vulnerability of its users in Son La face to face risks, seasonal changes and longer-term trends.

Most obvious benefit of biogas, which helps farmers in this respect, was that they got a reliable source of energy. One of the trends in Son La is the declining availability of firewood, which is also reflected in its rising price. Periodical problems with finding dry firewood in rainy seasons were also (partly) eliminated. Furthermore, in the time of the survey electricity black-outs were quite common in Son La and typical for dry season in the province, and users appreciated to be able to use their biogas lamps for lighting if if a black-out occurred.

In case that prices of pork meat would continue to decline as several farmers apprehended, biogas could stabilize/decrease vulnerability towards this trend. Pig raising would lost its primary role as a productive activity and its secondary role would came to the fore – producing an quality organic fertilizer for crops and thus supporting different productive activity (e.g. organic tea cultivation).

In long-term perspective, bioslurry could contribute to improved quality of local soils, which are rapidly degrading in the province especially due to more intense maize farming. Also, current ways of storage and disposal of animal manure in the province certainly pose health and hygiene risks for livelihoods of farmers through contamination of surface and ground waters. This trend could be partially inverted by wider dissemination of the biogas technology in the province. However, these long-term impacts could not have been confirmed in this research.

4.2.2 Limitations of the Programme and a potential for dissemination

From the survey it is obvious that there are indeed positive impacts of biogas digesters on livelihoods of local farmers, which are worth multiplicating throughout the province and other parts of Northwest Vietnam. What is therefore the prospect for the dissemination of the Programme and what are the limitations?

First of all, a potential clearly exists for integrating the biogas digester into everyday practice of local farmers. The integrated system is the common farming practice. Farmers are traditionally accustomed to see manure from their animals as a valuable component, for fertilizing fruit trees and vegetable, and they are also used to utilize crop residues as a source of energy. A biogas digester can fit into this practice when properly explained. The research among first biogas users in Son La revealed that the potential had not been fully harnessed in this respect, mainly because bioslurry was not yet fully utilized.

From the survey among non-users it followed that there were many of them interested in biogas.

Large potential exists especially in Con Noi district, in communes located around the National Highway No. 6 that focus on pig husbandry, or on dairy farms in Moc Chau. There is strong potential for bioslurry to be used as a fertiliser on tea farms in Moc Chau and partly in Yen Chau.

Son La is one of the poorest provinces of Vietnam and it should be made clear that the Vietnamese Biogas Programme is not intended to provide solution for households in extreme poverty. One of the main limitations is that a household need to have some minimal number of animals (approximately five pigs or two cows) for operation of a biogas digester, which already disqualifies many poor households in remote communes in Son La, especially ethnic minorities. In Son La animal husbandry is mainly concentrated in district administrative centres and along the main highway and other roads in reasonably good conditions. On the other hand, the main source of income in upland communities is hybrid maize, and animals (like local pigs) are usually kept only for households' own need. Moreover, the animals are usually free-grazed which hinders an effective collection and utilization of their manure in a biogas digester. However this does not mean that in poor communes no potential exists. The survey showed that there might be potential users even in remote communes, and these should not be excluded a priori from the Programme.

However, especially for these remote households, a poor accessibility brings many difficulties. Farmers in Son La reported higher construction costs due to complicated transportation of material during rainy season, or higher prices asked by masons who must travel to remote communes and require housing and food since they cannot return home everyday. Other issue was availability of water that is needed for the operation of a biogas digester: in several communes, local sources are drying out during every dry season.

Although many biogas users in Son La said they did not need a subsidy that the programme offers for financing, this would certainly not be the case for poorer households. Those of the poorer households that have minimum number of animals required to participate in the Programme could benefit from better focused system of providing subsidies to those in real need, or from other innovative support. Current system of microcredits in Son La might not be a best solution for poorer households to finance construction of a biogas plant; current microcredits schemes finance mainly smaller purchases.

4.3 Limitations of the research

As already mentioned in the section on methodology, the research was designed having in mind some limitations, so that biases could be reduced which could otherwise lead to impaired results. During the survey, other facts became evident which might have influenced the findings, and all these will be summarized below so to make a reader aware of them.

The research showed very similar impacts to those already known from plateau provinces of Vietnam, despite different geography and socio-economic situation. This, however, might be influenced by the fact that the survey in Son La took place in the moment when the Biogas Programme was entering the province and therefore the first users were so called 'easy-adopters'. It was find out that most of these users belonged mainly to richer and middle-income status groups.

Also, they were targeted partly deliberately: it was mentioned several times by AEC officials and confirmed by other experts focusing on development of agricultural extension services, that richer households are often targeted first when a new technology is being introduce; it is a way to minimize potential failures that could discourage other potential users. For these people the programme will bring very similar benefits as it brings for people in plateau provinces.

The research was limited to areas where at least some potential for biogas exists. This area was delimited based on information from local informants, who were asked to indicate such parts of province. Also due to time constraints, the survey took place only in the districts where there were some biogas users already. An opportunity scan could be done in other parts of the province.

The research was limited to biogas users, i.e. the demand side of the Biogas Programme, while another equally important part of the programme, masons (supply side), were not considered. The masons gain an opportunity though the programme to diversify their livelihood strategies and obtain an additional income in construction of biogas digesters. The programme therefore brings positive benefits for them as well, and in the same time the masons are crucial for establishing a viable biogas sector in the future. However, as the Programme was only entering the province in the time of the research, there were only very few local masons trained yet and most of the first digesters had been built by masons from other provinces. Thus, masons were not considered in the research.

5 Conclusion

The overall objective of this research was to contribute to better understanding of a potential of biogas for poverty reduction in remote mountainous parts of Vietnam. Can biogas indeed reduce poverty in Son La or in other similar places?

First of all, it is worth repeating that a biogas technology is not intended for the extremely poor farmers, because it requires some minimal number of animals to produce enough manure for operation; not only the number is important but also a way of keeping these animals. In Son La, many households from ethnic minority groups living in remote upland areas will be excluded from enjoying potential benefits because they only keep very few animals for subsistence, raising them in an extensive way that makes collecting of manure more difficult. In the first year of biogas operation in this province, the users were predominantly richer and middle-income households that lived in districts along the arterial road of the province. They were mainly Kinh, although there was already a significant number of Thai ethnic minority participating as well.

Although biogas cannot be a solution for households in extreme poverty, it can still contribute to improvement of livelihoods of many, even in relatively poor province like Son La. The survey showed first positive impacts on livelihoods of the new biogas users. Similar to other RETs, biogas provides cheap and secure energy. It can brings monetary savings but also comfort of use which is similarly important for the users. By utilizing manure from livestock it reduces negative impacts of husbandry on fragile environment of the mountainous province. Unlike most of the other RETs, it has a value added: bioslurry, a rich organic fertilizer, a by-product which can even turn similarly or more important than the energy itself. It can replace chemical fertilizers, reducing again negative impacts of farming on environment.

A hypothesis behind the research in Son La was that the impacts will differ from impacts already known from more peri-urban, plateau provinces of Vietnam, simply because geography and socio-economic conditions are different. It can be concluded that in general the impacts of biogas encountered in Son La were not significantly different. This might be however influenced by the fact that the Programme was just entering Son La and the digesters were very new, and as already mentioned, the users were mainly local richer and middle-income households living in places with good accessibility. These first users were local 'easy-adopters' who are always more willing to take risks of innovative technologies; because of this they were also deliberately targeted by local authorities, in order to minimize risks of failures from not finishing the construction and dropping out of the Programme. From the whole population of Son La province, these users had probably the most in common with users in peri-urban areas of plateau provinces. However, it can be expected that more of poorer households, which live in more remote upland areas of the province, will adopt the technology as the time goes and the technology becomes better known in the area. The impacts characteristic for these households will then become more prominent in the province, such as savings in time on collecting fuels, or reduction in indoor air pollution.

In the same time, however, the problems these households face will show up more often. Since the major concern among the poorer households was related to their ability to finance the construction,

a good mechanism of financial support should be developed for these households in order to minimize risks connected with construction of a plant. This mechanism should respect potential seasonal fluctuation of farmers' income. This and several other recommendations for further dissemination are elaborated further below.

The success of the biogas technology in reducing poverty or inducing development does not however lie in dissemination among as many users as possible. More important is the successful integration into specific local livelihoods without which the potential of biogas technology will go in vain. Specific factors which acts for and against the integration should be considered very carefully. The factors which supported this integration in Son La were for instance the increasing scarcity of firewood, which pushed for finding alternative technologies. In places with higher population density and concentration of more intensive husbandry, the pressure to solve problems of untreated animal waste was very important factor in favour of the successful integration. On the other hand, among the problems which could hinder the integration were scarcity of water in some areas (seasonal drying out of local sources), which is needed for operation, difficulties with transportation and application of bioslurry on sloping land, or traditional ways of food preparation of some ethnics.

In conclusion, biogas will not eradicate poverty in Son La, other Northwest Vietnam provinces or elsewhere. Biogas, as many other energy sources, is rather a means to development. It opens up a potential which needs to be utilized. The better it is integrated into livelihoods of its users, the more of its benefits can be harnessed. In remote mountainous areas there certainly exists more negative factors against successful integration. However if these are recognized and minimized, the biogas can make livelihoods of local farmers more sustainable and less vulnerable.

5.1 Recommendations

The following are the recommendations that emanated from the research, that might be useful for further dissemination and successful integration of the technology by local farmers in Son La and other similar places. Also, some ideas for future research are presented further below.

5.1.1 Further dissemination and integration of the technology

For reaching more remote farmers, the cooperation with local actors like VWU or farmers' associations should be as close as possible. These institutions have the best knowledge about individual households and can help in identification of potential users, promotion and access to credits, since the financial aspect remains an important obstacle for most households in remote areas.

Mutual sharing of experience on a local level is the best way to promote the biogas technology, because many of the current users, or those who have registered for building biogas plant in the near future, say they have learnt about biogas from their neighbours or relatives.

Any subsidies should be allocated according to a poverty status of individual households. In Son La there were richer households living in poorer districts/communes and vice versa. During the survey it became clear that for richer households the investment to the technology was not high and they did not have to take any loan.

In the upland areas, seasonality should be taken in account when advising on available credit opportunities. Money from selling maize is the main (or the only) income for many upland households and available only once a year – after harvest in October. This seemed to make microcredits less interesting because farmers were afraid they would not be able to repay them in small instalments throughout a whole year.

Results of recent surveys related to the technology, such as the one on the utilization of bioslurry on tea farms in Thai Nguyen province (Eije, 2007), should be disseminated in a comprehensible way among interested farmers to provide them with better information. A lack of information could influence the range of possible benefits. Cooperation with local universities could be also improved in this respect.[13]

Possible linkages to other development activities in the province should be explored and developed. In the case of biogas in Son La, such linkages could be made for instance with parallel programme of advising farmers on better marketing of agricultural products: bioslurry provides opportunity to get cleaner produce for the (international) market; further processing of produce in the time saved on collecting firewood etc. Furthermore, new users could be identified among farmers participating in projects of husbandry development (this was already happening in Son La, but was limited to larger and better-off farmers [14]).

5.1.2 Follow-up research

Following topics for further research resulted from discussions with local extension workers and biogas technicians: One of them was to assess the efficiency of bioslurry in comparison with chemical fertilisers when used on local crops. Another topic suggested was related to the impacts of biogas on quality of groundwater. According to the technicians and local authorities, the results would help to explain benefits of biogas more easily to those potential users who were sceptical about the new technology. In the field of research, the Biogas Programme could cooperate with local Tay Bac University as already mentioned, and with Thai Nguyen University of Agriculture and Forestry.

13 In Son La, SNV already had good relations with the local Tay Bac University, where they mainly organized workshops for University's staff. There were students and teachers already conducting research on the quality of organic fertilizers; research on bioslurry could be done and the results – when presented by local university – could encourage more farmers to utilize bioslurry.

14 When reaching further beyond these first easy-adopters, the mutual ensuring of sustainability could be harnessed: Installing biogas plant and seeing its advantages could motivate farmers to continue with husbandry development project, and also to continue keeping animals in pigpens. In the same time, the environment for the pigs would be clean and healthy, because the manure would be flushed regularly into the biogas digester.

References

AITCV (2005), *Biogas Project Evaluation Report.* Asian Institute of Technology Center in Vietnam.

APERC (Asia Pacific Energy Research Centre) (2010), *APEC Energy Overview 2009*, APERC.

Bajgain, Shakya, (2005), *The Nepal Biogas Support Program: A Successful Model of Public Private Partnership For Rural Household Energy Supply*. Ministry of Foreign Affairs, The Netherlands, SNV-Netherlands Development Organisation, Biogas Sector Partnership – Nepal.

Barnett, A. (2000), *Energy and the Fight against Poverty*. Economic Research Seminar Series. The Hague, Institute of Social Studies (ISS).

Barnett, A. (2001), *The Role of Energy in the Development of Sustainable Livelihoods*. Retrieved February 18, 2007, from http://www.livelihoods.org/post/Docs/SLenergy.doc.

CIA (2010), *The World Factbook*: Vietnam. [online]. Retrieved March 14, 2011 from https://www.cia.gov/library/publications/the-world-factbook/geos/vm.html.

DFID (2002), *Energy for the poor: underpinning the millennium development goals: Tackling poverty through access to clean and efficient energy services.* [online]. Retrieved March 24, 2007, from http://www.eldis.org/assets/Docs/10869.html.

DFID (1999). *Sustainable Livelihoods Guidance Sheets.* [online]. Retrieved February 28, 2007, from http://www.livelihoods.org/info/info_guidancesheets.html#6.

EIA (2006), *Vietnam Energy Data, Statistics and Analysis - Oil, Gas, Electricity, Coal.* [online]. Retrieved February 16, 2007, from http://www.eia.doe.gov/emeu/cabs/Vietnam/Background.html.

Eije, S. von (2007), *Dung for Dong: The economic impact of using bioslurry for tea production on a household level in Thai Nguyen Province, Vietnam*. University of Groningen.

Ervin-Ward, G. & Le Anh Tuan (2004), *Agricultural Waste and Rural Energy in Son La Province: Demand and Supply Study (Opportunity Scan) – Final Report.* SNV Vietnam.

IEA (2009), *World Energy Outlook 2009.* OECD/IEA.

Karki, A. B. (2006), *Country Report on the Use of Bio-slurry in Nepal*. Kathmandu: BSP-Nepal.

Karki, A. B., at al. (2005), *Biogas as Renewable Source of Energy in Nepal: Theory and Development*. Kathmandu: BSP-Nepal.

Lauridsen, M. I. (1998), *Evaluation of the Impact on Women's lives of the Introduction of Low Cost Polyethylene Biodigesters on Farms in Villages Around Ho Chi Minh City, Vietnam*. Livestock Research for Rural Development [online]. 1998, vol. 10, no. 3. Retrieved February 20, 2007, from http://www.lrrd.org/lrrd10/3/met1031.htm.

Leach, G. (1992), *The Energy Transition*. Energy Policy (February): 116-123.

Liljeström, R. et al. (1998), *Profit and poverty in rural Vietnam: Winners and losers of a dismantled*

revolution. Richmond, Surrey, England: Nordic Institute of Asian Studies and Curzon.

Minot, N. et al. (2003), *Poverty and inequality in Vietnam: Spatial patterns and geographic determinants*. Washington DC: International Food Policy Research Institute.

Minot, N. et al. (2006), *Income Diversification and Poverty in the Northern Uplands of Vietnam*. Washington DC: International Food Policy Research Institute.

Nguyen Duc Cuong (2005), *Biogas User Survey 2005 – Final Report*. Hanoi: BPD.

Ni, J.Q. and E.-J. Nyns (1996), *New concept for the evaluation of biogas development in third world countries*. Energy Conservation and Management. 37 (10): 1525-1534.

Otten, U. (2006), *Biogas Programme for the Animal Husbandry Sector in Vietnam: Mission Report on Project Preparation*. Bad Homburg.

Saghir, J. (2005), *Energy and Poverty: Myths, Links and Policy Issues, ENERGY Working Notes*. The World Bank Group.

Sen, A. (1993), *Capability and Well-Being*. In M. Nussbaum and A. Sen, eds. The Quality of Life, pp. 30–53. New York: Oxford Clarendon Press.

SNV (2006), *Agricultural Extension for Poor Upland Ethnic Minority Farmer Groups in North West Vietnam: Annual Plan June - December 2006*. Son La: SNV.

SNV (2011), *Brief report 2010 and plan 2011 of the Working Group on Domestic Biogas under the Energy for All Partnership*. [online]. Retrieved March 26, 2011, from http://www.snvworld.org/en/Pages/Publications-item.aspx?publication=596.

Swinkels, R., Turk, C. (2006), *Explaining Ethnic Minority Poverty in Vietnam: a summary of recent trends and current challenges*. Draft Background paper for CEM/MPI meeting on Ethnic Minority Poverty, Hanoi, 28 September 2006.

UNDP (1997) *Human Development Report 1997*. New York: UNDP.

WCED (World Commission on Environment and Development) (1987). *Our common future*. Oxford: Oxford University Press.

WB (2007), *Rural Development & Agriculture in Vietnam*. [online]. Retrieved February 15, 2007, from http://web.worldbank.org/.