Report on the feasibility study of a national programme for domestic biogas in Ethiopia.

For SNV – Ethiopia.

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0.1 Summary
Rural domestic energy supply in Ethiopia is (virtually) entirely biomass based. In combination with the increasing pressure of the rural population, this has led to rapid depletion of natural resources and degradation of the environment in large areas of the country.

As most of the rural households are involved in (subsistence) farming, integrating agriculture and animal husbandry, domestic biogas could theoretically not only foresee in the need for cooking energy, but also provide a good source for organic fertilizer. Furthermore, domestic biogas could improve the livelihood situation of rural households regarding aspects of workload, health and sanitation. From a need assessment perspective, therefore, domestic biogas would be very promising indeed.

This study researched the extent to which essential conditions for large scale dissemination of domestic biogas are present. It concludes that there is a significant technical potential for domestic biogas. In the four studied regions (Amhara, Oromia, SNNPRS and Tigray) this potential is estimated to be between 1.1 and 3.5 million households.

But the team also identified important constraints: the low level of disposable income of most rural households prohibits any significant investment; the scarce availability of process water endangers proper plant operation; the (very) limited rural dissemination infrastructure in combination with the scattered population pattern make dissemination activities laborious and (thus) expensive; the gender imbalance in decision making at household level will increase the threshold for the investment, and; the low awareness of alternative energy technology in general and domestic biogas in general will necessitate a large investment in promotion work.

Clearly, despite its promising features and the significant technical potential, implementation of a large scale domestic biogas programme will not be “plain sailing”. The team proposes a pilot domestic biogas programme in four regions over a period of 5 years, aiming to support the construction of 10,000 installations. In addition to the direct benefits the programme is expected to have, the sizeable pilot will provide better insights of the exact nature of Ethiopia’s rural domestic energy sector and dissemination constraints and allow the programme to adjust its implementation strategy accordingly. Total programme costs, including all hard and software, have been budgeted to approximately € 11 million.

The report is divided in 5 sections.

Section 1 addresses the background of the country, Ethiopia’s main climatic characteristics, the agriculture and animal husbandry sector and the energy situation. It ends with a brief explanation on biogas and its benefits.

Section 2 starts with the study set up. It furthers with the main study findings regarding installations visited, functionality, economics, operation, dissemination modalities and lists the organizations active in the field of domestic biogas.

Section 3 addresses the main conditions for large scale dissemination of domestic biogas, including technical, financial, social and institutional aspects. From a mapping of Ethiopia's livestock data and an interpretation of data regarding the availability of process water, a first estimate of the technical potential for domestic biogas is offered.

Section 4 presents the lessons learnt and the recommendations based thereon. Some main programme design considerations –technical design, sizing, costs and benefit of biogas, subsidy and credit are addressed in more detail. Section 4 ends with a brief reflection on opportunities of CDM as a co-financing mechanism.

Section 5 drafts the first outline of an activity schedule and budget for a possible pilot of a large-scale biogas programme in Ethiopia. The section concludes with listing some of the opportunities and threats of such a programme.

0.2 Acknowledgement

Ethiopia is a large country of great social and geographic variation and domestic energy –including biogas- is a multifaceted topic. Consequently, for the study our team leaned heavily on the sympathetic cooperation of a large number of households and professionals. Everywhere our questions were answered elaborately, where we overlooked relevant issues our hosts filled us in anyway, and we were provided with a wealth of background information and documentation.

The team is indebted to all the persons and organizations that took time to assist us and it was a privilege to have this many knowledgeable and experienced people sharing their understanding of domestic energy and rural development with us.

Thank you al very much for your contributions and cooperation; it provided the study with meaning and made doing the study a true pleasure.

Despite all your input, there will likely be errors in the report. Obviously, those are fully our responsibility.

Addis Abeba,
June 2006.

0.3 Table of content

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2	Description of regions in the study area
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6	Draft profile sketch SNV Senior Technical Advisor
	Addendum with comments of EREDPC

0.5 Abbreviations

AATPI	Appropriate Agricultural Technology Promotion Initiative (World Vison
ACSI	Amhara Credit and Savings Institute
AEMFI	Association of Ethiopian Micro Finance Institutions
ANRS	Amhara National Regional State
BoA	Bureau of Agriculture
BOAM	Support to Business Organizations and Access to their Markets (SNV)
BoE	Bureau of Energy
BoQ	Bill of Quantities
€	Euro
EIRR	Economic Rate of Return
EPRDF	Ethiopian Peoples Revolutionary Democratic Front
EREDPC	Ethiopian Rural Energy Development and Promotion Centre
EU	European Union
FIRR	Financial rate of Return
FDRE	Federal Democratic Republic of Ethiopia
ODA	Official Development Assistance
PASDEP	Plan for Accelerated Sustainable Development to End Poverty
Masl	meters above sea level
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNP	Gross National Product
GTZ	German Technical Cooperation
FAO	Food and Agriculture Organizations
GJ, TJ	Giga (10^9) Joule, Tera (10^{12})Joule
hh	household
ha	hectare
BLT	Branches, Leaves and Twigs
ETB	Ethiopian Birr
SNV	The Netherlands Development Organization
STVC	Selam Technical and Vocational Centre
GHG	Greenhouse Gas
CDM	Clean Development Mechanism
MDG	Millennium Development Goal

MFI	Micro Finance Institute
MoFED	Ministry of Finance and Economic Development
NGO	Non Governmental Organization
PPP	Public Private Partnership
REF	Rural Energy Fund
SME	Small and Medium Enterprise
SNNPRS	Southern Nations and Nationalities People's Regional State
UNDP	United Nations Development Programme
(US) $	(United States) Dollar
WB	World Bank
WBISPP	Woody Biomass Inventory Strategic Planning Project

0.6 References

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0.7 Exchange rates

1 Euro	10.41 Ethiopian Birr
1 Euro	1.19 US Dollar

Report on
the feasibility study of a national programme for domestic biogas in Ethiopia.


Preparation of dung cake

Section 1
Introduction and background

1 Introduction.

Horn of Africa

"The Horn of Africa is known today as a land of famine and war, but it is also the last secret kingdom of the world, a land of mystery and fierce beauty. Cut off by soaring mountain ranges, burning lava deserts, unexplored wildernesses and an isolated Indian Ocean coastline, the Horn of Africa is a great ark that has, for centuries, sheltered an astonishing variety of human societies against the storms of the world. From the sophisticated cultures of the Christian highlands and the Islamic coast to the proud nomads of the Ogaden desert and the primitive tribes of the last wildernesses of the continent, the region is a true microcosm of Africa and a time capsule in which we can see many stages of development of the human race."[1]

1.1 Recent history in brief.

Unique among African countries, the ancient Ethiopian monarchy maintained its freedom from colonial rule, with the exception of the 1936-41 Italian occupation during World War II. In 1974 a military junta, the Derg, deposed Emperor Haile Selassie (who had ruled since 1930) and established a socialist state.

Torn by bloody coups, uprisings, wide-scale drought, and massive refugee problems, the regime was finally toppled in 1991 by a coalition of rebel forces, the Ethiopian People's Revolutionary Democratic Front (EPRDF). Under federalism and through the 1990s political representation and territorial administration were recognized in terms of ethnicity[2]. A constitution was adopted in 1994 and Ethiopia's first multiparty elections were held in 1995.

A two and a half year border war with Eritrea ended with a peace treaty on 12 December 2000. Final demarcation of the boundary is currently on hold due to Ethiopian objections to an international commission's finding requiring it to surrender sensitive territory.

The current government, with the EPRDF as the ruling party, took charge in 1992, after

[1] Carol Beckwith and Angela Fisher, African Ark, 1990.
[2] Sarah Vaughan, Ethnicity and power in Ethiopia, 2003

having fought a war with the regime of Mengistu Haile Mariam, the Derg, for over a decade. As a result, Eritrea became an independent country, and Ethiopia a federation of reasonably independent regions (the Federal Democratic Republic of Ethiopia).

Region	Population [# of persons]			Share [%]		Area	Pop density
	Rural	Urban	Total	Total	Rural	[km²]	[# of pers / km²]
1 Tigray	3,367,000	746,000	4,113,000	5.8%	81.9%	56452	73
2 Affar	1,213,000	117,000	1,330,000	1.9%	91.2%	92371	14
3 Amhara	16,138,000	2,005,000	18,143,000	25.5%	88.9%	153474	118
4 Oromia	21,891,000	3,207,000	25,098,000	35.3%	87.2%	312980	80
5 Somali	3,438,000	671,000	4,109,000	5.8%	83.7%	321737	13
6 Benishangul	538,000	56,000	594,000	0.8%	90.6%	50542	12
7 SNNPR	12,922,000	1,163,000	14,085,000	19.8%	91.7%	117263	120
8 Gambela	191,000	43,000	234,000	0.3%	81.6%	25649	9
9 Harari	71,000	114,000	185,000	0.3%	38.4%	394	470
10 Addis Abeba	-	2,805,000	2,805,000	3.9%	0.0%	526	5333
11 Dire Dawa	98,000	272,000	370,000	0.5%	26.5%	1507	246
	59,867,000	**11,199,000**	**71,066,000**		**84.2%**	**1,132,895**	**63**

Source: CSA Statistical abstract 2003

1.2 Current political situation.

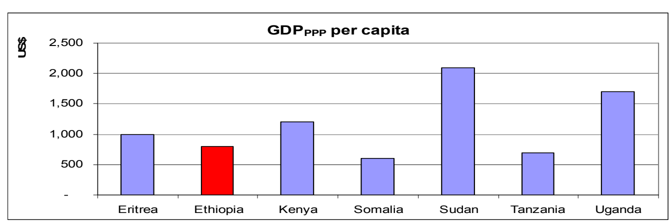
Ever since, except for few minor (threats of) wars over border disputes with Eritrea, the country has been fairly stable. In view of the volatile geo-political and socio-environmental situation in the Horn of Africa, this is an accomplishment to be valued highly.

Last year's election in May, however, threatened to change the political climate. The government, expecting voters to confirm their position, appeared to be surprised by significant popular support to the opposition. With some delay, the polling results now seem to be largely accepted, with new voting in a couple of hundred polling stations.

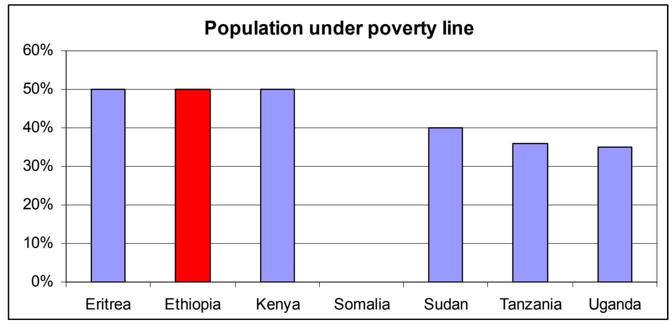
2 Country background.

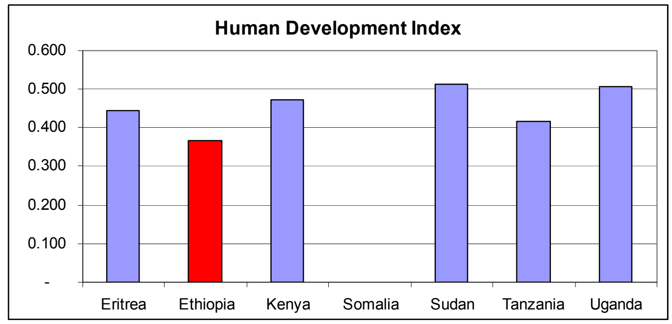
With a total land area of 1.1 million km^2, Ethiopia is about twice the size of France and the tenth largest country in Africa. It accommodates Africa's third biggest population, currently some 73.1 million people, at a population growth rate of over 2.3 percent per annum[3].

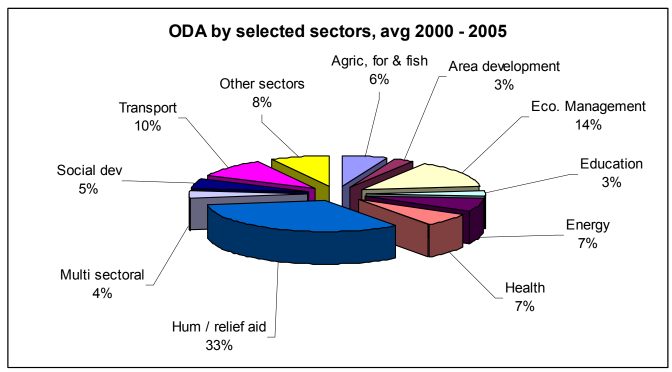
Ethiopia's physical landscape is characterized by great topographic variations; arid and semi arid low lands, dissected plateaus and massive mountains often traversed by deep river gorges and valleys.



[3] CIA World Fact book







With 85% of the population living in rural areas, mostly in small and very scattered settlements, the remaining 15% of the population lives in 922 towns having over 2000 inhabitants.

Ethiopia is one of the least developed countries; not only in the world, but also in the region it is scoring amongst the poorest: featuring a bottom 10 ranking for its Gross National Product (PPP) (ranking 223 out of 232 with US$ 800) and its Human Development Index (ranking 170/177; with an HDI of 0,367). 50% of the population lives below the poverty line.

Ethiopia is a receiver of substantial bilateral and multilateral development assistance to the tune of US$ 900 mln in 2000, steadily growing to US$ 1,920 mln in 2003. With a GDP$^{\text{off exch rate}}$ of US$ 9,034 mln (2005), ODA obviously has a significant relationship to the country's GDP.

Over this period, the lion share of ODA was allocated to humanitarian and relief aid (33% on average) against only 6% for agriculture and 10% for transport.

2.1 Poverty traps.

The PASDEP document identifies the following five poverty traps in Ethiopia. As all five are relevant for rural development and domestic energy issues, they are presented hereunder.

Productive resource base: A crucial mechanism, which has perpetuated poverty in Ethiopia, is the interaction of poverty and population pressure with the productive resource base. Unprecedented population pressures have resulted in decreasing plot size (average landholdings declined from 0.5 hectares per person in the 1960s to 0.11 in 1999), making an increasing number of households dependent on inadequately small and unproductive plots, and more vulnerable to the vagaries of unpredictable rainfall, and rendering some traditional farming practices unsustainable. These households are too poor to leave land fallow or invest in it, leading to a progressive deterioration of their asset base. In the past moving onto new lands absorbed this additional population growth, but in many areas the limits of useable land have been reached, forcing farmers onto lower productivity, more fragile lands.

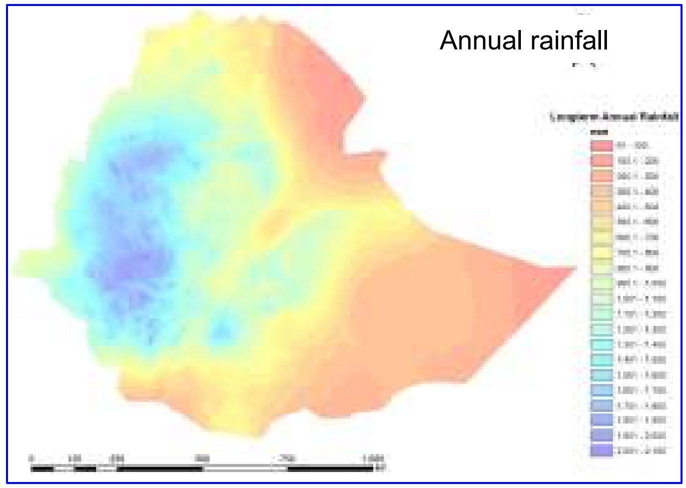
Investment in human capital: Poverty and low investment in human capital present another type of self-perpetuating dynamic. Investing in education may be prohibitive for poor households, due both the direct costs, as well as the fact that all members need to contribute to the family's income, including time-consuming tasks such as collecting water and firewood. Even if returns of education are high, the inability to finance that initial investment means that there is under-investment. Without significant increases in productivity it is difficult for capital to be accumulated, so that returns to unskilled labour are unlikely to grow. Poverty and low education, therefore, reproduce themselves in future generations.

Infrastructure: Low levels of infrastructure offer another example of perverse dynamics, as they result in underdeveloped markets, high transaction costs and coordination failures. The benefits of exchanges cannot be realized and the economy remains trapped in a largely subsistence-oriented structure. Without basic economic infrastructure, returns to private investment may be too low to spur dynamic growth; while the large, lumpy nature of infrastructure costs makes it hard to make the initial investments to break out of these traps. In the rugged and difficult geography of Ethiopia, many remote areas see their potential for dynamic private sector growth and diversification out of agriculture hindered by the lack of basic infrastructure.

Low-Risk / Low Return: Small farmers, who constitute the bulk of the population, are often caught in production of low-risk/low-return food grains. With insufficient cash funds, and unpredictable outcomes, they cannot afford to take the risk of diversifying from subsistence food production into potentially higher-return activities (such as growing cash crops for market), or of spending their limited cash on purchased agricultural inputs, because if they fail – either because of crop failure, price collapse, or failure of demand, they will not have either the basic food they would otherwise have produced, nor the cash to purchase it, and their families will go hungry.

Early-Childhood: Nutrition offers a similar story, with malnutrition very early in life affecting long-term mental and physical development, and thus limiting lifetime potential and productivity, and creating a low-income, low-consumption household in the next generation

3 Climatic conditions.



3.1 Rainfall

The country has a tropical monsoon climate. Topographic differences –central highlands vs lowlands- result in significant climatic variety and three distinct rainfall regimes. In general, precipitation ranges from 800 – 2000 mm per annum in the highlands (>1500 m) to less than 200 – 800 mm per annum in the lowlands.

In most areas, rain falls in two distinct seasons: the minor season (*belg*) begins in January / February and ends in April / May; and the main rainy season (*kiremt*) from June / July to September / October. In Southern Ethiopia the rainfall pattern is opposite, the larger, more important rainy season takes place in February, March, April and May with a second smaller one in September, October and November.

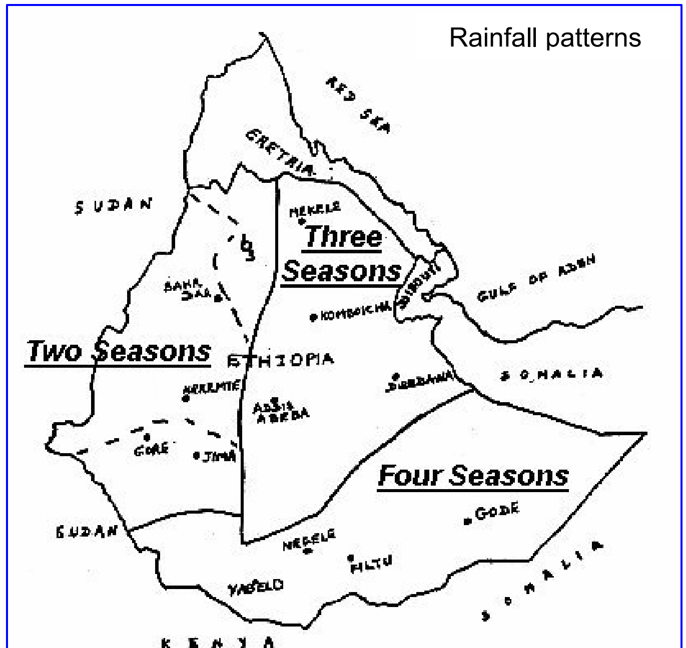


Fig. 2.1 - The Rainfall Regimes of Ethiopia

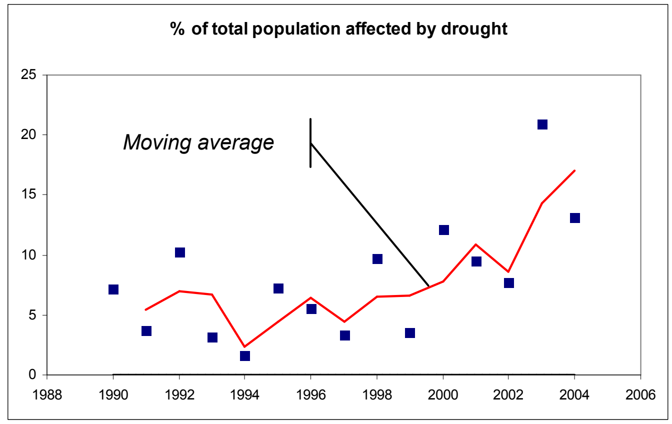
During the main rain season most parts of the country receive 60-90% of the rainfall. The *kiremt* is particularly important as 90-95% of the food is produced during this main *meher* crop season. However, in some parts of the highlands, the *belg* harvest may contribute up to 50% of the food supply[4].

3.2 Drought.

Ethiopia is a country where some 80 percent of the population depends for its livelihood on rain-fed agriculture, yet much of the good topsoil - more than two billion tons a year - gets blown away or washed down the Blue Nile River to Egypt. Periodic droughts have been Ethiopia's lot for hundreds of years. In recent years droughts are becoming more frequent and severe. A century ago the country suffered a drought every 10-15 years. Today they come with alarming regularity every five years or less. Although the drought-caused famine of 1984-85 remains well known, less serious but nonetheless significant droughts were observed in 1972-74, 1975-76, 1987, 1988, 1990-91, 1992-93, 1994-95, 1997-98, 2001-02 and 2002-03.

While global climate change may have something to do with increasing the frequency and intensity of drought in the country, other factors have also contributed to making Ethiopians more vulnerable to erratic or scarce rainfall. A high population growth rate,

[4] FAO crop and food supply assessment mission report, January 2005



dwindling farm size, unjust patterns of land tenure, inefficient farming techniques, deforestation, and degraded soils have all contributed to chronic disaster.

As a result, not only the frequency of droughts is increasing, but over the past 15 years the share of drought affected population affected appears to be rising[5].

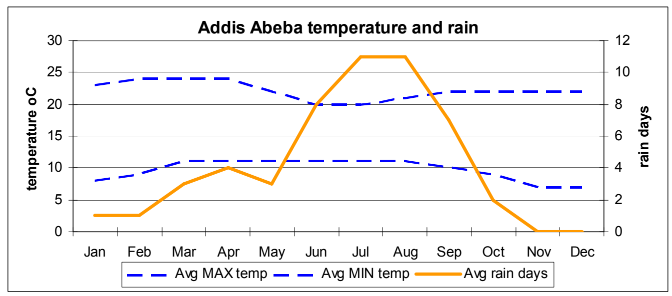
3.3 Temperature.

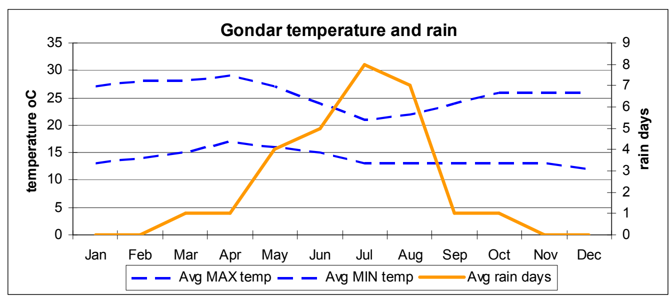
Ethiopia features extremely varied climatic conditions from cool to very cold in the highlands where most of the population inhabits, to one of the hottest places on earth at the Dallol Depression.

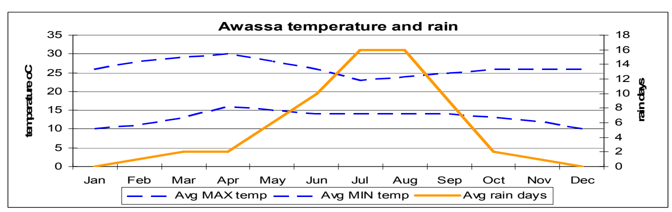
Most of Ethiopia was supposed to enjoy a tropical climate for its proximity to the equator, but, due to the fact that most of the country's land mass stands over 1,500 m (4,920 ft), this is not the case.

The climate is broadly divided into three zones.

– Dega (Cool Zone)-Areas above 2,600 masl where temperatures range from near freezing to 16^{O} Celsius. This is where most alpine and afro-alpine vegetation occurs.
– Woyina Dega (Temperate Zone)-Areas between 1,500 and 2,600 masl where temperatures range from 16^{O} Celsius to 30^{O} Celsius. This is where most of the population lives.
– Qola (Hot Zone)-Areas below 1,500 masl with both tropical and arid conditions where temperatures range from 27^{O} Celsius to 50^{O} Celsius. Bereha is a general term that refers to the extreme form of Qola.





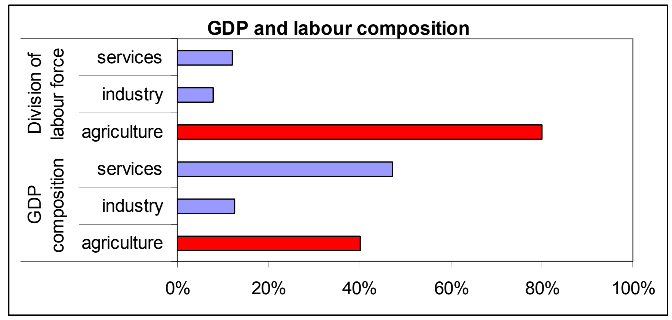


The graphs provide an impression on annual temperature and rainfall development in three distinct areas.

[5] December 2004, UNESCO et al National Water Development Report for Ethiopia,

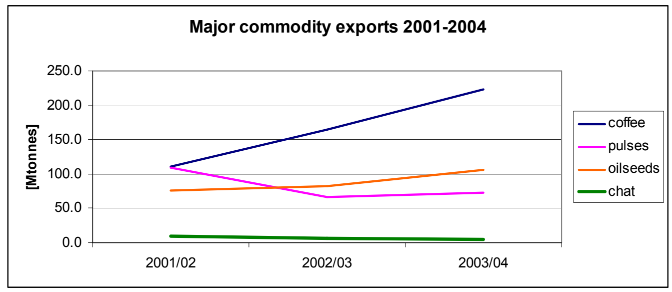
4 Agriculture and animal husbandry.

The structure of the economy is dominated by agriculture, which contributes 40.1% of the country's gross domestic product (GDP), 90% of the export earnings and 80% of the employment. The role of industry in the economy has always been very small. Currently, the contribution of industry to GDP is about 11%, and its share to employment is less than 5% of the total labor force.



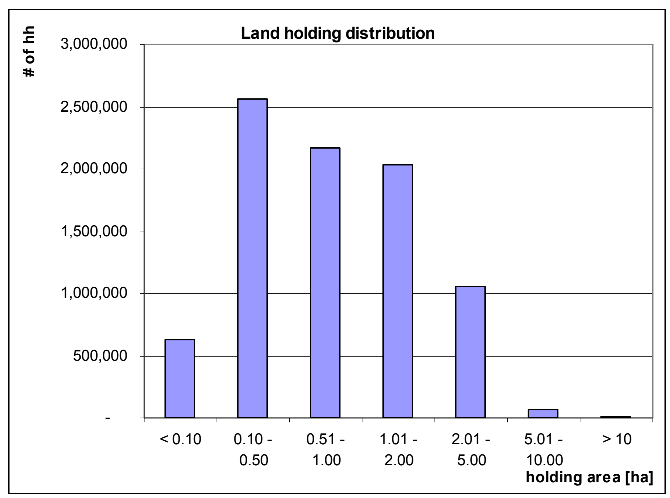
4.1 Agriculture.

Traditionally, Ethiopia's most important agricultural export commodity is coffee, followed by pulses, oil seeds and chat. Crops contributing to household food security vary over the different areas, but include teff, wheat, barley, maize, sorghum, finger millet and pulses.

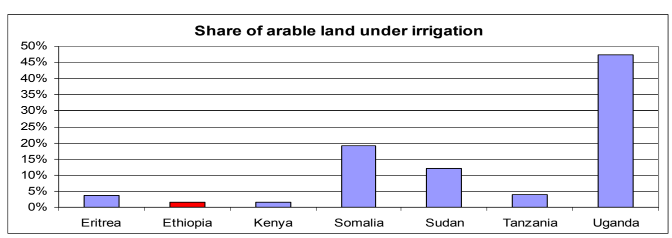


Despite its immense contribution to the national economy, the agricultural sector is largely characterized by subsistence farming. Frequent droughts and poor cultivation practices negatively impact production.

The average landholding is small; current estimates mention about 1 ha per holding, and under Ethiopian farming conditions often insufficient to sustain the household [ref014]. The table shows the landholding distribution for 1996[6]. Ethiopia's population increased since from 55 to 73 million, it is likely that the average land holding has further reduced consequently.



The sector is nearly totally dependent on rainfall, with only 2% of the total arable land being irrigated[7]. Ethiopia is the water tower of the region with 110 billion m^3 of surface water with an irrigation potential of 3-5 million ha excluding rainwater harvesting and underground water.



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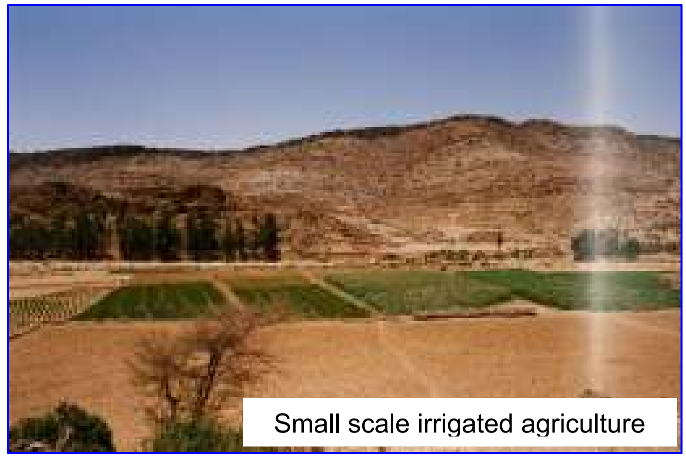
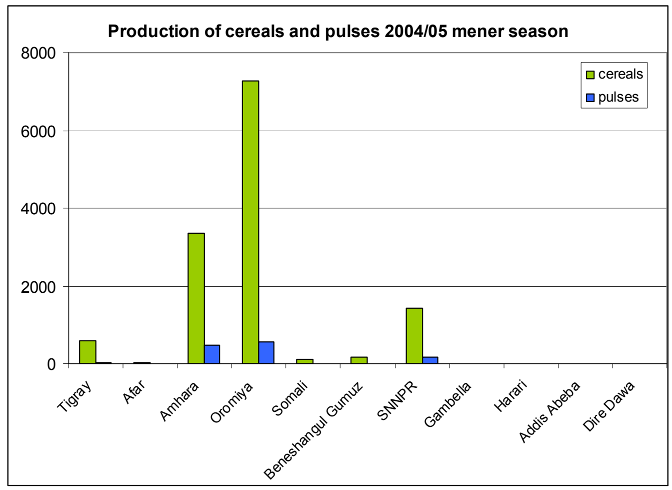
[6] Source CSA Agricultural Sample Survey 1995/96 in ref 014.
[7] CIA World fact Book

Currently, only 160,000 ha are under irrigation[8]. The current level of irrigation development is much lower than the 50% of the over 600,000 ha of irrigable land that should have been developed to meet the food demand of the present population in addition to what is being cultivated under rain fed agriculture.


Small scale irrigated agriculture

The proportion of area under improved seeds is less than 3%. For 2004, the FAO estimated that 12% of the maize and 8% of the wheat sown would have originated from newly purchased improved varieties. The proportion of area treated with pesticides is less than 10%. This coupled with low fertilizer use, susceptibility to pest and disease and extensive highland soil erosion has meant high variability in year to year agricultural production, which is predominantly in the hands of peasants working smallholdings.



The relatively low productivity of Ethiopia's crop sub-sector is not only the result of the low adoption rate of the many yield enhancing technologies, but also the poor promotion and marketing schemes, Government policy towards tenure security and agricultural terms of trade (price fluctuations between harvest of 20% (teff) to over 50% (sorghum) are not exceptional).

Jan 28 2006 **Ethiopia sees 15.1% increase in agricultural production in 2005-06**
Addis Ababa - Ethiopian Prime Minister Meles Zenawi says the country's agricultural production indicates a 15.1 per cent increase during the current harvest season and its overall economy would register a 'double-digit' growth at the end of the current fiscal year ending in June, the local press reported

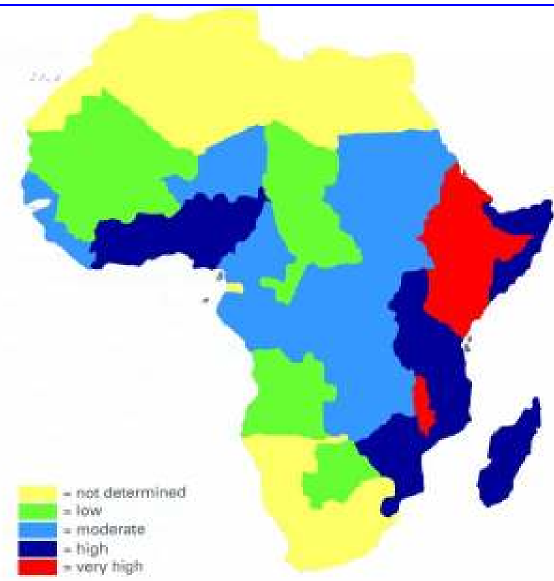
Chemical fertilizer is recognized as one of the key means to increase agricultural yields. Fertilizer use has been promoted under the previous as well as the current governments with distribution systems, extension and credit. For the 1995/96 cropping season, the average national application was 35 kg/ha for all holdings and 95 kg/ha for fertilizer-using holdings [ref014]. This must represent a steep increase for that time, as slightly earlier documents still mention an average national dosage of 10 kg/ha [ref013]. Nevertheless, the application isstill far below the nutrient needs of the heavily cropped soils.

Currently, the Government's extension programme, advises an economically optimum application rate[9] as 100 kg DAP and 100 kg Urea per ha for cereal crops.

[8] Dr Alemneh Dejene, FAO, The Nexus of natural resources degradation, food security and poverty in the Ethiopian Highlands: Towards sustainable agriculture and rural development, November 200
[9] This rate produces a marginal rate of return of 100%

More recently, the profitability of fertilizer application shows a declining trend, mainly as a result of increasing input prices against decreasing output prices.

The high population pressure, in particular in the Ethiopian highlands, in combination with the low adoption rate of improved agricultural practices result in massive soil degradation and a very high nutrient depletion (The amount of soil lost is estimated at 2 billion tons per annum [ref012]).



class of nutrient loss rates	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
low	< 10	< 0,9	< 4,1
moderate	10-20	0,9-1,5	4,1-8,3
high	20-40	1,5-3,3	8,3-16,6
very high	> 40	> 3,3	> 16,6

Depletion of nutrients in Africa (in kg/ha/year)

Bron: Stoorvogel & Smaling, 1990

4.2 Animal husbandry.

The livestock population in Ethiopia is the second largest in Africa, and ninth in the world. Livestock includes over 44 million cattle, 30 million small ruminants, 1 million camels and 4.5 million equines. Animal husbandry contributes to the livelihoods of 80% of the rural population. Livestock is an integral part of the farming system and is highly linked to land/soil and water resource management.

Over-grazed communal lands

This sector too is characterized by a low-input system based on common grazing and the use of crop residues. Common grasslands provide extensive pasture and browse for livestock in most regions, but are particularly important to livestock producers in the eastern regions of Afar and Somali, the southern zones of Bale, Borena and South Omo, and in the western lowlands ranging from Gambella to Tigray.

In the highlands, livestock are kept under settled or trans-human systems utilizing crop residues and common pastures and fallow land which have high clover content. Such livestock includes some 14 million oxen providing draught power for the mixed farming system that prevails.

Rapidly growing population in the face of limited agricultural productivity, very low rural incomes, ever-increasing fragmentation of agricultural land and consequent environmental degradation are some of the major problems from which the nation is trying to extricate itself.

Dairy production.
Almost 99% of the cattle, sheep and goat population are indigenous. The current national production of milk from cattle is about 400 litres for a lactation period, whereas cross-breeds (1% of the whole population) give 3000 litres over the same period.

There is serious degradation related to intensive cultivation, overgrazing, deforestation, soil erosion, poor water control, shortage of livestock feed and fuelwood crisis. These factors interact and lead to a vicious cycle often referred to as "the poverty, food insecurity and natural resources degradation trap"[10].

5 Energy demand & supply, policy and plans.

With less than 2% of Ethiopia's rural population having access to the national grid and 85% of the population living and working in rural areas – the lack of modern energy severely restricts social and economic development. Therefore the government has embarked upon a national energy access project that aims to increase electricity and other modern energy sources to a much larger proportion of the population over the next ten years.

Key issues are the availability, the relative cost of this energy, the sustainability and the environmental acceptability when harnessed for productive use. Except for petroleum, which is wholly imported, Ethiopia is endowed with many types of indigenous energy resources. Renewable energy sources such as hydro, solar, wind, etc. are available in reasonable quantities though they remain largely untapped.

> The National Energy Policy in Ethiopia aims to satisfy the basic (energy) needs of all households. The energy policy recognizes the importance of energy as a means for sustainable development. Key areas include:
> - Priority development of hydro and traditional energy resources.
> - Diverse and enhanced biomass based technologies (biogas, agricultural residue briquetting, ethanol production).
> - Energy conservation technologies and measures.
>
> Vital to the development of the energy sector are:
> - Self-reliance on indigenous resources.
> - Formulation of conducive sector regulations and directives.
> - Ensuring of environmental sustainability.
>
> In this respect, the Ethiopian Conservation Strategy adds:
> - A development process which integrates energy development with conservation, environmental protection and sustainable utilization of renewable resources;
> - Decentralized energy supply systems servicing remote areas;
> - Institutional and regulatory arrangements stimulate efficient energy development and utilization.
> - Development of renewable energy resources shall be preferred above the use of fossil energy.
> - Energy development and planning shall be incorporated at woreda and local development plans.

5.1 The primary energy resource base.

The main indigenous sources of energy are biomass, hydropower, fossil fuels, natural gas, coal, geothermal, solar and wind. To meet domestic energy requirements, rural populations use various forms of biomass almost exclusively (e.g.: fuel wood, agricultural residues and animal wastes such as dung). In addition to heavy dependency on biomass, there is limited use of electrical energy and a generally low level of energy consumption. Ethiopia, whose economy depends almost entirely upon subsistence agriculture, has had little need for electrical energy in the past. Most agricultural products ere exported directly with only little processing of those commodities that are consumed domestically. There has been awareness in Ethiopia that to raise the standard of living would require a gradual shift from an agricultural economy to one, which processes agriculture surpluses for foreign export as well as the development of other basic light and heavy industries.

5.1.1 Renewable energy

Hydropower: The hydro resource of the country is said to be of immense potential. The gross hydro potential of the country is estimated at 650TWh/year (CESEN, 1986). Out

[10] Dr Alemneh Dejene, FAO, The Nexus of natural resources degradation, food security and poverty in the Ethiopian Highlands: Towards sustainable agriculture and rural development, November 2003

of this potential, about 280TWh/year and 161TWh/year is believed to be technically and economically feasible respectively.

Primary energy and domestic biogas.

The mission estimates that the studied four regions accommodate between 1.1 and 3.5 million rural households with both sufficient cattle dung as well as water to operate a domestic biogas installation (see section 3 for details).

Taking the lower estimate, these households could generate over 1.3 m^3 biogas daily, equalling more than 11,000 TJ per year domestic energy. Assuming that the biogas will be used primarily for cooking, and that on average a household will use the stove for 2.5 hours per day, this would equal over 3500 MW installed power.

The investment for such a programme, including investment and overhead, could be safely estimated at € 1000 per installation. Power generation costs would thus result in approximately € 312 / kW.

Geothermal: This energy resource has proven reserve, which is extended from Danakil depression of Afar Region along the Rift Valley to the Kenyan border. About 7000 MW potential exists from geothermal (the Lake district 170 MW, Southern Afar 120MW, Central Afar 260 MW and Danakil Depression 150 MW).

Biomass energy resources: The country's natural forest which was estimated to have 40% before 50 years (45 million hectares) of the total land area now covers less than 3% (!) (3 million hectares) (EFAP, 1994). The total available woody biomass resources are estimated to be around 1,389 million ton in terms of standing stock and about 26 million ton in terms of annual sustainable yield.

Solar energy: Although Ethiopia is endowed with vast solar energy resources, these are not readily used. Because of its proximity to the equator, the country enjoys receiving adequate sunshine throughout the year. For Ethiopia as a whole, the average daily radiation reaching the ground is 5.2 Kwh/m2. The minimum annual average radiation is estimated to be 4.5 Kwh/m2 in July (the main rainy season) to a maximum of 5.55 Kwh/m2 in February and March. The radiation reaching the ground, however, varies significantly from one area- to another as well as from season to season (EEA, 2002).


Solar cooker provided by AATPI

Wind power: The wind energy potential of the country varies from place to place and from season to season, as the energy is absolutely seasonal and dependent on the velocity. In the western part of the country, the average wind speed at 10m a.g.l. is 3.5m/s. In the Rift Valley and eastern part of the country, the average values range between 3.5-5.5m/s (CESEN, 1986). From this wind speeds an estimated power level of 65W/m^2 and 200W/m^2 can be obtained. In addition, an average wind speed of 6.7m/s, at 10masl was observed in recent wind speed measurement carried out in the Mekele area. This justifies that the location is suitable for an economic operation of wind speed turbines (Benjamin, 2004).

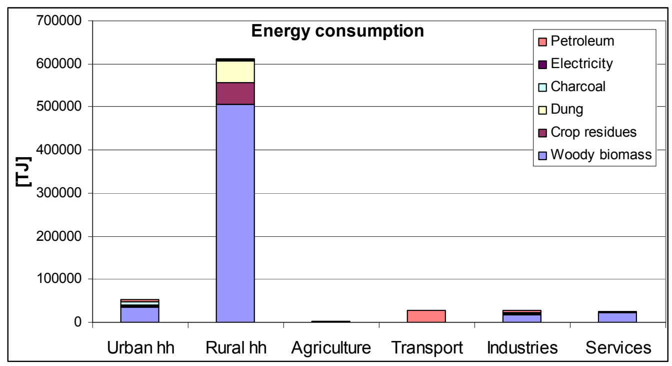
5.1.2 Non-Renewable Energy

Oil and Natural Gas: Exploration for oil and natural gas has been carried out to date. Recent sub surface drilling data confirmed the presence of 100-120 million ton of oil shale deposit at Delbi area (Tibebe M., Haile Michael F., 2003). There is also proven natural gas reserve of 108 billion m3 or 2.7 trillion cubic feet in Calub field alone (Asress, 2002).

Coal: A number of coal deposit sites have been identified in certain parts of the country. The total coal deposit of the country is estimated about 178 million tons (Tibebe M., Haile Michael F., 2003). The deposit quality varies from high quality to lignite category with low heating value, high ash content and low quality, but some of them can be exploited for household and industrial use as alternative source of energy.

5.2 The macro perspective.

The energy sector in Ethiopia is also one of the least developed in the world. The country's annual energy consumption amounts to ~ 746.000 TJ, equalling 130 GJ per capita per annum. Over 94% of the total consumption is supplied by biomass.



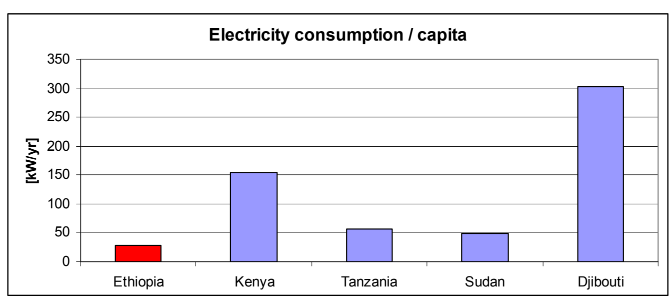
Energy consumption by sector and by source [TJ]

	Woody biomass	Crop residues	Dung	Charcoal	Electricity	Petroleum	Total	
Urban hh	34969	2824	3263	5856	1832	4161	**52905**	*7.1%*
Rural hh	507172	49186	50629	2709		3171	**612867**	*82.1%*
Agriculture						1497	**1497**	*0.2%*
Transport						26743	**26743**	*3.6%*
Industries	17101	1409	1396	112	1864	4573	**26455**	*3.5%*
Services	22110	1031	1046	109	1145	331	**25772**	*3.5%*
Total	**581352**	**54450**	**56334**	**8786**	**4841**	**40476**	**746239**	
	77.9%	*7.3%*	*7.5%*	*1.2%*	*0.6%*	*5.4%*		*100.0%*

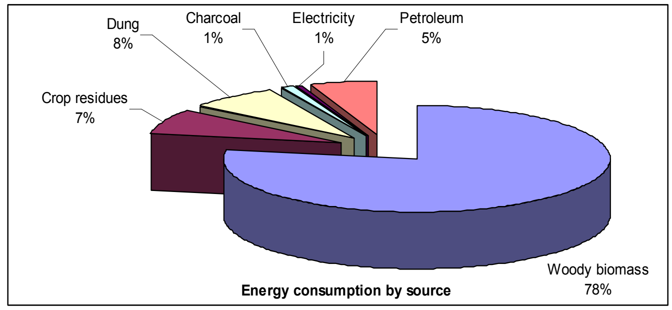
source EREDPC 1999

With over 94% of the total consumption supplied by biomass, wood contributing the lion share, Ethiopia is third in the list of countries using traditional fuels[11].

In line with the above, the per capita electric energy consumption in Ethiopia is –even in the regional context, extremely low at 28 KW/year.

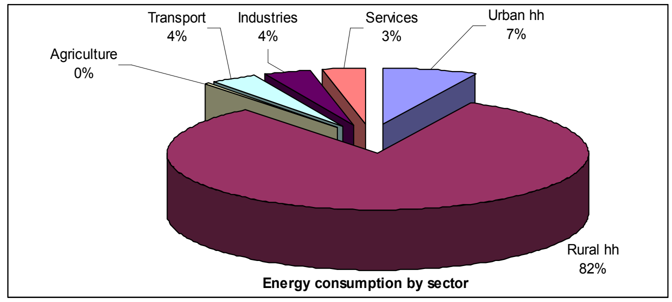


[11] World Bank 2002



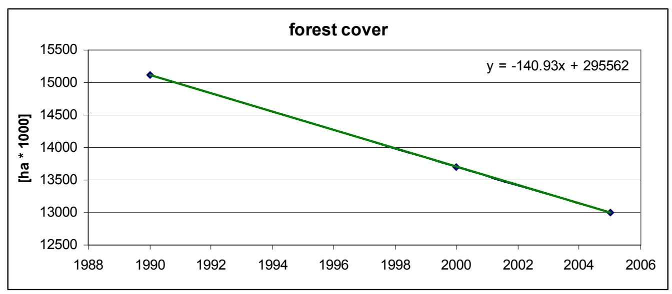
Electrification rates are correspondingly low; the national electrification rate is 10% overall, dropping below 1%[12] for rural Ethiopia (average rural electrification in sub-Saharan Africa amounts to 4%).

Nearly 90% of the total energy consumption is for residential use with the main purpose being cooking and baking.



The recent woody biomass study has compiled data on each regions woody biomass stocks. Standing stock is some 1,187 million tons with an annual increment of 52.5 million tons[13]. Consumption is detailed as some 48.7 million tons.

Including dead wood as fuel, there is a sustainable biomass supply of some 60.9 million tons. This suggests there is no overall deficit but that the problem of deficits is local and not national. The margins, however, are very small, as witnessed by the constinuously declining forest cover of the country



Out of 482 Woredas surveyed, 336 were consuming more than their annual increment and this is especially the case for Woredas in the highland areas. The demand and supply of construction poles is becoming a serious problem that cannot be ignored in reforestation programmes.

Fuelwood burning contributes to deforestation with biomass fuels supplying nearly 95 percent of the country's energy market. The countries forest cover diminishes –quite linearly- with 141000 ha per year over the past 15 years (other sources noting a deforestation rate at 100,000 to 200,000 ha annually). The current national forest cover is claimed to be below 3%.

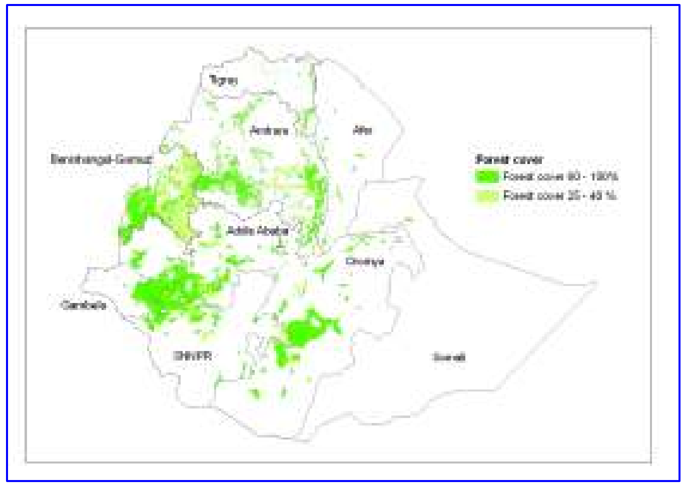

Degraded slopes

"Poverty is both cause and effect of environmental degradation"

[12] Aklilu Dalelu (PhD), Rural electrification in Ethiopia: Opportunities and Bottlenecks 2001(?)

[13] World Bank ISPP, 2003.

There are significant regional differences, with the forest coverage in Amhara region reportedly down to 3%, and the Tigray region is probably worse-off. At the other hand, forest coverage in parts of South and West Ethiopia is still lush at places.



5.3 The micro perspective

The staple food in Ethiopia is injerra. A large (60 cm diameter) spongy pancake made of fermented teff dough. A family would at least once, but often twice a day, eat injerra with vegetable or meat sauce (wot).

Traditionally, injerra is baked in batches (20 to 40 at a time), mostly two times a week on a clay plate over an open fire. By its nature –clay plate at > 150°C, large diameter and open fire- these traditional “metads” have a high energy consumption (stove efficiency ~ 7%); an average family would burn 10 kg of fuelwood per session for baking injerra only. Injerra baking may account to up to 60% of the total energy consumption of a household

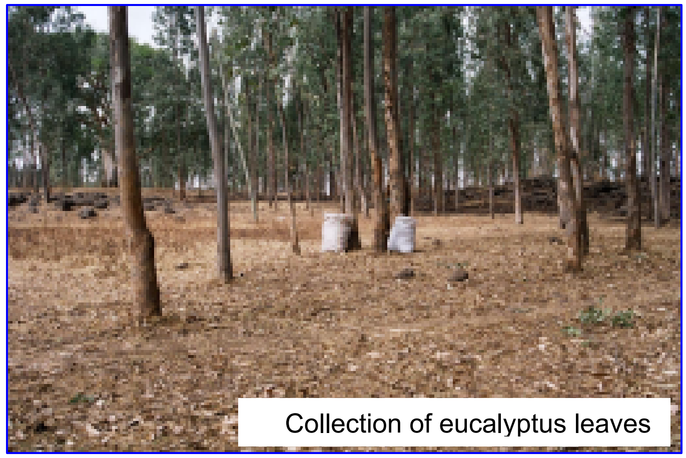

Traditional “metad”

Improved, more efficient stoves have been disseminated in Ethiopia over a long period. Especially the cement “Mirte metad” is promoted intensively, but improved clay metads (Lakech, charcoal) and traditional closed stoves (especially in Tigray) are –locally- well known too. The Mirte metad claims to reduce fuelwood consumption by 50%. The local clay models reportedly are only slightly worse (Lakech 25%, local closed metad, 40% savings).


“Mirte” improved metad

In addition, the sauce (“wot”) that comes with the injerra is cooked as well. Traditionally in clay pots (although these are slowly disappearing) and simmering over a long time.

The result is a delicious but very energy-intensive dish. Fuelwood consumption was reported to be over 700 kg per capita per year (a WB/UNDP assessment from 1984 mentioning 2 kg/cap/day for cooking only ref 013), whereby metads are often fired with branches, leaves and twigs (BLT) and agricultural residue.



Collection of eucalyptus leaves

Fuelwood supply is getting scarce in Ethiopia as the supply source dwindles, being substituted by other forms of biomass fuels like dung, BLT and agricultural residue. In 1986-87, the demand for fuelwood exceeded supply by twofold with 42 million cubic metres while supply remained at 24 million cubic metres. By 2000, demand exceeded by four times reaching 58 million m^3 while supply dwindled to 11 million m^3. The alternative use of dung and crop residues as fuel instead of organic fertilizers affects crop productivity significantly when most farmers cannot afford to buy chemical fertilizer.

Commercial drying and storage of dung cake

Although data from different sources do not always match, calculations would indicate dung cake use amounts to some 2.5 tons per household per year.

Observations and interviews second the impression of fuel scarcity in rural Ethiopia. In Amhara region, the fuelwood demand (17 million tons) outnumbers the supply (3.6 million tons) near five fold. Many interviewed households in Tigray indicated that they were not using fuelwood at all anymore because it became too expensive.

As a result, the cost of domestic energy is high and rapidly increasing. In many parts of the country dung cake and agricultural residue is (rapidly becoming) a commercial energy source, traded on markets. At places, air dried dung cake can sell for as much as ETB 1 per piece of ~ 250 grams and families storing dung cakes for sale are not an exception in large parts of Orromia, Amhara and Tigray.

At the Bahr Dar market charcoal is sold at ETB 1.50 to 1.70 per kg, and fuelwood at ETB 0.60 to 0.80 per kg. The bureau of Agriculture reported that these prices have tripled over the past four years. Much of the fuelwood, charcoal, dung cake and agricultural waste at the market is transported in and out over large (>30 km are no exception) distances.

Bahr Dar fuelwood market

5.4 The energy sub-sector institutional set-up

The Ministry of Rural Development: Established in 2001, and responsible for initiating rural development policies, (such as rural electrification) ensuring conducive environment for development are created, supporting regions in expanding rural development as well as monitoring the Food Security Program.

The Ministry of Water Resources: Responsible for formulating national sectoral policies and strategies concerning the protection and utilization of water resources, issuing permits to construct and operate water works, determining the conditions and methods required for the optimum allocation and utilization of water that flows across or lies between more than one regional government. The Ministry of Water Resources has also responsibilities in the study, design and supervision of medium-large scale hydropower projects.

The Ministry of Infrastructure: The Ministry was established in 2001, and one of its responsibilities is to look into the expansion of the energy development in the country and promote the growth and expansion of the country's electric energy supply. It also supervises the activities of the Ethiopian Electric Agency and the Ethiopian Electric Power Corporation.

The Ethiopian Electricity Agency (EEA): The agency was established in 1997. According to proclamation No. 86/1997, the objective of the Agency is to promote the development of efficient, reliable high quality and economical electricity services. The EEA is the government's regulatory body ongeneration, transmission, distribution and sale of electricity are carried out in accordance with the stated proclamation.

*The Ethiopian Electric Power Corporation (EEPCO):*The Ethiopian Electric Light and Power Authority (EELPA), the sole Government agency since its establishment in 1956 was responsible for generating, transmission, distribution and sales of electric energy throughout the country on the principles of commercialization and decentralization of electricity nationwide until it was restructured and reorganized in 1997 and became a public company called EEPCo (Ethiopian Electric Power Corporation) with its board of management designated by government.

The Ethiopia Rural Energy Development and Promotion Centre (EREDPC): Established in 2002 with the objective to create an enabling environment for the development and promotion of rural energy resources and technologies. It is thus responsible among others, to identify the energy resources suitable for the rural areas, study the energy demand, supply and consumption patterns of the rural areas, evaluate the social, economic and environmental impacts of using various energy sources and technologies, raise the awareness of the rural community and provide trainings concerning the production, distribution, utilization and conservation of energy.

The Rural Electrification Fund (REF): Established in 2003 with the objectives to provide loans and technical services for rural electrification projects on renewable energy sources carried out by private operators, cooperatives and local communities as well as to encourage the utilization of electricity for production and social welfare purposes in the rural areas. The Fund is to be operated by the Rural Electrification Board and an Executive Secretariat. The Secretariat is responsible among others, to review applications from rural electrification project sponsors and decide upon them based on the criteria set by the Board, sets out criteria for the selection of Trust Agents, prepare directives and selection criteria and procedures for the issuance of loans, promote and support access to and productive use of electricity in the rural areas, as well as facilitate and co-ordinate the rural electrification programme activities with other rural development programmes.

5.5 Domestic energy in summary

The most prominent issues in Ethiopia's domestic energy sector include:

- Heavy reliance on biomass fuels,
- By tradition a relatively high domestic energy consumption,
- Low levels of renewable energy and/or energy efficiency technology,
- Energy demand in most (visited) areas significantly exceeds the supply.

As a result:

- Fuelwood is over-harvested in many areas, contributing to deforestation of already ecologically sensitive areas,
- Fuelwood and charcoal have been and are rapidly becoming more expensive.
- Households (and to a large extend institutions) cope by substituting fuelwood with dung cake and agricultural residue.

The –often painfully obvious- consequences include:

- Massively denuded areas, particularly in Tigray, Amhara and the Rift Valley
- Further degradation of soils, large eroded areas with gullies, further reduction of soil fertility.
- Reducing agricultural productivity, both for cropping as well as livestock.

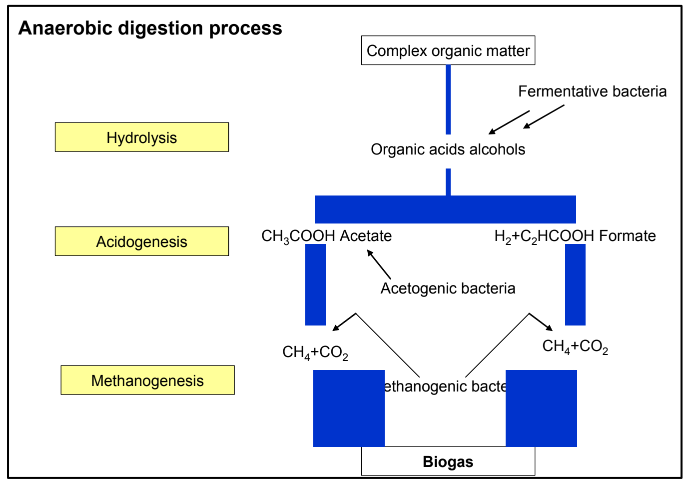
6 Biogas.

Substance	Symbol	%
Methane	CH_4	50 – 70
Carbon dioxide	CO_2	30 – 40
Hydrogen	H_2	5 – 10
Water vapour	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces

Source: biogas handbook Nepal

When any organic matter such as animal dung, crop residue or kitchen waste is fermented in the absence of oxygen, biogas is generated. Biogas contains combustible methane (~ 60%) along with carbon dioxide and traces of other gasses. This gas can serve as a convenient fuel for a variety of applications such as cooking, lighting and motive power. The bio-slurry that comes out of the plant after the gas is produced can be used –directly or as a composting agent- as organic manure to augment soil fertility. Thus, biogas technology produces fuel without impairing the fertilizer value of the dung.

Biogas production is a bio-chemical process occurring in three stages: hydrolysis; acidogenesis and methanogenesis, during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors influencing biogas production are the level of acidity of the feedstock and the temperature. It is well established that biogas plants work best with a near to neutral solution and a temperature of around 35^{0}C.



6.1 Benefits of domestic biogas

The benefits of biogas in energy supply, agriculture, health, sanitation, gender and environment are well documented. There are a number of aspects of biogas production that have multiple benefits:

Animal dung and night soil is collected regularly and fed into the biogas plant, this:

- reduces <u>pollution</u>: that leads to a cleaner farm environment;
- reduces <u>human and animal disease</u>: by improving sanitary conditions related to bad sanitation and polluted surface water for both the household and the greater catchment-area, and;
- reduces <u>greenhouse gas emissions</u>: depending on the traditional manure handling, the improved manure management system can significantly reduce GHG emissions.

The generated gas substitutes conventional fuels. In doing so, biogas:

- reduces <u>indoor air pollution</u>: that is caused by incomplete combustion of conventional fuels is minimized, resulting in a reduction of eye and respiratory illnesses particularly of those most heavily exposed to smoke namely women and children;
- reduces <u>workload</u>: especially in regards to fetching firewood, maintaining the fire and cleaning cooking pots. The use of biogas can reduce workload by 2 to 3 hours per day, particularly the workload of women and children;

- reduces fuel expenses: traditional domestic fuels increasingly become part of the formal economy. Biogas significantly decreases consumption of these traditional sources;
- increases opportunities to use appliances: such as gas lamps and water heaters;
- reduces greenhouse gas emissions: from the conventional energy sources;
- reduces deforestation: by reducing the demand for firewood;
- provides income generation opportunities: by providing an energy source for technologies and activities such as incubators, kilns, lanterns and cooking flame that is a new resource or more cost effective than previous sources.

The residue of the anaerobic process - bio-slurry-, is a potent organic fertilizer. When used in this way it can:
- provide a superior organic fertiliser: in terms of available nutrients and soil texture, increasing agricultural yields with 20-40%.
- provide a catalyser for composting other agricultural waste: Applying this practice increases the amount and quality of organic fertilizer;
- improve handling safety: of residue due to the fact that the process of digestion followed by composting makes handling of the residue much safer from a hygienic point of view;
- reduce chemical fertiliser costs of farmers: by reducing the amount of synthetic fertiliser used;
- reduce greenhouse gas emissions: through avoiding the application and production of synthetic fertiliser
- enables farmers to participate in animal husbandry in areas in which discharge regulations would otherwise have been prohibitive: anaerobic digestion reduces odour and environmental load resulting from livestock holding.

These benefits, although not all equally tangible, do not only profit the investor, but have an impact on the community at meso and macro levels as well. (See also the biogas tangibility matrix in Section 4.3)

6.2 Biogas & Sustainable Development

Sustainable development covers three aspects of society - economic, social and environmental. Biogas contributes to these three aspects of sustainable development in the following ways:

Bruntland & biogas

The generally accepted definition of Sustainable development, published in the Bruntland Report in 1987:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Domestic biogas is compatible with the Bruntland definition by:
- meeting household energy and income generation needs;
- reducing greenhouse gas emissions
- reduces reliance on fire wood therefore pressure on forest resources
- reduces ground and surface water pollution
- reduces reliance on non-renewable energy sources and raises the profile of renewable energy technology
- providing a long term solution to pollution and energy needs
- reducing reliance on chemical fertizer and improving soil condition and fertility through proper application of bio-slurry

Domestic biogas digesters contribute to economic development because:
- The expenses for domestic energy are significantly reduced.
- The labour required to maintain traditional energy systems (such as firewood collection) can be used in more directly economically productive

ways.

- Substitution of petroleum products will reduce the countries foreign exchange demand.
- Application of bio-slurry increases the yield and reduces the need` -and expenses- for synthetic fertilizer.
- A vibrant biogas sector creates significant employment and related economic activities, particularly in rural areas.
- Reduced disease (human and animal) can improve productivity.

Domestic biogas digesters contribute to social development because:

- The reduction in domestic workload, particularly for women and children, increases opportunities for education and other social activities.
- Respiratory illnesses resulting from indoor air pollution and gastro-enteric diseases as a result of poor sanitary conditions reduce significantly.
- In rural areas, biogas digesters often initiate innovation (education, sanitation, agriculture).
- Increase awareness of alternative farming and animal husbandry practices and environmental impacts of behaviour.

Domestic biogas digesters contribute to environmental development as follows:

- Substituting conventional fuels and synthetic fertilizer, and changing traditional manure management systems, biogas installations reduce the emission of greenhouse gasses significantly.
- Bio-slurry improves soil texture, thus reducing degradation, and reduces the need for further land encroachment.
- Reduction of firewood use contributes to checking deforestation and reduces forest encroachment.
- Improved manure management practices reduce ground and surface water pollution, odour and improve aesthetics.

6.3 Biogas & the United Nations Millennium Development Goals.

Domestic biogas programmes contribute to reaching the UN-MDGs in the following ways:

MDG 1 Eradicate extreme poverty and hunger.

Target 1: To halve extreme poverty

In general, households who install biogas are not amongst the poorest of the poor due to the fact that for a biogas plant to function a household must have a minimum number of animals that is often more than a very poor family has. However, the biogas dissemination process and the resulting reduced claim on common ecosystem services do affect the livelihood conditions of (very)

Biogas and the World Summit on Sustainable Development

As a follow-up to the Rio Summit of 1992, the World Summit on Sustainable Development was held in Johannesburg in 2002. Energy was highlighted as a key topic for discussion as it was felt that there had not been enough focus on it at the previous summit. As with the previous Plan of Implementation, waste management, pollution control and social sustainability were highlighted.

The Plan of Implementation states that about two billion people, or one third of the world's population, presently lack access to electricity or modern energy services and rely on burning firewood or biomass to meet their cooking and heating needs. Meeting the energy needs of these people with modern energy services was a major issue at the Summit, and governments committed themselves to "improving access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources."

poor non-biogas households as well. For example:

- Construction and installation of biogas creates employment for landless rural people
- Biogas saving on the use of traditional cooking fuels increases the availability of these fuels for (very) poor members of the community
- Pollution control and waste management benefit all members of the community

MDG 3 Promote gender equality and empower women.

Target 4: Eliminate gender disparity in education

It is predominantly women and girls who spend the most time and effort providing traditional energy services and using a domestic energy supply. Biogas directly benefits this group in the following ways:

- Biogas can provide light that helps women and girls to extend the amount of time in the day that they can study and gain access to education and information or engage in economic activities.
- Domestic biogas reduces the workload of women by reducing the need to collect firewood, tend fires and clean the soot from cooking utensils. This can save on average 2-3 hours per household per day
- The reduced smoke from replacing traditional fire wood stoves with biogas can improve the health of women (and children) who are most exposed to the dangers of wood smoke.
- The provision of biogas can provide an additional or more cost effective home based energy source that can enable women to participate in home based enterprises to generate additional income or at least generate income in a way that suits their life and obligations.

MDG 4 Reduce child mortality.

Target 5: Reduce by two-thirds the under-five mortality rate

Half of the world's population cooks with traditional (mostly biomass based) energy fuels. Indoor air pollution from burning of these fuels kills over 1.6 million people each year, out of which indoor smoke claims nearly one million children's (<5) lives per year. Diseases that result from a lack of basic sanitation, and the consequential water contamination, cause an even greater death toll, particularly under small children (<5 mortality caused by diarrhoea is approximately 1.5 million persons per year).

- Biogas stoves substitute conventional cook stoves and energy sources, virtually eliminating indoor smoke pollution and, hence, the related health risks that particularly affect children who are often heavily exposed to indoor smoke.
- Biogas significantly improves the sanitary condition of the farm yard and its immediate surrounding, lowering the exposure of household members to harmful infections especially children who spend extended periods in the farm yard.
- Proper application of bio-slurry will

Biogas and the Millennium Ecosystem Assessment

As part of the implementation of the MDGs, the Millennium Ecosystem Assessment was released in March 2005. This assessment examined the relationship between ecosystems and achieving the MDGs. It not only found that not sustainable ecosystem management and development are imperative for reaching the MDGs, but moreover that ecological limits to worldwide growth will affect both developed and developing countries.

In addition to providing predictions and evidence the assessment provided a series of proposed responses and interventions. Biogas programmes have elements that are relevant to each of these responses and interventions.

improve agricultural production (e.g. vegetable gardening), thus contributing to food security for the community.

MDG 6: Combat HIV/AIDS, malaria and other diseases.

Target 8: Halt / reverse the incidence of malaria and other major diseases

Indoor air pollution and poor sanitary conditions annually cause millions of premature deaths.

- Biogas virtually eliminates health risks (e.g. respiratory diseases, eye ailments, burning accidents) associated with indoor air pollution.
- Biogas improves on-yard manure and night-soil management, thus improving sanitary conditions and protecting freshwater sources, lowering the exposure to harmful infections generally related with polluted water and poor sanitation.

MDG 7 Ensure environmental sustainability

Domestic biogas can help to achieve sustainable use of natural resources, as well as reducing (GHG) emissions, which protects the local and global environment. Application of bio-slurry increases soil structure and fertility, and reduces the need for application of chemical fertilizer.

Target 9: Integrate the principles of sustainable development into country policies and program and reverse the loss of environmental resources.

- Large scale domestic biogas programmes positively influences national policies on sustainable development (e.g. agriculture, forestation, poverty reduction)
- Biogas programmes usually comply with and support government policies and programmes that have positive environmental impacts including pollution control, green house gas emission reduction and forestation

Target 10: Halve the proportion of people without sustainable access to safe drinking water and basic sanitation.

- Biogas reduces fresh water pollution as a result of improved management of dung.
- Connection of the household toilet to the biogas plant significantly improves the sanitary conditions in the farmyard therefore reducing the risk of water contamination.

6.4 Biogas & PASDEP.

Ethiopia's guiding strategic development framework of the period 2005 to 2010 -the Plan for Accelerated and Sustained Development to End Poverty- is largely compatible with the MDG requirements. The PASDEP argues that to have a lasting impact on poverty and to finance the necessary social investment for human development, economic growth should be to the tune of 8% p.a. for the next ten years; about double of the country's current economic performance.

The report urges for progress on 8 major areas, hereunder the relevancy of domestic biogas regarding improvement in those areas is briefly discussed.

Agriculture: because it still represents the bulk of economic activity, especially in rural areas, and because the potential to shift to higher-valued crops has not yet been exploited.
Biogas reduces the workload of the farming household (fuelwood collection, cooking, cleaning kitchen utensils, weeding of vegetable fields), so increasing the labour availability for productive agricultural activity.
Bio-slurry, properly applied, is a powerful organic fertilizer, potentially increasing yields with 10 to 40%. Organic produce fits well into a high-value crop policy.

Much more rapid development of the modern private sector; because there is no other sustainable way to generate high growth in the long term, nor to create the millions of off-farm jobs that are needed.
A domestic biogas programme is relatively (non-agricultural, skilled) labour intensive, providing good quality employment opportunities (see “expected results, section 5.4)

Exploitation of niches markets and opportunities wherever they present themselves, such as tourism, mining, and production of spices.
Applying bio-slurry, farmers can embark up on growing organic crops, a high value niche market.

A major expansion of exports, and diversification beyond coffee, which has been subject to declining prices; in order to fuel growth, to widen the economic base and reduce susceptibility to shocks, to earn essential foreign exchange, and, in the longer-term, to reduce the dependency on foreign aid;
Organic produce could be an export commodity. Biogas can replace kerosene for lightning, thus reducing foreign exchange expenditure.

Infrastructure: to better link markets and producers, to enable business to take place, to lower the costs of international trade and improve Ethiopia’s competitiveness, and to allow people easier access to essential services.
No direct link with domestic biogas.

A continued increase in the education and skill levels of the workforce.
A domestic biogas programme implies a significant investment in training and education of –in particular- the rural population (see section 5.4).

Unleashing the potential of Ethiopia’s 35 million women – because they represent a major under-used resource, and although they already do much of the country’s work, they tend to be trapped in low-productivity occupations, in part due to lower education levels; their potential is held back by poorer health, and repeated and dangerous pregnancies; and much of their time is consumed with low return tasks such as the gathering of water and fuel wood.
Studies in Asia revealed the households switching to biogas reduce the workload related with fuelwood collection, cooking and cleaning of kitchen utensils with 2 to 3 hours per day. Typically, women and girls are involved in these activities. Hence, biogas improves the development conditions and opportunities for women and girls.

Biogas eliminates indoor smoke pollution and improves on-yard sanitary conditions. Women and children benefit from this improvement disproportional, further improving the developmental opportunities of women.

Slowing the rate of population growth: because if there continues to be an additional 2 million persons per year, all other interventions will have very limited impact – it will be impossible to produce enough food, provide enough land, create enough jobs, or finance enough health and education services to keep up.
Biogas in general improves the livelihood of households. In the long run, this will reduce the requirement for large families.

6.5 History and current status of domestic biogas in Ethiopia.

Biogas technology was introduced in Ethiopia as early as 1979, when the first batch-type digester was constructed at Ambo Agricultural College. Attempting to ease the impact of the energy crisis of the 70s, the Ethiopian Rural Energy Development and Promotion Centre introduced new and renewable energy into rural areas of the country[14]. The focus of the programme was (and largely is) foremost on introduction and demonstration pilots.


Fixed dome plant, Mekane Jesus, SNNPRS

Anaerobic technologies are not widespread in Ethiopia. In 1991 the EEA reported 103 biogas installations constructed by 9 different institutions / organizations [ref 013]. Early 2000, reports mention less than 350 household digesters (up to 30m^3), a “small number of institutional biogas installations (up to 100 m^3), 6 community bio-latrines, and 4 bio-digester septic tanks[15]. In addition, EREDPC mentions the introduction of the cheaper “plastic bag” biogas plants[16].

Recently, World Vision Ethiopia introduced biogas under its Appropriate Agricultural Technology Promotion Initiative (AATPI). So far, some 150 plants have been constructed (or are in the process of being so). In all, the total number of domestic biogas plants would be in the range of 600 to 700 installations.

Section 2 of the report presents the observations of the study regarding to the visited biogas installations.

[14] EREDPC, Ministry of Energy & Mines, Ethiopia; Indicative dissemination strategies of biogas energy in Ethiopia
[15] Christopher Kellner, Bio digester septic tank and bio latrine, construction of standardized systems for utilization and demonstration
[16] Dr. Getachew Eshete et al, Identification study on renewable energy and energy efficiency in SNNPRS and Ethiopia.

Report on
the feasibility study of a national programme for
domestic biogas in Ethiopia.

Section 2
Study findings.

1 Study objectives

The objective of the study is to thoroughly assess the feasibility to set-up and implement a national biogas programme in Ethiopia[17]. More specifically, the study will address the following areas:

- Country background including agricultural & livestock sector, energy demand and supply, energy policy and plans;
- History of domestic biogas;
- Potential demand for domestic biogas;
- Possible institutional set-up for a national biogas programme, and;
- Outline for a national programme on domestic biogas.

1.1 Methodologies

The following activities and methodologies are proposed:

A. Preparation of a mission to Ethiopia by collecting secondary information, contacting key respondents and informants in Ethiopia and abroad, and drafting checklists for biogas plant visits and interviews;
B. Mission to Ethiopia to visit domestic biogas plants constructed in the past, to meet with key respondents and informants for interview and discussion. The mission shall include a workshop to discuss with the main stakeholders the roles of the different actors in Ethiopia and the outline of a possible national biogas programme;
C. Formulation of the draft study report and submission for comment to SNV/Ethiopia, members of the Biogas Practice Team (BPT) of SNV, RNE in Addis Ababa and DGIS/DMW.
D. Submission of the final study report by incorporating the comment from SNV/Ethiopia, members of the BPT, RNE/Addis Ababa and DGIS/DMW.

1.2 Limitations

The study team necessarily had to be selective in its destinations; the lowlands in the East and South East, with large migratory cattle herds, and the South-West with its large forests were not visited as the biogas potential can be expected to be relatively low in those areas.

Over 4 weeks, the study team travelled large parts of North-West, North and South Ethiopia, visited many (ex) biogas households, some non-biogas households and interviewed many organizations that directly or indirectly are involved in domestic energy and rural development. Even so, in the period available, the team cannot claim to have a full and in-depth picture of the domestic energy situation in Ethiopia.

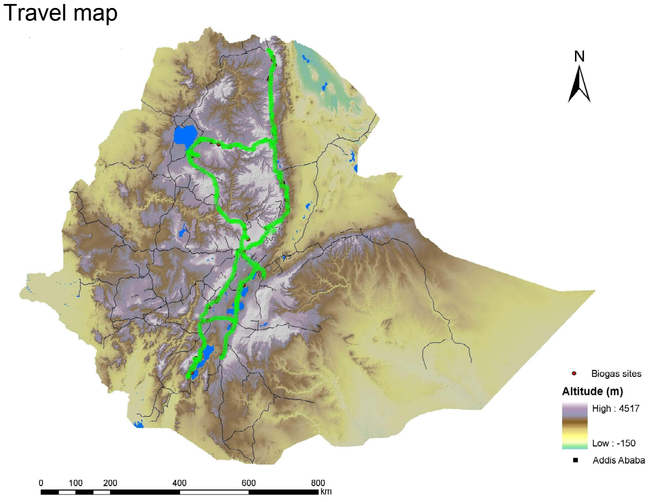
"Feasibility" is multi-facetted; this study focused more on socio-economic, energy & environmental, technical and organizational / institutional aspects, and less on commercial / marketing aspects. As such, the study may indicate the potential market for biogas, but to a much lesser extent the active, commercial demand.

[17] The ToR for the study is provided as annex 1 to the report

2 Study observations

The study team travelled some 4000 km over a period of 3 weeks in the North-West, the North and the South of Ethiopia. The visited regions included Orromia, Amhara, Tigray and the Southern Nations, Nationalities and Peoples Regional States (SNNPRS). A brief description of the 4 regions is provided in Annex 2.

Travel map

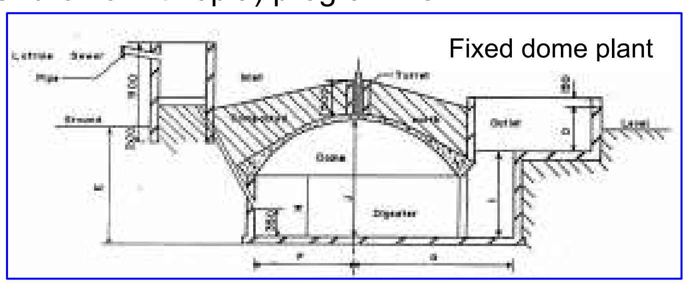


Apart from visiting relevant (government and non government) organizations, the team visited sites showing domestic biogas plants (57), bio-industrial biogas installations (5), institutional installations (3) and community biogas / sanitation facilities (1). The map provides an impression of the area covered.

2.1 Types of installations visited

Of the 57 domestic biogas plant sites visited, 25 were of the “fixed dome” design and 32 of the “floating drum” design.

- The fixed dome plants visited resulted from
  - The World Vision AATPI programme
  - Christopher Kellner’s efforts within and outside the GTZ / Lupo programme
  - An older Mekane Jesus (the Evangelical Church of Ethiopia) programme.
- All floating drum installations were constructed under governmental demonstration / pilot programmes over the past 13 years or so.

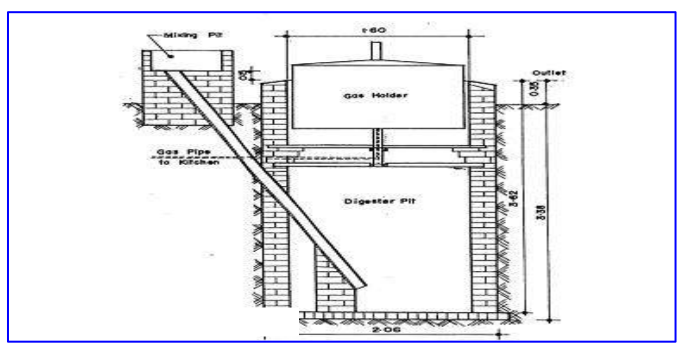


Fixed dome plant

The oldest installations visited dated back some 12 to 14 years. Most of the older plants were government-built floating drum installations, although the “Mekane Jesus” fixed dome plant south of Arba Minch is believed to be some 12 years old as well.

The youngest installations visited were the fixed dome plants constructed with the support of the AATPI programme of World Vision. These plants were only just in operation at the time of visiting.

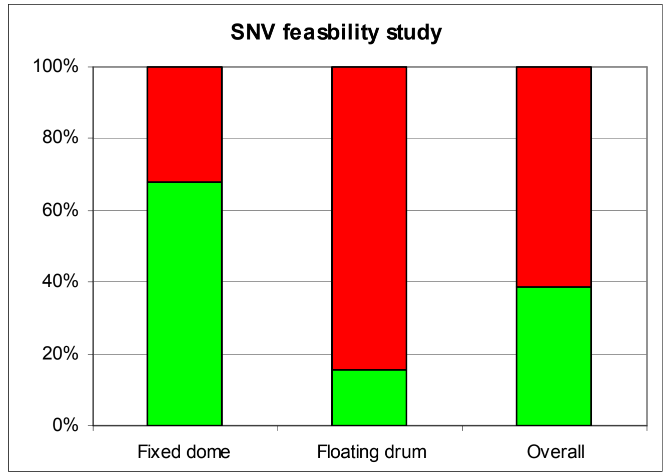
In general, most plants, even the dismantled ones, showed evidence of decent workmanship.



Floating drum plant

2.2 Functionality

Overall, 60% of the visited installations were not functioning –i.e. gas could not be utilized- at the time of the visit. Fixed dome installations (68% functioning) were scoring significantly better than floating drum installations (16% functioning).



With this observation it should be noted that World Vision recently started the AATPI[18] programme in Tigray and Oromia, for which fixed dome installations are constructed. The study team visited a fair share of the World Vision installations. Many of the floating drum installations, on the other hand, are up to 14 years old. Obviously, the chance that installations become dysfunctional increases with time, putting floating drum plants at a disadvantage in the study's selection.
Main causes for non-functioning of the visited installations include:

2.2.1 Technical problems:


Indian double biogas stove

– Mainly smaller issues, like water trapped in the piping, unprotected piping damaged by cattle, broken stoves and biogas lamps, leaking gas-hoses.
– Occasionally major technical issues like broken digesters and inlet pipes were observed.
– The nearly-total absence of technical back-up services clearly aggravates the impact of smaller technical problems. Meeting with plant owners desperate for technical advice and assistance was no exception for the study team.
– Many of the observed problems could be solved with less than half a day work of a skilled technician and little investment to the extent that the team could even repair some of the break downs during the visit.


Structural damage

2.2.2 Water shortage:

– Particularly around Dessie, Amhara region, a remarkably high share of older (floating drum) plants was not in operation. Most of these plants would

[18] Word Vision Appropriate Agricultural Technology Promotion Initiative

seem principally operable; we were reported that a severe drought some six years ago (1998) not only had its toll on the cattle holding (households reporting that they had to sell of their entire herd of 30 cattle) but also caused drying up of many water wells, making water-availability “suddenly” a major issue.

– In other places too, the large distance to the water source was reported to be the reason to stop operating the plant, often in relation with children leaving the house (thus reducing the energy requirement of the household as well as the “free” labour of the children for fetching water).

2.2.3 Dung shortage:

– Sometimes induced by droughts, and sometimes a result of changing cattle holding style.
– In other cases the amount of available dung was clearly not in relation with the expectations the farmers were lead to believe. This was particularly true for households that –with all good intentions- were provided a biogas metad; without exception, all of those households reported that insufficient gas prevents using the biogas metad.


Dismantled drum

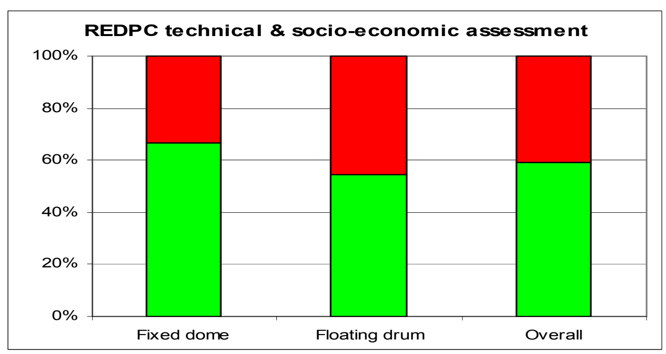
2.2.4 Abandoned:

– Few plants were abandoned; families move, and a biogas plant cannot be moved along (although one household did take the steel drum of the floating drum plant).

2.2.5 “Loss of interest”:

– In a few cases, break downs were claimed that did not add up with the observations, very simple repairs would be carried out for years, etc. Obviously, owners lost interest in operating the plant, but the underlying cause was not always clear.

The findings of the study team are supported by the findings of the Ethiopian Rural Energy Development & Promotion Centre (EREDPC) in their (unpublished) study report of about half a year earlier [ref 008].



This study found a higher share of functioning floating drum plants. The explanation could be that many of the floating drum plants our study team visited were actually reported to be just out of action.

The REPDC report mentions lack of water; reduced animal holding; abandoned (resettlement); loss of interest; management, and; minor technical problems as causes for the installation not functioning.

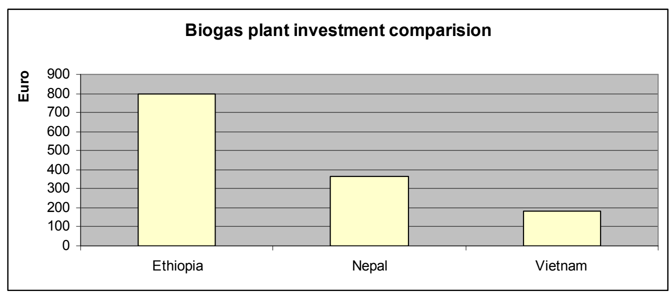
An even less encouraging report came from the Amhara Mines & Rural Energy and Promotion Office: of the batch of 54 floating drum biogas plants constructed in the period 10 to 12 years ago, a report of 2003 claimed none of them was still working.

Similarly, the Bureau of Energy of the SNNPRS surveyed 78 installations constructed between 1989 and 2004: Out of the 65 floating drum installations, 19 were functioning and out of 6 fixed dome plants only 1 was functioning. Of 7 plants of which the type was not indicated, 4 were in function.

Also on the 103 installation reported in 1991 by the EEA, Mr. Melis Teka Nega reports: Almost all of the plants were not working after some time due to[19]:

- Installations not were constructed from with the farmers' interest in mind, but rather with a political motive;
- Gas management, every family was cooking at the same time
- Labour contribution for feeding the installation.

2.3 Economics



2.3.1 Investment costs.

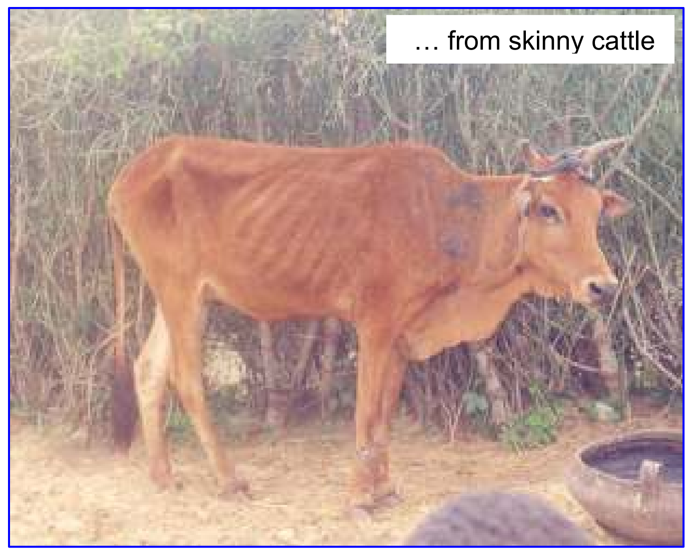
The reported investment costs for domestic biogas plants range from some ETB 6,000 to 12,000 for fixed dome installations (8 to 20m^3). Floating drum plants are more expensive, and would typically start at ETB 8,000 for the smallest size of 8 m^3 digester volume. In these reports, it was not always clear to which extent the farmer contributed to the costs (in kind or in cash) and how far these costs were included in the reported investment.

A detailed Bill of Quantities from 1995 informs on the costs of a 8 m3 floating drum installation. In this BoQ the total costs amounted to ETB 8,451 (materials ETB 7,268 + labour ETB 1,183).

Although the reported investment costs should be taken with care, the conclusion that biogas plants in Ethiopia are high, both in absolute as well as relative terms, seems valid.

[19] These issues should probably be seen in the context to communal, shared biogas installations.


Low dung production …


… from skinny cattle


Traditionally burned bricks

2.3.2 Plant size.

In relation with the amount of available dung, the plant size of the visited installations was too large. Typical domestic plants would have a digester volume of at least 8 m^3, but more often sizes of 12 to 20 m^3 were observed. Most households, however, would have only three to eight up to fifteen heads of cattle. These cattle, typically, would roam around at fallow land and collective grazing grounds, would be poorly fed and (as a result?) rather small.

The amount of available dung, as observed, could in many cases be as low as 5 or 6 kg dung per head per day.

Assuming an average cattle holding of six heads, the amount of available dung would thus not exceed, say, 36 kg per day. Further assuming a hydraulic retention time of 60 days for the highland plateau and a dung / water ratio of 1:1, an installation with a 4 m^3 digester volume would suffice.

The average live weight for Ethiopian cattle is reported as 250kg [ref 013]. For comparison, the average live weight of Dutch cattle is 600 kg[20].

2.3.3 Used materials.

Most pipe fitting materials, ball and gate valves, lamp mantles and cement are generally available in larger villages. Even so, all visited installations had a high share of “exotic materials”. Digesters of floating drum plants were without exception constructed in locally available stone, but the metal drums were mostly constructed in government workshops in the region’s capital. Fixed dome installations were all built in bricks that had been trucked-in over long distances.

For both designs, appliances were either manufactured in the region’s capital, or imported (Indian) stoves and lamps were provided. Except for the lamp mantles, which

[20] BINAS science information

are used for kerosene lamps as well, none of the biogas appliances or spare parts are locally available.

The use of non-local materials increases the investment costs. Clay bricks can easily double in price if transported over larger distances; the metal drums by nature need a truck to get them on site. Moreover, non-local products, particularly appliances, valves and taps, aggravate the maintenance problem as replacements, spare parts and repair knowledge are rarely locally available.

The high investment costs of the observed plants and the high incidence of minor technical problems leading to dysfunctional installations can both to some extent be attributed to the use of non-local materials for plant construction and appliances.

2.3.4 Investment subsidy:

Most of the visited installations were fully subsidized. Exceptions included:

- A few government-built floating drum plants whereby the household contributed the labour costs for digging the pit;
- All World Vision installations, where households provided similar labour;
- The plants constructed by the efforts of Christopher Kellner in Fiche, that were fully paid for by the households,

The popular view would hold that full subsidies undermine the ownership of the installation, resulting in the biogas plant not receiving the desired “tender love and care”. The study team visited a few sites where this could be observed; plants were neglected, abandoned for seemingly no reason, the smallest investment for repair being avoided. However, this practice was not the rule; many plants were kept alive despite absence of any technical back-up system. The study team visited quite a number of installations that –for their age of 10 to 13 years- had been kept in good working condition.

2.3.5 Investment credit:

None of the installations was financed with credit. Although all regions currently appear to have a fair micro credit network, only recently the MFIs adjusted their loan conditions in such a way that investments the size of a biogas installation could be accommodated.

2.4 Operation

Many (60%!) of the visited installations were not in operation at the time of visiting. The remaining plants can be divided in very new plants that would work without too many problems. And older plants (mostly > 10 years) that, against all odds, were kept in working order by the owners.

It is from this last group that the study team got an impression of how plants were kept in operation, what farmers would do to get repairs done and, from the first group, where and when it went wrong.

Households would at times go a long way to keep installations working: Trying to arrange heavy lifting equipment to have a drum lifted out of dried slurry; submitting a written (!) request to government officials to have a pipeline repaired; walking a broken stove to the next village for repair etc. Clearly, many owners appreciated their plant highly and at times expressed desperation in getting technical assistance and advice.

2.4.1 Cooking stoves.

Households used biogas for cooking and lighting. Cooking particularly of wot (sauce for injerra), coffee and boiling hot water.

Most farmers had one single stove, few in addition a larger one for baking local bread.

Stoves were of local (no-brand) origin, manufactured by Selam in Addis Abeba, or imported from India. Many older locally produced stoves were heavily corroded, only a few had an adjustable primary air intake. As a result, but also because of the low gas pressure of some of the floating drum plants, many stoves did not seem to burn optimally.

2.4.2 Biogas lamp.

In rural Ethiopia, only 2% of the households have access to electricity. Illumination is done mostly by kerosene (“mash” pressure lamp and simple “kuraz” wick lamps) and to a lesser extent with candles and battery lamps.

Not surprisingly then, that biogas lamps are highly appreciated. Where households had working lamps, the lighting ranked highly on appreciated benefits. So much so that often the feeding of the biogas plant was taken care off by the children, in order for them to have light in the evening. Subsequently, it was observed that the interest in the biogas plant waned when a biogas lamp stopped functioning.


Indian biogas stove


“Selam” biogas stove


Locally manufactured biogas stove


Local biogas lamp

As the kerosene pressure lamp is well introduced in rural Ethiopia, mantles (that are used both for the "Masho" kerosene pressure lamp and the biogas lamp) are widely available at reasonable costs (ETB 2-3 per piece). Mantles are very fragile; household reported to replace them weekly to monthly.


Indian biogas lamp

The observed biogas lamps were all (duplicates) of Indian design. Without exception, all glasses were broken, and often replaced by mesh wire. And nearly without exception, the biogas lamps were in a terrible state of repair, with many non-functioning.

Selam Vocational Training Centre showed a very promising pilot cast aluminium biogas lamp, which might be marketable for around ETB 200.


"Selam" proto biogas lamp

2.4.3 Maintenance.

Many (but not all!) farmers showed limited understanding of the working of the installation. As a result, plants would stop functioning as a result of a minor issue as simple as water being trapped in the pipeline, even when a water trap was installed.


Main pipe repair

Dried-up substrate in digesters, as a result of temporary water shortages, is another maintenance problem frequently observed, particularly with the floating drum installations (low pressure, difficult to remove the drum).

Clearly, the situation is further aggravated by the absence of technical back-up and spares parts.


Unblocking inlet pipe

2.4.4 Water collection.

The effort for water collection appears to be underestimated during the selection of the household. For many of the visited non-functioning installations, absence of water (dried-up substrate in digester, see above) was reported as the main cause.

A number of plants visited (e.g. around Dessie) seemed to have become non-functional after a severe drought period. Drought affects all aspects of rural live brutally and biogas installations are not exempted. However, with proper advice and assistance these installations could / should be revived after the drought period. For a country with frequent, recurring drought periods, the absence of mitigating mechanisms in this respect is surprising.

2.4.5 Slurry use.

Many farmers highly appreciated the bio-slurry. Proper application of slurry (direct or diluted, dried and composted) on the vegetable garden was not an exception, and farmers reported increased yields and reduced weeding.

2.4.6 Bio-metads.

Although some farmers were supplied with biogas operated metads (baking plates for injerra) none of the visited households was using this stove as its gas consumption was claimed to be too high. The design of an appropriate domestic bio-metad is challenging:

Limited amount of biogas:

- Based on the household visits of the study team, typically 25 to 35 kg of dung should be expected available as substrate. Thus, the amount of disposable biogas would be limited to, say, 0.8 to 1.4 m^3 per day.
- The normal stove, the biogas lamp and the bio-metad are competing for the available gas. It can easily be seen that 3 hours of a normal, smaller stove (~ 250 litre biogas / hour) and 3 hours of a biogas lamp (~ 120 litre biogas / hour) per the day will deplete already (nearly) all the available biogas.

Biogas metad

Intrinsic inefficiency of metads:

- From an energy efficiency point of view, the metad is a nightmare; heating a clay plate (poor heat transfer) of huge diameter (up to 60 cm, significant heat losses) to a temperature of 150 to 180 ^oC is bound to consume large quantities of fuel.
- Although the study team was unable to obtain gas-use figures for bio-metads, judging from the size and burner design consumption might well be as high as 1000 litre / hour.
- For a bio-metad, heat distribution over the plate, heat transfer through the plate and heat loss will be major issues. Technically, solutions might be available but these would likely further increase costs and necessitates proper research.

Biogas metad test model

Injerra baking by batch:

- Housewives typically will prepare injerra batch-wise; twice a week some 20 to 30 injerra's.
- The gas requirement for one batch will be considerable (say 2 hours equalling perhaps 2 m^3), exceeding the gas storage capacity of most domestic biogas plants

Possible technical improvements for bio-metads:

- improved burner for better heat distribution,
- aluminium or cast iron plate for better heat transfer,
- plate of smaller diameter (reducing the diameter from 60 cm to 50 cm reduced the area to be heated with one-third)
- placing the bio-metad in a "Mirte-like" housing to reduce heat losses.

Improved metads (local, Mirte and Lakech) are currently widely available and strongly promoted by multiple actors. Their efficiency improvement is significant and these stoves can be fuelled by multiple fuels including dung and agricultural residue, these stoves seem - for the moment- more appropriate and economic for the preparation of injerra than (the potential of improved) bio-metads.

2.4.7 Toilet connection.

Connecting a toilet to a biogas plant is a sensitive issue for most rural households. Interviews with biogas practitioners in the region indicated that families may be reluctant using the bio-slurry -or even the biogas- of plants fed with human faeces.


Toilet connected to biogas plant

Not surprisingly, then, is that very few of the visited biogas plants even had a preparation (second inlet pipe) for future toilet connection.

A few plants formed a happy exception: some of the World Vision/AATPI and GTZ/ Christopher Kellner plants did have a connected toilet and proudly satisfied owners.

But also some older initiatives proved innovative enough to promote toilet connection


Connected toilet in need of maintenance

In view of the advanced and fairly widely implemented health education programme of Finnida (extension, mobilization, water pumps, latrines with special slabs and separate urine collection, etc), it can be expected that proper extension would go far in "softening" taboos around toilet connection

2.5 Dissemination modalities.

Dissemination of biogas in Ethiopia can, in extremis, be grouped in two approaches.

The older approach, mainly practiced by government agencies (EREDPC, Bureaus of Energy and Bureaus of Agriculture), could be characterized as a stand alone, technology driven. The objective often is to pilot / demonstrate the technology in certain areas.

The newer methodology, practiced in particular by World Vision, would then be more a development approach in which households are offered a full "development package" that would serve as a springboard towards a "happy and self sufficient" life.

The picture presents some observations of both approaches in opposition, and –with the following remarks- largely is self-explanatory.

Stand-alone technology driven	Full package development driven
Mainly government	Mainly NGO
Non-poor farmers	Poor farmers
Fair, but expensive plants	Fair, but expensive plants
Single-actor construction	Single-actor construction
Isolated	Clustered
No technical back-up	Limited ownership
Limited ownership	Limited org. cooperation
Ltd operational integration	Very costly package with
Limited org. cooperation	high "white elephant" risk

2.5.1 Single-actor construction:

In both approaches, most installations were constructed by the "own organization" as opposed to involving local craftsmen and private entrepreneurs in the process. Evidently, this allows for short lead times and simple quality management arrangements in the construction process. The consequence, however, is that knowledge and skill on operation, construction and maintenance is not locally retained. The initial gain, thus, is off-set as soon as repair, maintenance and extension requirements are expressed by the owner.

World Vision Ethiopia AATPI

Around Wukro in northern Tigray and Adama in Oromia (rift valley), World Vision is supporting poor families with "development packages. Besides ample technical advice, families are provided with "hardware" that would serve them, once all is in place, as a "springboard" to a rich life in a self-sufficing way. The hardware component, to some extent depending on the area, would include:

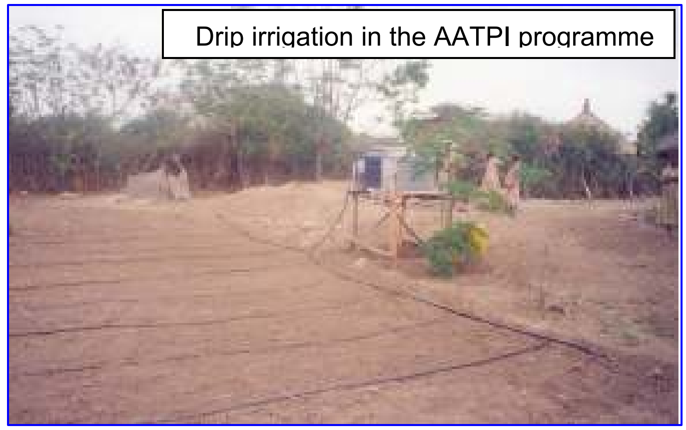
- Biogas plant (fixed dome, with stove and lamp)
- Latrine, connected to the biogas plant
- Wheel barrow and rake, to collect additional manure for the plant
- Small scale (100 – 250 m^2 vegetable garden) drip irrigation system
- One dairy cow (heifer)
- One donkey + donkey cart for water collection
- Dug wells and engine – water pump
- Parabolic solar cooker

World Vision is further contemplating on a cattle fattening programme, providing fodder for the first animal free of costs, after which farmers are expected to carry the programme on their own strength.

The investment for a typical package would be in the range of ETB 30,000 per household

2.5.2 Isolated:

Building biogas plants in isolation as opposed to clustered (say 20 biogas plants in one limited area) construction makes dissemination, supervision, extension and maintenance processes unnecessary complicated and biogas plants expensive.



Drip irrigation in the AATPI programme

Finnida extension material

2.5.3 Operational integration:

To enjoy all biogas benefits to the max, it is important to integrate the biogas plant in its rural, agricultural setting. To that extent, dissemination programmes should aim to integrate biogas with initiatives to improve cattle stables (floor), sanitation (connected latrines, hand washing programmes) agricultural production (bio-slurry use, drip irrigation, vegetable growing, dairy and meat farming, cut and carry promotion), water harvesting, area closure and reforestation etc.

2.5.4 Organizational cooperation:

Biogas dissemination programmes can be expensive. In line with the above, to improve effect and efficiency, and to support sustainability, it would be recommendable for different (local) programmes to work together more closely.

NB:

- For “argument’s sake” the situation is presented dialectically. The reality is not so black and white; the Bureau of Energy in Awassa, SNNPRS, for instance indicated that they are increasingly cooperating with manufacturers of the private sector, and one of the visited households mentioned its contribution to the tune of ETB 4,000 for the installation
- The “Christopher Kellner” approach differs from the above two extremes in scale of dissemination, and in that the households were not offered financial support, only technical advice.

2.6 Policy and strategy.

Interviews at regional Bureaus of Energy and Bureaus of Agriculture left the study team with the impression that regionally and at this “executive” level, the involved officials are very well aware of the (domestic) energy crisis and its socio-economic and environmental ramifications. Often detailed studies on biogas history, domestic energy consumption and energy sourcing are available. And often, proposals are submitted to alleviate the energy / environment pressure.

Unfortunately, despite policy largely being in place, at the higher “political” level, the issue seems not to get the required attention and priority. This results in totally inadequate funding for even the smallest surveys or dissemination programmes. The executing bureaux thus are typically seriously resource-limited (project finance, transport, staffing), resulting more in frustration than implementation.

The interview with Ato Asress, director Ethiopian REDPC, however, gave some indication that also at central political level the severity of the situation starts to hit home.

2.7 Organizations active in the biogas sector.

"Biogas sector" is probably too large a concept for the combined biogas activities in Ethiopia, but the following organizations were visited that implement biogas activities:

2.7.1 Ethiopian Rural Energy Development and Promotion Centre.

The central (federal) organization mandated for all issues on domestic rural energy. The centre constructed biogas installations under own management and implements / commissions rural / domestic energy studies. Increasingly, the Centre supports the Bureaus of Energy in implementation of regional rural energy policy. The EREDPC has a "biomass desk"; knowledge on socio-economic and technical issues of biogas is very good.

2.7.2 Regional "Bureaux of Energy".

All regions run a Bureau of Energy, whereby the precise name may differ from region to region as it is often moved around between water, energy, agriculture and mining sectors. Indications are, however, that in view of the threatening energy - environmental situation, the Bureaux of Energy will increasingly become more independent. The Bureaux of Energy construct small numbers (say 10 p.a.) of biogas plants under own management (mostly floating drum designs). Bureaux execute or participate in rural household studies, focussing on the domestic energy situation. Currently, most Bureaux focus on dissemination of improved metads (Mirte, Lakesh etc).

Large biogas installation constructed by Selam

2.7.3 Selam Technical Vocational Training Centre.

Based in Addis Abeba, Selam is a leading Technical Vocational Training Centre, with a significant production capacity. Inspired by Christopher Kellner, Selam embarked up on biogas technology some 5 years ago.

The Centre mainly constructs larger fixed dome installations (up to 200 m^3), turn-key, for the bio-industry around Addis Abeba, but they have been involved in some domestic installations as well. Selam operates three biogas plants on its own premises.

In general, Selam, over the past 20 years or so, has built a solid reputation on quality and this shows in their biogas plants.

2.7.4 Ashebir Teferra.

A result from the Selam Vocational Training Centre; Ashebir Teferra is constructing fixed dome biogas installations, mainly for the bio-industry, around Addis Abeba.

2.7.5 Biofarm.

Organization directed by Dr. Getachew Tikubet. Biofarm promotes an integrated approach to biogas, not dissimilar to the Chinese 3 in 1 and 4 in 1 ideas and the considerations the Carmatec team in Tanzania documented. Biofarm provides technical services to the World Vision AATPI programme for the construction of domestic biogas plants. The organization is a bit secretive about the technology they promote. From our observations, their "Chinese design" is comparable to the "Lupo" design of Christopher Kellner, with large cylindrical vertical inlet and outlet.

Biofarm's approach could be described as a mix between "single-actor construction" and technical consultancy, whereby sometimes construction is done by Biofarm masons and sometimes local technicians are trained on pilot plants. In terms of sustainability and pricing, the team was left with some questions about Biofarm's dealings. Unfortunately, the study team was stood up for the interview.

2.7.6 Women and Children Development Organization.

WCDO promotes a latrine – biogas – kitchen – vegetable garden set-up for poor urban communities. The biogas plant is of the "Christopher Kellner – Lupo" fixed dome design, measuring 25 m3. WCDO constructed some 9 units over the past 6 years, of which the team visited a well functioning unit in Awassa.

Report on
the feasibility study of a national programme for domestic biogas in Ethiopia.

Section 3
Potential demand for domestic biogas.

1 Conditions for large-scale dissemination.

Conditions for large-scale dissemination of domestic biogas in Ethiopia

	Condition	Score	Remark
Technical	Even daily temperatures over 20°C throughout the year	++	Average maximum temperatures range in the 20s throughout the year. On the plateau, however, night temperatures may drop to 10°C or slightly lower during the rainy season
	At least 20kg of fresh animal dung available per plant per day	++	As argued earlier, under the current holding regime sedentary farmers would need at least 4 cattle. Large parts of the plateau have an average cattle holding of 4 or more per household.
	Availability of water required to mix with fresh dung in a 1:1 ratio	+/-	Water availability is very area dependent, and in most parts of Ethiopia recurrent droughts have to be taken in consideration.
	Sufficient space for biogas plant in the compound of potential users	++	Compound space is not an issue in rural areas; farmers have yards of reasonable size.
	History of proper performing biogas installations	+/-	60% non-functioning is not a good track record, but up to 750 plants nation wide is not a large amount either.
Financial	Traditional practice of using of organic fertilizer	+	Traditionally, dung is used as fertilizer. Unfortunately, energy shortage increasingly force households to use dung as energy source instead
	Scarcity of traditional cooking fuels like firewood	++	Fuelwood is scarce to the extent that its use is considered a luxury in large parts of the country
	Potential users have access to credit	+	All visited regions have good, albeit recent, micro credit facilities. There is, however, no experience yet with biogas credit
	Livestock farming is the main source of income for potential households	++	Farming integrates cropping and livestock. Hence, livestock may not be the main source of income, but it is an indispensable part of it
Social	Role of women in domestic decision-making process and life	– –	Traditionally, domestic decision making is male skewed. The decision for an investment in a biogas installation would definitely be within the male domain.
	Biogas plant can be integrated into normal working routine at the farm	++	In view of the integrated farming system, biogas will fit seamlessly in most situations in the highlands, where cattle are night-stabled.
	Awareness of effects of biogas technology among potential users	-	In view of the low penetration of new technologies in general and biogas in particular, many farmers may not be very aware
	Willingness among potential users to attach a toilet to the plant	+/-	Handling (products of) night soil definitely is a sensitive issue. However, there are some good examples.
Institutional	Political will of the Government to support a national biogas programme	+	At REDPC and BoE level, the political will is certainly there. The MoFED and BoFEDs, however, have not been consulted in this detail yet
	Willingness of (potential) stakeholders to get engaged in biogas programme	++	Both from government side (REPDC, BoEs, BoAs) as well as NGO side (UNDP-GEF, Selam, RNE, SNV-Ethiopia) the team met with considerable enthusiasm.
	Availability of organizations having access to potential users	+	The government's agricultural extension network reaches down to kebele level, but habitats are much dispersed.

Score	*Condition*
++	*Fully met*
+	*Met*
+/-	*Doubtful*
-	*Not yet met*
--	*Falls short*

1.1 Technical aspects.

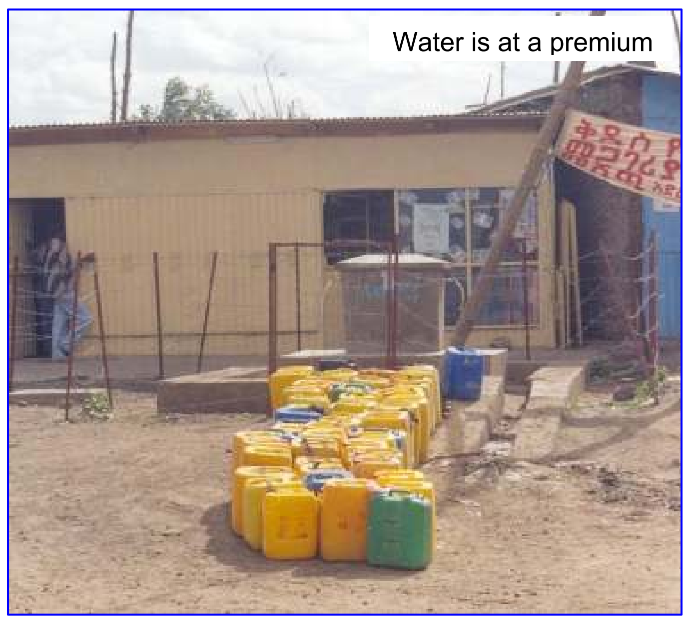
Temperature: Climatic issues will hardly limit the potential for large-scale dissemination of domestic biogas. Over 78% of the population lives above 1800 m.a.s.l. The average temperature range at these altitudes, 15 – 20^{0}C, is high enough for plants –properly located and covered with soil- to function throughout the year.

Livestock keeping: The current practice of cattle roaming on communal grazing lands and fields outside the cropping season limits the amount of available dung to some extent. In addition, cattle are mostly not well fed and often skinny. The low productivity in terms of milk and meat also reflects negatively on the amount of dung produced. Hence, farmers should rather have a minimum of four heads of cattle to secure sufficient dung availability. Improvement of cattle sheds and floors would improve this situation considerably for most farms.

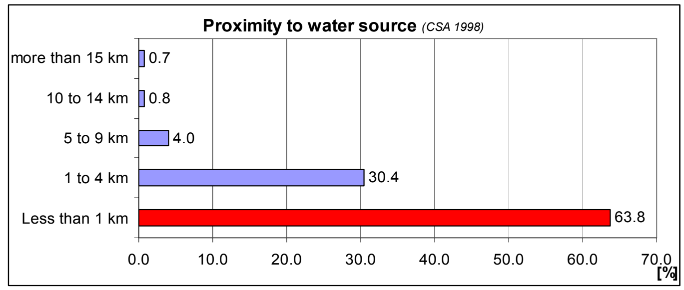
Little fodder, small cattle …

It is likely that the free grazing practice gradually but increasingly will be replaced by "cut and carry", stable feeding of livestock, as the traditional practice may just have to high a toll on the environment. Parallel, other cattle breeds would be introduced, improving the situation for biogas.

Water: The availability of water is critical. The findings of this mission too indicated that water should not be further away than 20 to 30 minutes. There are definitely many farm locations that meet this requirement, but there will be many that don't too. Careful and strict selection should avoid disappointment in any future programme. In addition, following the World Vision example, a more integrated approach whereby water harvesting techniques, water wells and a water-carrying donkey become economically feasible, would improve the situation.



Water is at a premium



The 1998 census would indicate that nearly 64% of the rural population live within 1 km (approx 12 minutes walking) of a water source and 30% of the population lives at a distance of 1 to 4 km from a water source (12 to 48 minutes walking).

Assuming that a proximity of 20 to 30 minutes would be equivalent to a distance of maximally 2 km, and assuming that population shares in the 1 to 4 km segment is distributed evenly, in total 64 + (30/4) = 71% of the rural population would live within 20 to 30 minutes from a water source.

This would not quite match the observations of the mission in some of the visited areas (Amhara, Tigray). In addition, water source yields may reduce significantly during longer dry periods, forcing water carriers to use lower quality water (not a problem for biogas) at even longer distances.

Access to safe water would be another proxy to account for regional variations in water accessibility[21]. The share of the rural population thus having access to safe drinking water, say 22%, is considerably lower than the share of the rural population living within 30 minutes from a water source. Part of this difference may be explained by not all water sources providing safe drinking water and "access" might be defined more narrow in the second source

Access to safe drinking water

Region	rural	total
Amhara	23%	31%
Oromia	23%	30%
SNNPRS	*21%*	28%
Tigray	*26%*	34%

Source: MoWR - WWDSE 2001

Space: The study team did not visit any farm where the physical space requirement of a biogas plant could have been a limiting factor. Besides, when fixed dome installations would be promoted in stead of floating drum plants, the required amount of place will further reduce.

Track record: There are only few domestic biogas plants in Ethiopia. Although their track record is worrying, their impact on the reputation of the technology would be limited as the technology as a whole is little known.

Biogas & resettlement.

In an attempt to lower the anthropogenic pressure in heavily degraded areas, the previous regime introduced quite rigorous resettlement programmes. Communities were resettled in villages (often also a new concept) in more prosperous areas, often provided with a wide range of services. Among these services could be biogas installations.

The policy intentions might have been right, but resettlement occasionally met with fierce resistance. In some areas, bad "resettlement experiences" might be associated with biogas.

[21] For SNNPR and Tigrai region, a figure on rural accessibility was not available. The share has been calculated assuming 75% of the share of the total, as is the case for Amhara and Oromia regions, would result in the rural access to safe water.

1.2 Financial aspects.

1.2.1 Handling manure: While the benefits of manure-use as fertilizer are well known to farmers it is only used frequently in some areas in the South of Ethiopia. In most areas the competing value (opportunity costs) as energy and income source is too high to allow the farmers the luxury to use it for the crops. The fact that most of the visited biogas households used the bio-slurry for fertilizing vegetables and other crops shows that farmers will use the organic fertilizer if their energy needs are covered form other sources.


Intensive small scale farming in Gurage area

Many farmers visited by the study team, over the whole country, had smaller or larger vegetable gardens on their farm yard. These farmers used their manure (or bio-slurry in the case of biogas households) as manure for their crops. In some areas, however, vegetable growing is more intensive than others; Gurage, for instance, is a typical intensive vegetable growing area, and manure has a high fertilizing value. In other areas (parts of Amhara and Tigray), cattle are using common grazing grounds and manure is less handled by farmers.


Dairy farm, Addis Abeba

1.2.2 Dairy production: Increasingly, farmers embark up on dairy production as a commercial activity. To that extent, dairy cooperatives with transport / refrigeration facilities are popping up. The traditional diet of most (rural) families knows little dairy products (some butter for cooking, “aib”, the local cottage cheese and little “urgu” (local yoghurt) to eat with injerra), promotion aims especially on increasing urban dairy consumption.

1.2.3 Selling dung-cake: As the efficiency of a biogas stove is easily five times higher compared with a traditional (dung-cake) stove, contrary to common belief, biogas would not compete with the commercial value of dung cake as an energy source, as a farmer would be better off converting the dung to biogas rather than burning it directly. Additionally, the farmer would reap the fertilizing benefit of bio-slurry

Fuel prices	Unit	ETB	Euro
Agricultural residue *(50% repl value wood)*	[/kg]	*0.38*	*0.04*
Dung cake	[/kg]	0.40	0.04
Fuelwood	[/kg]	0.75	0.07
Charcoal	[/kg]	1.50	0.14
Kerosene	[/ltr]	3.00	0.29

1.2.4 Fuelwood: The scarcity of fuelwood in most of the visited areas is factual, as is its high and rapidly increasing price. So much so that fuelwood and charcoal are gradually becoming luxury goods for rural households. Besides fuelwood, BLT, dung cake and agricultural residue are increasingly becoming commercial energy sources, traded at markets.

1.2.5 The value of biogas: This value depends directly on the value of the substituted fuels. The table provides the calculated value of 1 m^3 of biogas, based on the fuel price, the substitution ratio (biogas stoves have a significant higher efficiency than traditional stoves) and the assumed fuel mix (the share of the substituted fuel in the total energy supply. The table shows two values; the economic value, taking the full market price of the substituted fuel into account, and the financial value, taking only a share of the market price into account. Thus, the financial value better allows for the fact that rural farmers acquire fuel often by hard labour (often by the women and children) rather than buying it on the market.

Biogas replacement value	Unit	substitution ratio	fuel mix	economic value	financial share	*Euro* financial value
Agric residue + BLT *(50% repl value wood)*	[Euro/m^3 gas]	7.06	15%	0.038	10%	0.004
Dung cake	[Euro/m^3 gas]	6.05	15%	0.035	30%	0.010
Fuelwood	[Euro/m^3 gas]	9.79	68%	0.480	70%	0.336
Charcoal	[Euro/m^3 gas]	1.99	1%	0.003	80%	0.002
Kerosene	[Euro/m^3 gas]	0.63	1%	0.002	100%	0.002
Biogas	[Euro/m^3 biogas]		100%	**0.56**		**0.35**
	Vietnam values:			**0.16**		**0.10**

Striking in the results is not only the significant difference of Euro 0.20 between the economic and the financial value of biogas, but also that the value of biogas is three times higher in Ethiopia (economic € 0.56, financial € 0.35) as compared with Vietnam (economic € 0.16, financial € 0.10).

1.2.5 Micro credit: With the micro credit facilities modernizing and extending their services, credit is becoming a feasible financing option for biogas in many of the visited areas. Credit terms are not prohibitive, but it has to be taken in mind that there is no experience with biogas credit yet. Hence, micro financing organizations may require assistance in covering the risk initially.

In the past, farmers did have a reputation of being reluctant to take loans. Obtaining credit could be difficult; micro credit facilities were less developed and land could not be used as collateral. The situation has improved since, but the extent to which this reluctance may still hamper a biogas credit component would need further study during the preparation of the implementation document of the programme.

1.3 Social aspects.

1.3.1 Role of women: The team did not get the impression that women play a crucial role in making decisions in the household, and certainly not where a financial investment of the size of a biogas plant would be concerned.

A more balanced, scientific view, however, could be obtained from Guday Emirie's dissertation (reference 011); in the chapter on "decision making patterns in the extended family" (5.4.2.1) structure the following can be read:

The dominant family structure is characterized by formal and informal power structures based on the principles of sex, age and relatedness. The gender division of power is primary, with males, except the very young ones) having power over females. Decisions regarding education, marriage of children, construction of a house, farm work schedules of the household members, hiring farm labourers land allocation and the use of farm inputs are made by the (mostly male) head of the household.
Wives make decisions pertaining to child care, food preparation and household management. Male dominance is paramount, but when asked to define who the ultimate decision maker in family matters is, most husbands express that both wife and husband make decisions jointly.

Obviously, with biogas being a significant investment for the household, whereby a large share of the advantages of the technology benefit women and children in particular, male skewed decision authority is an important potential programme risk.

1.3.2 Integration in farming practice: Biogas will easily find its place in the typical integrated farming set-up of the Ethiopian highlands. Cattle is night stabled, yards allow enough space for placing an installation, vegetable gardens are often adjacent to the yards, distances to the kitchen and the stable can mostly be chosen favourable for biogas.

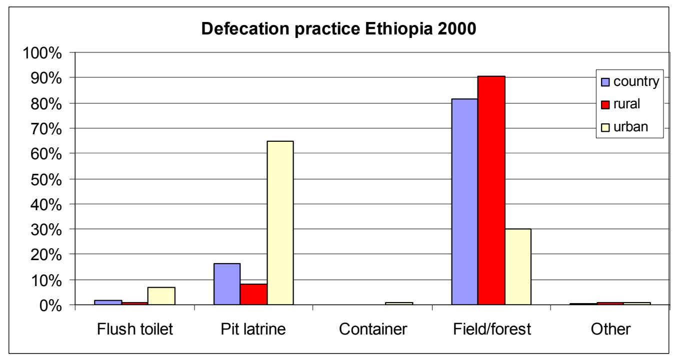
1.3.3 Awareness on benefits: With the low current penetration of the technology, one cannot expect wide awareness of the benefits of biogas. Information and promotion, hence, shall be a significant component in any programme. Biogas benefits, however, are likely to be very appealing for most households; not only in view of the scarcity of energy and fertilizing sources, but also from a workload, health and sanitation point of view.

1.3.4 Toilet connection: The taboos around handling (products of) human faeces seem not as principally imbedded in culture and religion as can be the case in India or Nepal. Advanced sanitation programmes, as for instance the one from Finnida in Amhara, are making good progress.

Latrine promotion

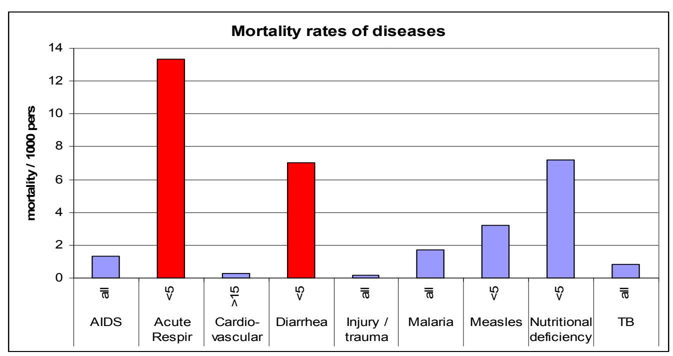
Nevertheless, households are likely to be reluctant to connect their toilet to the biogas plant. Proper information and extension on the advantages and the risks of toilet connection is the key to a successful programme component, as is the provision of a second inlet pipe that allows the connection at a later stage.

Compulsory connection would be ill advised; risking that households avoid using the bio slurry or even the gas. It should be noted that modern sanitation facilities are not quite common place yet in rural Ethiopia.



1.3.5 Health: Biogas installations improve the health situation of families. Most prominently by eliminating indoor air pollution, the main cause of respiratory diseases, and in particular for women and small children who are often close to the cooking fire. Biogas installations further improves the sanitary condition of the farmyard and its direct environment by feeding animal manure directly to the installation and connecting a toilet to the plant respectively.

As such, biogas installations directly contribute to the betterment of the two of Ethiopia's three main diseases in terms of mortality rate.



1.4 Institutional aspects.

1.4.1 Political will: The federal Rural Energy Development and Promotion Centre and the regional Bureaux of Energy are very well aware of the domestic energy issue and its ramifications on rural livelihood, agriculture and environment. These government offices are not only mandated to support and coordinate a larger scale domestic biogas programme, they would probably also be best place in terms of knowledge and skill related to domestic energy. The impression from the interviews is that any biogas programme would find eager supporters in these organizations. The team's impression is, however, that the capacity of these organizations, in terms of operating funds, infrastructure and manpower, may be insufficient to effectively support a larger initiative. Hence, programmes should consider an appropriate capacity building component.

At higher level, particularly regarding the Ministry and Bureaux of Finance and Economic Development (MoFED / BoFED), further study will be required to gauge the willingness to co-finance (directly or "in kind") such a large scale programme. The BoFED officials visited showed a good understanding of the issues around rural development, energy and environment.

Indirectly, through the interviews, it transpired that in political circles of the government the awareness of energy and environment, and hence the concern regarding providing basic energy services to rural poor households, is very limited indeed.

1.4.2 Stakeholders: Potential enthusiastic stakeholders from the Government side could include at central level the REPDC and Bureaux of Energy (and agriculture) at regional level. At national as well as regional level a cooperation agreement with the Ministry / Bureaux of Finance and Economic Development will likely be necessary and helpful.

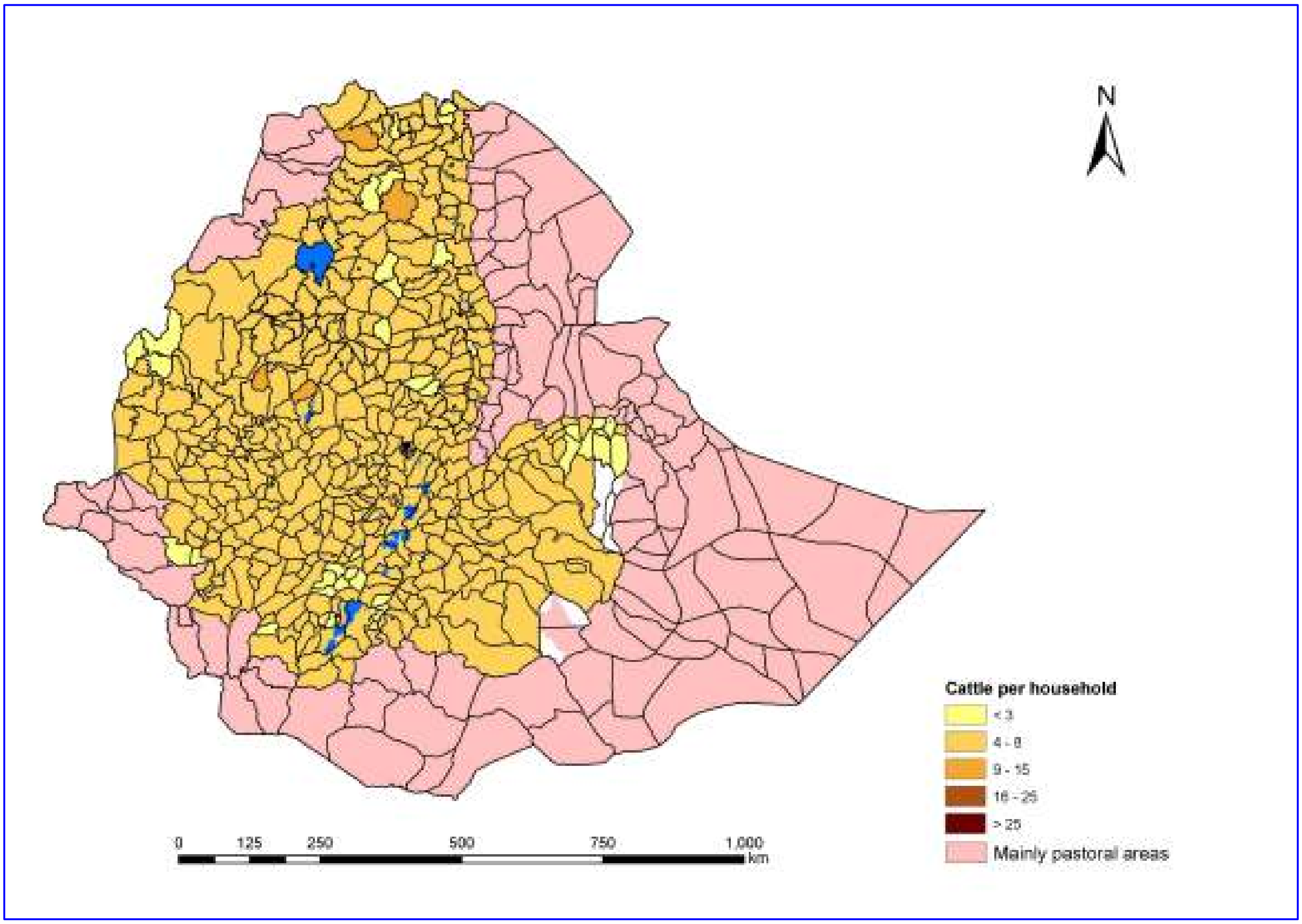
The private sector does not show great presence in rural Ethiopia. For construction and maintenance, any programme would have to invest in establishing (initially small and informal) biogas enterprises. In some areas, linking with Mirte manufacturers or technicians trained for pump and latrine construction (e.g. Finnida) might be a good option.

For starting-up, Selam would be a good partner for manufacturing and marketing of appliances as well as applied research and development. Selam would also –at least initially- be well placed to provide biogas mason and technician training.

UNDP-GEF, and the Netherlands Embassy in Ethiopia should certainly be approached with an eventual programme document; both would look favourably at co-financing such initiatives.

Biogas would add well to SNV-Ethiopia's new BOAM (support to Business Organizations and Access to Markets) initiative, and SNV would be well-placed to channel biogas technical and programme experience from the Asia Biogas Programme to Ethiopia.

2 Livestock population mapping.



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As argued earlier, in view of the cattle stabling customs as well as the poor diet of most cattle in Ethiopia, households should rather have 4 heads of cattle to ensure sufficient available manure (>20 kg / day) to produce a reasonable amount of biogas per day (> $1m^3$ biogas / day). The map indicates that most parts of the studied regions (Amhara, Oromia, SNNPRS and Tigray) have an average cattle population larger than 4 heads per household.

3 Technical potential.

To come to a first estimate on the potential for domestic biogas, the number of households with 4 or more cattle is taken at Woreda level. As substrate, manure of other stabled animals (donkeys, horses) would do equally well. However, avoiding an over-optimistic picture, for the calculation only cattle holding is considered.

The availability of manure as substrate for the installation is not the only technical parameter. Equally important, and much more critical in the Ethiopian context, is the availability of process water. Practically, in view of the considerable amount of water that has to be fed to the installation, the water source should be within 20 to 30 minutes from the farm yard.

3.1 Amhara.

Amhara counts nearly 3.2 million households, out of which 81% keep cattle. Out of these 2.6 million cattle holdings, 39% are keeping 4 or more cattle.

- The country average for proximity to a water source within 20 to 30 minutes is 71%. The high technical potential for domestic biogas in Amhara region thus would amount to approximately **716 thousand installations**.
- In rural Amhara 23% of the population has access to safe drinking water; the low technical potential thus would amount to **232 thousand installations**.

Amhara Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Awi	6346	175494	137552	638868	78%	101	4.6	0	137552	100%
East Gojam	14186	406823	333321	1257843	82%	89	3.8	207136	126185	38%
North Gondar	45486	462119	375422	1931400	81%	42	5.1	85427	289995	77%
North Shewa (K3)	16077	369828	287843	1018055	78%	63	3.5	240700	47143	16%
North Wollo	12702	324963	253403	910492	78%	72	3.6	187463	65940	26%
South Gondar	14607	407519	336299	1181472	83%	81	3.5	300694	35605	11%
South Wollo	17212	553574	441555	1582857	80%	92	3.6	415106	26449	6%
Wag Hemira	8479	80546	61467	355056	76%	42	5.8	0	61467	100%
West Gojam	13413	413888	347974	1399484	84%	104	4.0	129473	218501	63%
Total Amhara	**148509**	**3194754**	**2574836**	**10275527**	**81%**	**69**	**4.0**	**1565999**	**1008837**	**39%**
					Distance to nearest water source <1km					71%
					Rural access to safe water					23%
					Technical potential domestic biogas Amhara region					
							Based on watersource distance			**716274**
							Based on access to safe water			**232033**

3.2 Oromia.

Oromia counts over 4.6 million households, out of which 79% keep cattle. Out of these 3.6 million cattle holdings, 78% are keeping 4 or more cattle.

- The country average for proximity to a water source within 20 to 30 minutes is 71%. The high technical potential for domestic biogas in Oromia region thus would amount to approximately **1.978 million installations**.
- In rural Oromia 23% of the population has access to safe drinking water; the low technical potential thus would amount to **641 thousand installations**.

Oromia Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Arsi	23713	573680	480821	2783892	84%	117	5.8	0	480821	100%
Bale	60805	297018	256654	1614990	86%	27	6.3	0	256654	100%
Borena	70604	321428	227715	1732020	71%	25	7.6	0	227715	100%
East Harerghe	23544	406076	338674	975054	83%	41	2.9	338674	0	0%
East Shewa	13893	353342	264953	1416553	75%	102	5.3	20576	244377	92%
East Wellega	22181	295540	229597	1458188	78%	66	6.4	0	229597	100%
Illubabor	16411	220714	158226	794176	72%	48	5.0	0	158226	100%
Jimma	18486	514489	417041	1805867	81%	98	4.3	148888	268153	64%
North Shewa (K4)	11269	269663	222689	1173542	83%	104	5.3	53721	168968	76%
Oromia Zone	4073	78911	60704	326825	77%	80	5.4	0	60704	100%
West Harerghe	17461	309862	261931	994224	85%	57	3.8	150711	111220	42%
West Shewa	21812	554009	449463	2431375	81%	111	5.4	14667	434796	97%
West Wellega	24316	354436	214316	1034513	60%	43	4.8	68448	145868	68%
Hundene	372	15045	11288	34008	75%	92	3.0	11288	0	0%
Total Oromia	**328939**	**4564213**	**3594072**	**18575227**	**79%**	**56**	**5.2**	**806973**	**2787099**	**78%**
					Distance to nearest water source <1km					71%
					Rural access to safe water					23%
					Technical potential domestic biogas Oromia region					
							Based on watersource distance			**1978840**
							Based on access to safe water			**641033**

3.3 SNNPRS.

SNNPRS counts nearly 2.7 million households, out of which 75% keep cattle. Out of these 2.0 million cattle holdings, 39% are keeping 4 or more cattle.

– The country average for proximity to a water source within 20 to 30 minutes is 71%. The high technical potential for domestic biogas in SNNPRS region thus would amount to approximately **550 thousand installations**.
– In rural SNNPRS 21% of the population has access to safe drinking water; the low technical potential thus would amount to **163 thousand installations**.

SNNPRS Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Amaro Special Woreda	1557	23714	17374	78473	73%	50	4.5	0	17374	100%
Basketo Special Woreda	419	10348	7509	23611	73%	56	3.1	7509	0	0%
Benchi Maji	23159	102783	81521	319902	79%	14	3.9	72986	8535	10%
Burji Special Woreda	1353	7980	6433	32970	81%	24	5.1	0	6433	100%
Dawuro	4380	81637	65541	292664	80%	67	4.5	0	65541	100%
Derashe Special Woreda	1526	23278	12396	66701	53%	44	5.4	0	12396	100%
Gamo Gofa	12153	257901	205707	850291	80%	70	4.1	93563	112144	55%
Gedeo	1356	141168	41506	117356	29%	87	2.8	41506	0	0%
Guraghe	7914	419708	335151	1353983	80%	171	4.0	130601	204550	61%
Hadiya	4026	253305	199648	733814	79%	182	3.7	199648	0	0%
Kaffa	10539	157734	128591	575024	82%	55	4.5	20742	107849	84%
Kembata Alaba Tembaro	2493	193843	144008	472681	74%	190	3.3	144008	0	0%
Konso Special Woreda	2323	36261	22919	103413	63%	45	4.5	0	22919	100%
Konta Special Woreda	2287	17062	13780	52576	81%	23	3.8	13780	0	0%
Shaka	1530	29386	18755	65817	64%	43	3.5	13574	5181	28%
Sidama	6779	528046	404560	1573318	77%	232	3.9	244331	160229	40%
South Omo	23145	91237	60446	1392822	66%	60	23.0	8483	51963	86%
Wolayita	4525	297226	230520	658886	78%	146	2.9	230520	0	0%
Yem Special Woreda	753	16353	13315	51387	81%	68	3.9	13315	0	0%
Total SNNPRS	**112217**	**2688970**	**2009680**	**8815689**	**75%**	**79**	**4.4**	**1234566**	**775114**	**39%**

Distance to nearest water source <1km 71%
Rural access to safe water 21%

Technical potential domestic biogas SNNPRS region
Based on watersource distance **550331**
Based on access to safe water **162774**

3.4 Tigray.

Tigray counts nearly 725 thousand households, out of which 77% keep cattle. Out of these 559 thousand cattle holdings, 44% are keeping 4 or more cattle.

– The country average for proximity to a water source within 20 to 30 minutes is 71%. The <u>high technical potential</u> for domestic biogas in Tigray region thus would amount to approximately **176 thousand installations**.
– In rural Tigray 21% of the population has access to safe drinking water; the <u>low technical potential</u> thus would amount to **65 thousand installations**.

Tigray Zone	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]
Central Tigray	10327	230761	174810	627831	76%	61	3.6	162010	12800	7%
Southern Tigray	9408	183354	136515	631185	74%	67	4.6	46361	90154	66%
Western Tigray	24652	180952	152793	1081963	84%	44	7.1	20264	132529	87%
Eastern Tigray	5795	129897	95216	324150	73%	56	3.4	82341	12875	14%
Total Tigray	**50182**	**724964**	**559334**	**2665129**	**77%**	**53**	**4.8**	**310976**	**248358**	**44%**
					Distance to nearest water source <1km					71%
					Rural access to safe water					26%
										45847
					Technical potential domestic biogas Tigray region					
							Based on watersource distance			**176334**
							Based on access to safe water			**64573**

3.5 Summary technical potential.

In total, the four regions of the study area count together nearly 11.2 million households. 8.7 million households (78%) are keeping cattle. Out of these 8.7 million “cattle holdings”, nearly 5 million (55%) are holding 4 cattle or more.

Country wide, 71% of the rural households live within 20 to 30 minutes walking from a water source. The “high” technical potential for domestic biogas in the 4 regions hence is estimated on some **<u>3.5million households.</u>**

On average, 23% of the households in the four visited regions have access to safe water. The “low” technical potential for domestic biogas in the studied area thus would amount to approximately **<u>1.1 million households.</u>**

Region	Area [km2]	House holds [# of hh]	Cattle holdings [# of ch]	Cattle population [#of heads]	% Cattle holdings [%]	Cattle density [head/km2]	Avg cattle holding / hh [head/hh]	cattle holding <4 [# of ch]	cattle holding >4 [# of ch]	share cattle holding >4 [%]	hh water < 30 min [%]	hh access to safe water [# of ch]	Technical potential <u>HIGH</u> [# of ch]	Technical potential <u>LOW</u> [# of ch]
Amhara	148509	3194754	2574836	10275527	81%	69	4.0	1587506	1110264	43%	71%	23%	788,287	255,361
Oromia	328939	4564213	3594072	18575227	79%	56	5.2	799379	2787099	78%	71%	23%	1,978,840	641,033
SNNPRS	112217	2688970	2009680	8815689	75%	79	4.4	1213824	758760	38%	71%	21%	538,720	159,340
Tigray	50182	724964	559334	2665129	77%	53	4.8	284879	290733	52%	71%	26%	206,420	75,591
Total study area	**639846**	**11172901**	**8737922**	**40331572**	**78%**	**63**	**4.6**	**3885588**	**4946856**	**57%**	**71%**	**23%**	**3,512,268**	**1,131,324**

Report on
the feasibility study of a national programme for domestic biogas in Ethiopia.

Section 4
Design considerations.

Storage jar

1 Lessons learnt.

From the study findings, the following main lessons can be learnt:

1.1 Technical issues.

1.1.1 Domestic biogas installations cannot supply the full domestic energy demand:

- Sedentary farmers may occasionally have reasonably large cattle herds, but the average seams not to exceed the range of 4 to 8 heads per household. Most of these households use fallow land and communal grazing grounds for their cattle during the day, having the cattle on stable during the night only. In addition, the condition of stables is rarely geared towards efficient collection of dung and urine. Hence, the amount of dung available as substrate for the installation seems limited; an average of 20 to 30 kg of dung per day seems a prudent estimate. Gas production, hence, for most potential clients will unlikely exceed 1 to 1.5 m^3 biogas per household per day.
- Domestic energy consumption is typically high. Preparation of daily food – especially injerra baking- is not only energy intensive, but also requires a large amount of energy in a short period of time. The amount of gas that can be stored in domestic biogas installation of simple design is limited –roughly up to about 50% of the daily production.

1.1.2 Non-local materials increase investment costs and maintenance problems:

- To a certain extent, application of "non-local" materials cannot be avoided (e.g. cement, most fitting materials). In view of the investment costs, however, significant savings can be made by constructing in stone rather than bricks.
- Many of the appliances (gas taps, stoves, biogas lamp) could be manufactured locally. This may further reduce the costs, but more importantly will increase the chance that smaller and larger repairs can be made locally as well, reducing the "out-of-operation" time considerably.

Traditional coffee on local biogas stove

1.1.3 In relation with the available dung, most installations are over sized:

See also "1.1.1", the proper digester size for typical rural Ethiopian households would be 4 to 6 m^3 rather than the often observed 8m^3 or larger.

1.1.4 Without proper technical back-up, any plant will fail sooner or later:

- However good the initial construction quality, smaller or larger maintenance and repair requirements will sooner of later hamper proper operation of a biogas installation when proper (locally available and affordable) technical back-up installations is not available.

– Equally important in this respect is the proper maintenance and operation training and instruction for the owning household.

1.2 Operational issues.

1.2.1 Farmers need proper instruction to maximize the benefits from their investment:
Operation of many of the visited installations could improve:

– in drier periods, part of the thinner liquid discharge can be re-used to mix new input;
– cattle sheds and shed floors can be improved to make dung collection easier and more efficient and to accommodate cattle urine collection;
– maintenance instructions (booklet) could assist farmers in simple maintenance and repair (gas hose, gas tap repair, cleaning stoves, draining water from the pipeline etc);
– bio-slurry can be used as catalyser for composting other agricultural waste, thus increasing the amount of organic fertilizer and making it easier to handle.


Floating drum plant, out of operation


Direct bio-slurry application

1.2.2 Biogas installations as a "stand alone" application are likely to fail:
Households that judge their installation only on its capability to substitute conventional cooking fuels are likely to put less effort in keeping their installation in good working order. Other formal (illumination, bio-slurry fertilizer) as well as non-formal advantages (smoke reduction, improving sanitation etc) should be promoted and appreciated as well.

1.2.3 The plant's water requirement shall not be underestimated.
A significant share of the visited installations became non-functional when collecting the daily amount of water proved to be too large a burden for the household. A limit of 20 to 30 minutes to reach the water source, as used in other biogas countries, seems prudent.

1.3 Economic issues.

1.3.1 Investment costs for biogas are prohibitive for farmers:

The costs of the visited installations (ETB 8000 to 15,000) are prohibitive for most farmers. Even with a significant reduction of the investment costs, supporting financing facilities will be necessary.

1.3.2 Full subsidy schemes show disadvantages:

- Nearly all visited installations had had a very large or full subsidy component. In some cases, non-functionality could be attributed to little feeling of ownership of the family, which could be induced by the family not having had to pay for the plant.
- In view of the requirement of the country as a whole, a full subsidy approach would be infeasible from a sourcing point of view.

1.3.3 Micro-finance can play an important role in making domestic biogas affordable:

Most visited biogas installations were constructed in a period when micro-finance facilities were not well developed. However, currently micro-finance institutions increasingly adjust lending conditions in such a way that biogas financing becomes a promising opportunity.

1.4 Dissemination issues.

1.4.1 Cooperation to promote full integration of the technology:

Relevant organizations (Bureau of Energy, Bureau of Agriculture, extension networks, government and non-government organizations active in the fields of water, health and sanitation) could cooperate to stimulate that biogas households make full use of their installation.

1.4.2 "Single actor construction" weakens local technical back-up facility.

- Most of the visited installations were constructed by non-local organizations in a "project" modality. Once the project is executed, the organization typically withdraws from the area, and with them construction and maintenance knowledge and skills.
- More appropriate and sustainable, project organizations should invest in training and support for local construction entities, the private sector, which can continue to provide services after the project is terminated.

1.4.3 Standardization will improve quality.

- Homogeneous design standards both for the installation and the appliances, will make large scale dissemination less complex and improve the quality of the services at large.
- Standardization will better accommodate proper training of users, constructors, extension workers and technicians
- The necessary quality standards will only be really effective when combined with a quality management system that is mandated to monitor service quality and propose and implement adjustments where necessary.

1.5 Policy issues.

1.5.1 EREDPC seems the best placed lead agency for a federal domestic biogas programme:

- Coordination of a federal domestic biogas programme would be within the mandate of the EREPDC. The centre would be willing and able to take-up this role, they have experience and expertise in biomass / biogas.
- Indication is that the policy integration between EREPDC at national level and the Bureaux of Energy at national level will improve.
- The Ministry of Finance and Economic Development would be the prime programme contracting partner, more so when contributing or matching programme resources would be required.

1.5.2 *The Bureaux of Energy would seem the best placed coordinating, supervising and integrating agencies at regional level:*

- The Bureaux of Energy are mandated to support implementation of a large scale biogas programme. Most BoEs have experience in smaller biogas projects and in larger improved cooking stove and metad dissemination projects.
- The Bureaux of Energy showed a good and broad understanding of the local domestic energy issues.
- The Bureaux of Energy do not have their own extension network. In a sectoral approach this may actually be to their advantage; the Bureaux will be “forced” to work together with other actors in the rural domestic energy arena. Important actors include the Bureaux of Agriculture and their extension network at Woreda and Kebele level and (non-) government organizations in the fields of water, health and sanitation.

1.5.3 To ensure effective participation of the national EREDPC and the regional BoEs, a significant organizational / institutional support component should be considered:
Although the organizations are mandated and experienced, both national as well as regional bodies are chronically short of resources of all sorts.

1.5.4 The extension network of the Bureaux of Agriculture would be an asset for a large scale dissemination programme:
The agricultural extension network is rather dense, and under further development. The objective is to have one or two extension workers in each Kebele. This apparatus would offer good opportunities for biogas extension and programme monitoring.

1.5.5 The regional micro-finance institutions can play an important role in a large scale domestic biogas programme:

- The regional micro-finance institutions are developing strongly both in reach and product variety.
- Lending conditions are broadened in such a way that currently biogas financing could (to a large extent) be accommodated.

- Already an important task of the MFIs is the channelling of pensions, money transfers and insurance schemes. Management, administration and channelling of subsidy funds would definitely be within their capabilities.
- In view of their large and increasing network, MFI's can be an important biogas promotion partner.

2 Recommendations.

From the study findings and lessons learnt, the team suggests the following recommendations:

2.1 Sectoral, market oriented approach.

For domestic biogas technology to make a difference in the national energy scenario, dissemination has to be on a large scale (provided, of course, the technology proves appropriate). Such approach has a long-term perspective, in which broad sectoral cooperation is critical (Public Private Partnership). Hence:

- EREDPC and the BoEs as coordinating and supervising organizations;
- Financing activities, both credit as well as subsidy channelling, by participating micro-finance institutions.
- Developing good federal, regional and local networks for promotion and extension;
- Construction, after sales service and manufacturing services by the local private sector;
- ID/OS and capacity building support of all actors, at all levels when and where required.

2.2 Pilot of reasonable size.

In the perspective of a truly large scale programme, a pilot of sufficient size should be considered. For this:

- The pilot areas could include all four visited regions: Amhara, Oromia, SNNPRS and Tigray, as they all give sign of sufficient potential.
- A reasonable pilot size, in view of experience in other countries, could be 10,000 installations over a period of 5 years. This would imply tentatively 2500 installations per region.
- A domestic energy survey should provide detailed information on the (rural) domestic energy situation. Therefore, the programme shouldould start with a domestic energy study in confined areas (Woreda level) to:
    - Identify energy demand and supply characteristics
    - Livestock keeping characteristics and modalities
    - Water availability (and other secondary parameters)
    - Enable a correct assessment and screening for potential biogas clients.

  The National Biogas Programme Office (within the EREDPC) would formulate the Terms of Reference. The regional Bureaux of Energy will implement the survey, with –where necessary- assistance of the national office.
- To allow efficient and effective implementation and supervision, construction should take place in a limited number (say 5) of Woredas per region (resulting in

~ 500 plants per Woreda). Selection of the initial programme areas should follow the finding surveys as mentioned under 2.1.

- Construction should take place in batches of 10 to 20 installations within one smaller area (Kebele, village) to create a good environment for commercialization, financing and extension.
- As a result, the pilot would establish between 500 and 1000 domestic biogas cores.
- The pilot shall provide detailed information and justification for the potential and opportunity for succession.

2.3 Investment costs.

Reduction of plant investment costs seems possible by:

- Proper (smaller) sizing of installations.
- Application of locally available materials (fixed dome constructed in stone instead of bricks).
- Development and introduction of a biogas financing facility.
- Partial investment subsidy.

2.4 Technical aspects.

Quality management will prove a critical success factor in the programme. Therefore:

- Standardize design, construction and manufacturing services for domestic biogas
- Stimulate / support local manufacturing of appliances (taps, stoves, lamps).
- Introduce a quality management system embedded on the sector standards.
- Certify (training of) biogas constructors and technicians.

2.5 Specific recommendations for SNV-Ethiopia.

For SNV-Ethiopia, as initiator of the study, to guide their initiative towards implementation of a biogas programme, the following specific recommendations are suggested:

2.5.1 Decision of SNV-Ethiopia.

Based on the feasibility study, SNV-Ethiopia will have to decide to further pursue (or not) the development of a national biogas programme. In case of a positive decision SNV-Ethiopia may consider allocating one of its staff to properly guide the early preparatory phase.

Outcome step 1 by July 2006.

- SNV formally decides to pursue the development of a biogas programme in Ethiopia. This is reflected in SNV-Ethiopia’s trimester and annual planning.
- SNV allocates the responsibility for the early preparation to one of its staff.

2.5.2 Selection programme partner(s).

Main implementation partner: The report suggests the EREPDC as the most suitable partner at national (federal) level, with the Bureaus of Energy as regional partners. It is recommended that SNV-Ethiopia enters an exploratory trajectory with EREPDC to map mutual interest, opportunities and, when mutually satisfactory, enter into a

Memorandum of Understanding or Letter of Intend regarding the joint development of an Implementation Document for the programme.
Other key partners: In addition, it seems advisable for SNV-Ethiopia to approach other potential key programme partners in an early programme development stage. Most prominently on the list would be:

– The Royal Netherlands Embassy: The impression is that the Embassy may support a biogas programme. Such programme fits well in the current policy framework of the ministry. Early involvement of the embassy may properly prepare the system.
– UNDP-GEF: UNDP indicated that a biogas programme would fit well within their GEF policy framework. GEF co-financing, hence, is an opportunity.
– UNICEF-WASH: Not tested during the survey, but it seems that cooperation between the UNICEF-WASH programme and a biogas programme could be an opportunity. SNV-Ethiopia could further explore this option.

Outcome step 2 by August 2006:

– MoU / LoI signed with main implementing partner (probably EREDPC) on the joint development of the implementation plant for the programme.
– Possibly LoIs signed with other key partners on their involvement in the future programme.

2.5.3 Recruitment and selection SNV Senior Technical Advisor.

It will be important for SNV-Ethiopia to timely have in-house expertise available to initiate, stimulate and guide the preparation and implementation process proper. A draft profile sketch is attached to this report for this purpose (annex 6).

Outcome step 3 by September 2006:

– Formal profile sketch, core competencies and terms of reference (first 6 months) for the Senior Technical Advisor developed by SNV-Ethiopia.
– Recruitment and selection procedure started.
– Senior Technical Consultant contracted.

2.5.4 Development of the Programme Implementation Document.

Jointly with the main programme partner, (the Senior Technical Advisor of) SNV-Ethiopia will develop the implementation plan. In addition to the detailed description of the planned implementation, the following issues will be dealt with during this period:

– Development of PDF-A application for the GEF
– Further stake-holder analysis.
– In depth institutional / organizational assessment of main (potential) programme partners.
– More detailed information on “disposable income” of farmers
– Mapping of opportunities for investment-credit facilities
– Mapping of opportunities for financial management and fund channelling.

Outcome step 4 by January 2007:

– Programme Implementation Document (PID) developed.

– Brief reports on “issues” submitted and duly integrated in the PID.
– PID submitted to (potential) donors.
– Memorandum of Agreement signed between the main implementation partner and SNV in the implementation (5year) of the programme.

2.5.5 Assistance from SNV HQ / Biogas Practice Team.

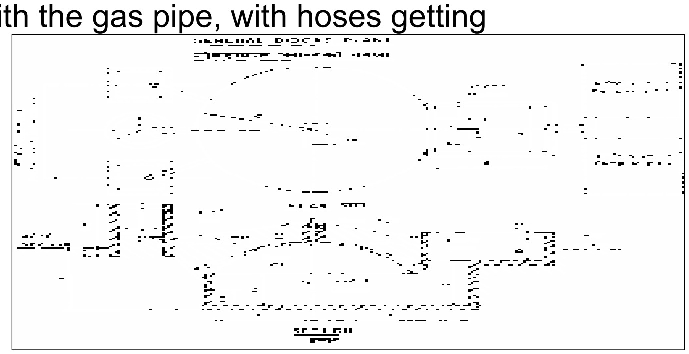
SNV Head quarters, more in particular the Biogas Proactice Team will assist SNV-Ethiopia where necessary, but more in particular with:
– Drafting the profile sketch (see annex 6) and competency table for the Senior Technical Advisor.
– Selection and recruitment of the advisors
– Technical consultancy and backstopping in the preparation and formulation of the implementation plan.

3 Some particular considerations.

3.1 Installation design

Also in view of the study findings, the main criteria for domestic biogas plant designs for rural Ethiopia would include:
– robustness in construction and operation;
– opportunity to accommodate a high share of local materials, and-to a lesser extent;
– correct sizing and;
– low cost.

The construction of a *floating drum installation* is straight forward, with little chance of error. And for the owner, with the drum clearly indicating the amount of gas available, the set-up is understandable. However, although some of the visited floating drum installation showed admirable endurance, its intrinsic setbacks like: low gas pressure (especially for lamps and longer pipelines but also for discharge of more viscose –more dry- slurry); cumbersome connection of dome with the gas pipe, with hoses getting brittle easily; the expensive construction and transport of the steel dome, would not make it the design of choice for Ethiopia.



The *fixed dome design* would be able of a significantly higher gas pressure and would by its nature not have the costs for a steel drum or its connection problem. On the other hand, fixed dome plants would need a higher level of on-site workmanship, and are less forgiving for construction mistakes. Especially gas-tightening the dome has, depending on the design, proven to be critical. Moreover, where fixed dome installations are constructed in bricks and these bricks have to be trucked–in, a large part of the investment advantage will be lost.

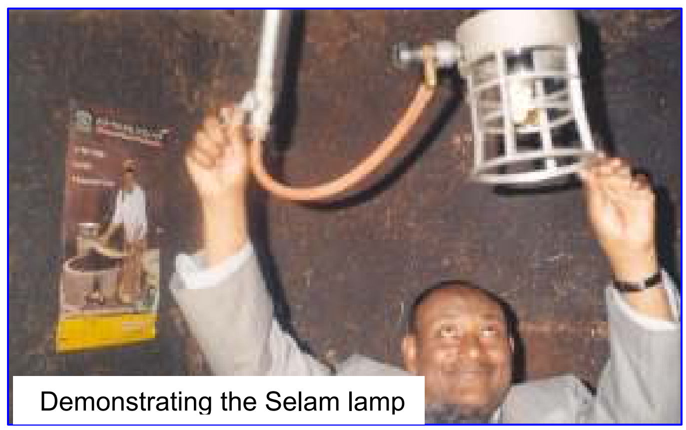
As the experience with domestic biogas did not establish a vested construction custom in Ethiopia yet, the study team proposes to introduce the (modified) fixed dome design that has been used in Nepal successfully for many years[22].

Its design is extremely robust, both in construction as well as operation, allows using stones as well as bricks for the construction of the round wall, and requires of all fixed dome designs probably the lowest level of craftsmanship. In addition, as the design has been used intensively over a long period of time, construction and after sales service standards and a variety of training material will be readily available.

3.2 Appliances.

Based on the appliances observed during the household visits, significant improvement can be made:

- Selam is developing (currently pilot stage) a promising biogas lamp. If the expectations are met, this would be an excellent alternative for the current (copies of) Indian biogas lamps. Alternatively, the Biogas Partnership Nepal developed a reliable biogas lamp that could be manufactured in Ethiopia as well
- Many of the observed biogas stoves would leave room for improvement. SNV has experience with locally manufactured stoves (Nepal, Cambodia and to a lesser extent Vietnam) that seem appropriate for the Ethiopian market, and could be manufactured locally in small batches.
- The quality of the observed gas taps was not always convincing. SNV has experience with simple, robust designs that can be manufactured locally in small batches



Demonstrating the Selam lamp

Cambodian biogas stove

[22] A brief version of the construction manual for this model installation is provided as annex 3

3.3 Plant size.

In general, the installations visited during the study seemed over-sized in relation with the amount of manure available. With most livestock roaming on (common) grazing lands during the day and many of the cattle being “at the skinny side of healthy”, the amount of available dung of one head of cattle will likely be in the range of 5 to 6 kilo per day.

For a biogas installation to become interesting for the family, it would have to be able to produce at least around 1 m^3 biogas per day. This would require –say- 20 to 30 kg manure being fed to the installation every day. Hence, a family would need at least the manure of a herd of 4 to 5 cattle. For such “typical” biogas household, a correctly sized installation would have a digester volume of $4m^3$.

The table below provides the relation between digester-size, feeding, water requirement, cattle holding and gas production, where it should be noted that actual sizing shall depend on weighing the actual amount of available dung over a longer period (one week) rather than on the number of cattle. The impression of the mission is that for typical households, digester sizes of 4 or 6 m^3 will suffice.

		4 m^3 digester		6 m^3 digester		8 m^3 digester		10 m^3 digester	
		min	max	min	max	min	max	min	max
Feeding	[kg dung/day]	24	36	36	48	48	60	60	90
Water requirement	[ltr water/day]	24	36	36	48	48	60	60	90
Cattle (night stabling only)	[heads]	4	6	6	8	8	10	10	15
Gas production	[m3/day]	0.84	1.26	1.26	1.68	1.68	2.1	2.1	3.15

3.4 Investment costs

Based on the considerations of 3.1 to 3.3, investment costs of domestic biogas installations –particularly when constructed in stone, could be reduced. Although a small “zero-series” in rural areas shall prove the point, it seems that construction 4 and 6 m3 installations in rural areas under ETB 5,000 would be possible.

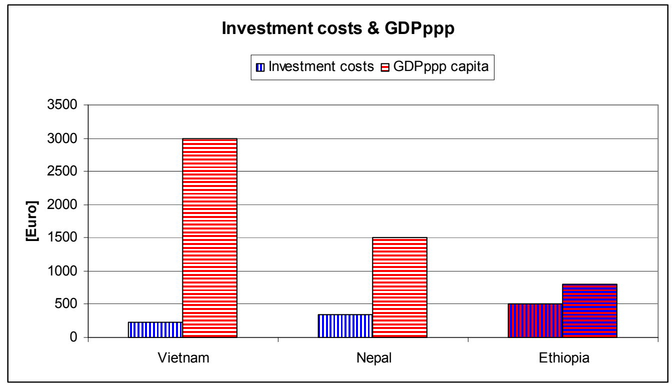
Below the Bill of Quantities for the GGC 2047 model biogas plant constructed in stone. The similar design in bricks would be approximately 50% more expensive.

Investment costs GGC 2047 biogas plant for Ethiopia *for construction in stone* *[ETB]*

			4 m^3 digester			6 m^3 digester			8 m^3 digester			10 m^3 digester		
		unit	qty	costs	total	qty	costs	total	qty	costs	total	qty	costs	total
1	**Contribution farmer in kind**													
1.1	Unskilled labour	[person days]	20	300.00		25	375.00		30	450.00		35	525.00	
1.2	Sand	[bags]	60	300.00		70	350.00		80	400.00		90	450.00	
1.3	Gravel	[bags]	30	120.00		35	140.00		40	160.00		50	200.00	
1	Total farmer contribiution				**720.00**			**865.00**			**1,010.00**			**1,175.00**
2	**Supplied materials**													
2.1	Cement	[bags]	12	720.00		14	840.00		18	1,080.00		21	1,260.00	
2.2	Stone, cut	[m^3]	4	200.00		5	250.00		6	300.00		7	350.00	
2.3	Reinforcement rod	[kg]	11	110.00		11	110.00		14	140.00		14	140.00	
2.4	Fitting material	[set price]		605.00			605.00			753.00			753.00	
2.5	Appliances	[set price]		600.00			600.00			900.00			1,200.00	
2	Total materials				**2,235.00**			**2,405.00**			**3,173.00**			**3,703.00**
3	**Technical services**													
3.1	Skilled labour	[person days]	2	90.00		2	90.00		2	90.00		2	90.00	
3.2	Semi skilled labour	[person days]	8	360.00		8	360.00		11	495.00		11	495.00	
3.3	Annual maintenance fee	[fee per visit]	4	180.00		4	180.00		4	180.00		4	180.00	
3	Total services				**630.00**			**630.00**			**765.00**			**765.00**
4	**Company fee**													
4.1	Overhead	[person days]	1	45.00		1	45.00		1	45.00		1	45.00	
4.2	Risk coverage	[share of 2]	5%	111.75		5%	120.25		5%	158.65		5%	185.15	
4.3	Company profit	[share of 2+3]	20%	573.00		20%	607.00		20%	787.60		20%	893.60	
4	Total company fee				**729.75**			**772.25**			**991.25**			**1,123.75**
5	**Programme fee**													
5.1	QC contribution fee	[fee per visit]	2	50.00		2	50.00		2	50.00		2	50.00	
5.2	Participation fee	[lump sum]		50.00			50.00			50.00			50.00	
5	Total programme fee				**100.00**			**100.00**			**100.00**			**100.00**
	Total investment				**4,414.75**			**4,772.25**			**6,039.25**			**6,866.75**

3.5 Costs & benefits of domestic biogas.

Despite –possibly- the opportunity to reduce the investment costs for a domestic installation, the initial costs are still (very) high, both in relative as well as absolute terms.



The high investment costs of biogas plants in Ethiopia seem to be (at least partially) off-set by the high biogas substitution value (see Section 3, chapter 1.2.5)

3.5.1 The tangibility of benefits.

The benefits of domestic biogas are divided over multiple levels (micro, meso and macro) of society and are differing in the extent to which they can be translated in direct economic gain (formal versus informal[23]). As indicated in the tangibility matrix, although the farmer is expected to pay for the (lion share of) the installation, the household will only reap a small part of its benefits, and an even smaller part that could actually assist in repaying the investment (micro, formal).

Biogas benefit-tangibility matrix		
	Informal	**Formal**
Micro	– Reduced indoor smoke-induced illnesses. – Reduced poor-sanitation induced illnesses. – Reduced drudgery from fuelwood collection. – Reduced pressure for illegal forest encroachment. – Reduction drudgery from weeding fields. – Reduced workload for food-preparation. – Reduced soil erosion / degradation. – Improved opportunity for education.	– Increased efficient productivity. – Reduced direct medical costs. – Reduced expenses on conventional energy sources. – Reduced chemical fertilizer expenditures. – Increased opportunity for (small-scale) organic agriculture. – Improved agricultural yields. – Increased family income.
Meso	– Reduced risk of erosion and landslides in mountainous areas. – Improved forest quality and quantity. – Reduced pollution of the environment as a result of uncontrolled dumping of animal waste.	– Increased employment and income generating opportunities. – Opportunity to develop markets for (organic) agricultural produce.
Macro	– Reduction of illness-induced production losses. – Improved biodiversity. – Increased non-marketable (NT)FP availability. – Increased efficient productivity. – Reduced mortality. – Improved human resource base. – Reduced risks as result of global warming.	– Reduced (forex) cost on medication. – Reduced health system expenses. – Reduced (forex) costs on chemical fertilizer. – Reduced (forex) costs on fossil fuels. – Increased availability marketable (NT)FP. – Increased agricultural production. – Increased tax revenues. – Generating CDM revenues.

Clearly, cost – benefit considerations depend heavily on the perspective taken.

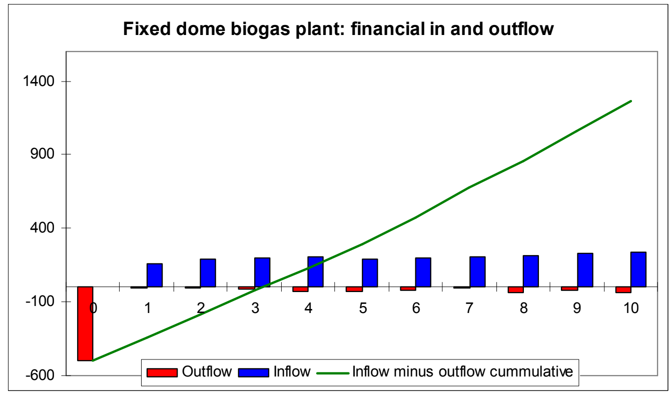
[23] As mentioned, "formal benefits" can be translated directly in economic gain; one can attribute a price to it. For "Informal benefits" this tends to be more complicated and indirect, and they tend to refer more to benefits in the social and environmental domain. This is not to say that formal benefits should be valued higher, rather that the economic system often poorly allows to value social and environmental benefits properly.

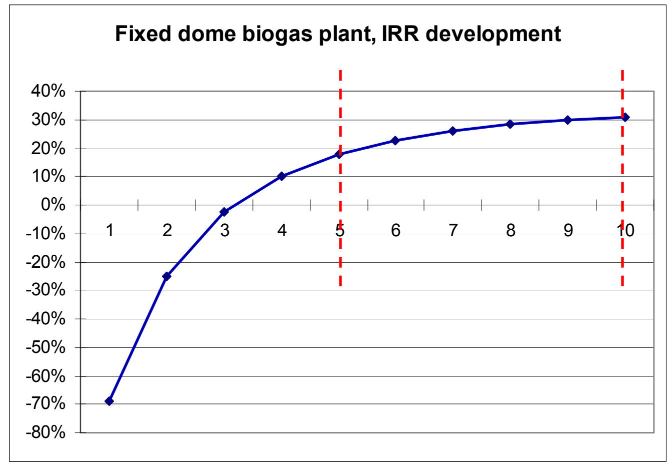
3.5.2 Cost - benefits, the micro view.

At micro level and particularly at the shorter term, the main –if not the only- benefit of a biogas plant that assists the farmer to repay its investment is the direct savings in conventional domestic fuel. Assuming:

- the average biogas production at 1 m^3 per plant per day;
- the biogas substitution value at € 0.35 per m^3 (financial value, see Section 3, chapter 1.2.5)
- the investment at € 500 per plant, while including maintenance costs,

a household would look at a simple pay-back period of about 2.5 years.



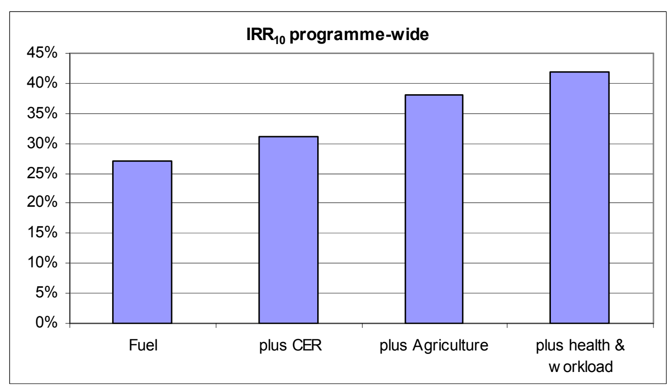


The (financial) return on their investment would be 18% in a 5 year perspective and 31% in a 10 year perspective.

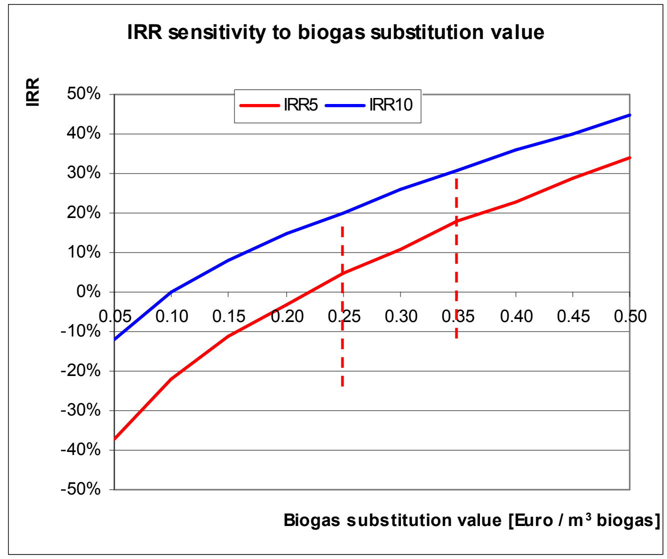
3.5.3 Cost – benefits, the macro view.

For a cost-benefit calculation at macro level, revenue as a result of reducing greenhouse gas emissions, higher profits in the agricultural sector (reduction of chemical fertilizer, increasing yield) and improvement of health and sanitation conditions can be included.

For most of these items, the study team does not have a detailed quantification of those benefits for the rural situation in Ethiopia. The graph, hence, is based on very rough estimates, and is only presented to underline that at macro level large scale dissemination programmes have significant economic merit.



3.6 Subsidy

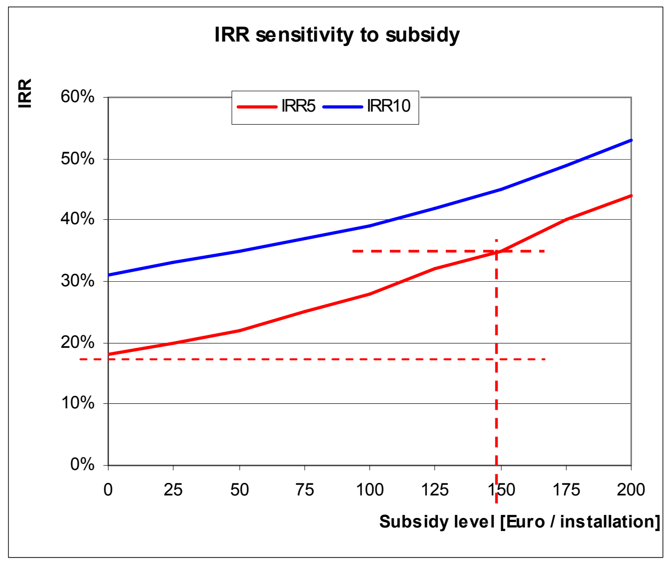


Although investment in a domestic biogas installation appears to be modestly economically feasible, in practice the return is highly sensitive to the actual replacement value. This value depends to a large extend to how the household acquires domestic energy. In the five year perspective, a drop in the real value of only € 0.10 would bring the IRR already under the lending rate.

Because the investment is so sensitive to the biogas substitution value, and in view of:

- the high investment costs in relation with the per capita GDPppp of the country;
- the significant gap between financial and economic biogas substitution values;
- the significant gap between the internal rate of return at micro and macro level,

an investment subsidy component seems justified.



Based on earlier investment assumptions, an investment subsidy of € 150 would improve the IRR in a 5 year perspective with 17%.

The FIRR and EIRR would be important parameters to establish / justify the subsidy level. In addition, the extent to which households can be offered a biogas loan under appropriate conditions (maturity, grace period, interest rate), as well as other dissemination barriers, would be an important consideration.

These barriers include:

- limited rural awareness on biogas benefits, in particular in relation with environment and agriculture;
- limited rural availability of technical services in general and biogas / energy services in particular;
- limited concentration of farm(er)s in villages and the related high costs for promotion and dissemination of innovative technologies
- the large extent to which the rural economy in general and domestic energy in particular is still in the informal domain.

The subsidy is proposed to be independent from the installation size. Larger installations typically would belong to farmers with more cattle. These farmers can be expected to contribute more to the investment than smaller farmers. Besides the equity perspective, also from a technical and economic perspective a flat-rate subsidy would be preferable: a flat-rate subsidy amount will stimulate plants being properly sized (not too large in relation to the amount of dung available); this will improve the economics of the plant as well as the technical functioning.

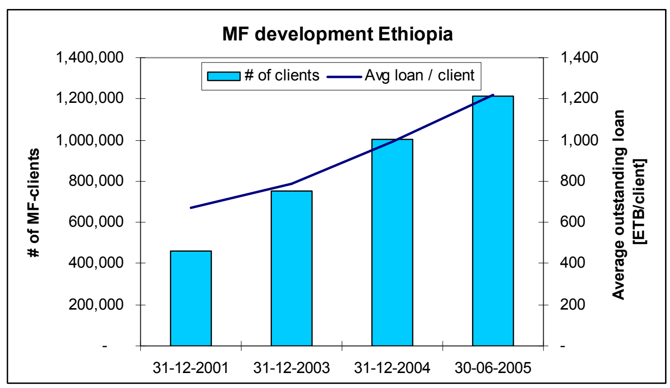
A flat-rate subsidy of ETB 1,500 seems justified. In absence of a transparent poverty stratification system at household or kebele level, properly administrating a poverty targeted subsidy will get too complicated.

3.7 Credit.

Credit and savings organizations in Ethiopia seem to develop rapidly; the Association of Ethiopian Micro Finance Institutions (AEMFI) counted 26 member organizations.

MFIs are regulated by the Ethiopian Development Bank; out of 26 organizations, 16 received a loan at least twice. Funding is sourced by donor grants, equity, savings-mobilization and borrowing from commercial banks. Fund–availability at the banks may not be a first issue.

Over the 3 ½ year period between Decembers 2001and June 2005, their number of clients tripled and the outstanding loan quadrupled. By June 2005, the MFI's had over 1.2 million loan clients among them (ranging from ~ 1600 to 126000 clients), with a total outstanding loan portfolio of nearly ETB 1.5 billion. The average outstanding loan per client then reached ETB 1,220.



According to AEMFI, their typical clients would be poor rural households, taking on average a loan of ETB 2000, with 80% of the loans under ETB 5,000. Loans are taken to finance agricultural input, establishment of small businesses and consumption.

Loan repayment is good, member organizations calculate with 6% non-repayment risk. Repayment schedules can vary between every two weeks to monthly, or even annual. Loans are provided as group loans, repayment is arranged by "peer-pressure". Collateral will be required for loans larger than ETB 5,000.

Interest rates are established by the member – MFI's themselves, and range from 9 to 24% per annum. Maturity of loans varies from under one year for smaller loans up to 5 years for loans over ETB 5,000. About 40% of the loan is covered by savings, down from 75% in 2001.

The visited regional credit organizations (Amhara, Tigray, Oromia) acted "carefully positive" on the prospect of extending biogas loans. As biogas is relatively unknown, and does not provide direct income (rather savings that are not always easily monetized) they indicated they may want some sort of an additional guarantee.

Against this institutional back-drop, biogas credit seems a realistic option, although participating Saving and Credit organizations may need safeguards to protect their loans. To provide a first indication the effect of a loan on a biogas investment was calculated with:

– a subsidy amount of ETB 1,500;
– an interest rate of 12% per annum;
– a loan maturity of 5 years.

Financing scheme for biogas plant type GGC 2047 built in stone	4m^3			6m^3		
Farmer contribution	720.00			865.00		
Supplied materials	2,235.00			2,405.00		
Technical services	630.00			630.00		
Company fee	729.75			772.25		
Programme fee	100.00			100.00		
Total investment			**4,414.75**			**4,772.25**
Own contribution	720.00			865.00		
Subsidy	1,500.00			1,500.00		
Remaining investment			**2,194.75**			**2,407.25**
Annual repayment	**608.85**	[ETB/annum]		**667.79**	[ETB/annum]	
Monthly repayment	**50.74**	[ETB/month]		**55.65**	[ETB/month]	
Financing costs	849.48	[ETB]		931.72	[ETB]	

The table provides the result for a 4 and 6 m^3 installation built in stone. Monthly costs of a biogas plant would be ETB 51 to 56[24]. Assuming that the installation would replace fuelwood only, and further assuming:

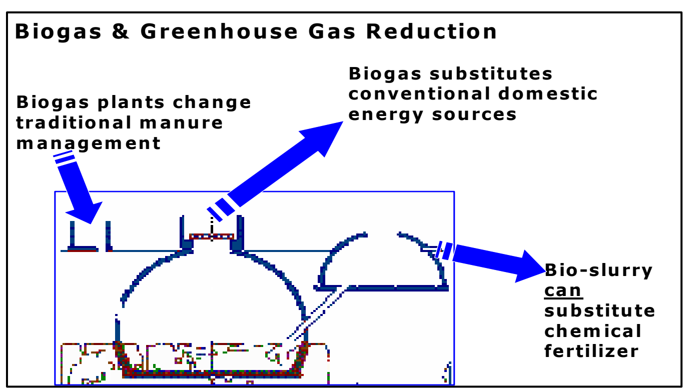
– an average installation producing 1 m^3 biogas per day;
– a substitution ration of 5 kg fuelwood per cubic meter biogas, and;
– a fuel price of ETB 0.75 per kg of fuelwood,

the monthly savings of ETB 112.50 would easily repay the loan.

According to the experts of the EREPDC, a biogas credit scheme with repayments up to ETB 1,000 per year would be feasible for farmers with cash crops.

3.8 Biogas and the Clean Development Mechanism.

The fermentation of animal dung in domestic biogas digesters, and the subsequent application of biogas and bio-slurry, contributes to the global reduction of greenhouse gasses (GHG). As such, the programme will qualify for the Clean Development Mechanism (CDM) of the UNFCCC.



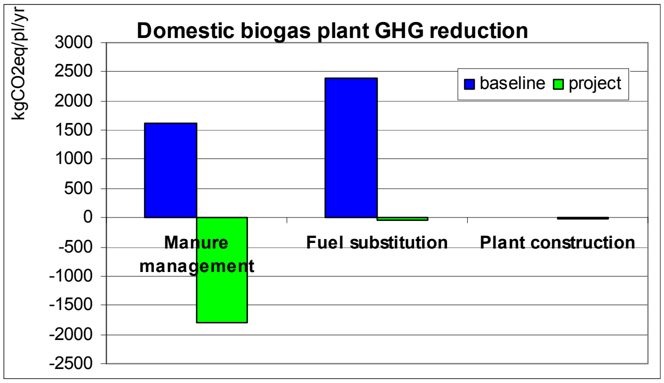
In principle, applying domestic biogas could reduce GHG emissions in three ways:

– Substitution of conventional domestic energy sources,
– Modification of the traditional manure management practice; and;
– Substitution of chemical fertilizer.

[24] "Financing costs" represent the total of the interest costs over the repayment period,

In Ethiopia, however:

– cattle is largely free grazing and storage of dung under (semi) anaerobic conditions is not customary, and;
– application of chemical fertilizer is hardly practiced, and in addition substitution of chemical fertilizer by bio-slurry will be complicated to monitor.

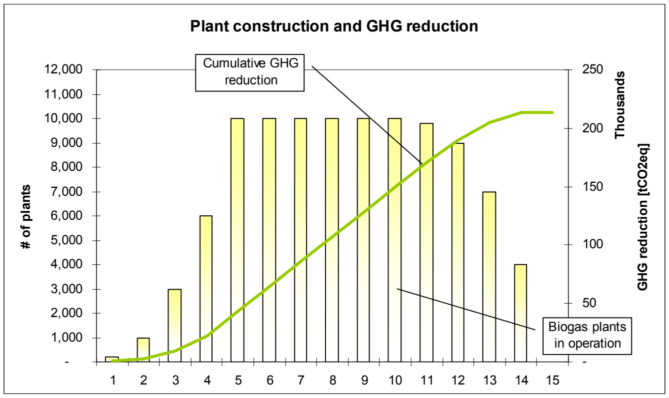


Hence, the main feasible source of GHG reduction would be the substitution of conventional energy sources. In the case of most households, this thus would mean substitution of the non-renewable share of fuelwood would be the main source of greenhouse gas reduction.

The graph provides the preliminary calculated results of GHG reduction for a typical Ethiopian biogas household. GHG reduction would tentatively be in the range of 2 tons CO_2 equivalents per installation per year.

Regarding these preliminary calculations of greenhouse gas emission reduction, little additional explanation is due.

– The GHG reduction is based on substitution of fuelwood, assuming a non-renewable biomass share of 50%.
– The presented reduction only takes into account the 5 year project period. In reality a first crediting period would be 7 or 10 years, potentially increasing the GHG reduction to over 200,000 tCO_2 equivalents.



The potential value of the GHG reduction in a Clean Development Mechanism is significant. However:

– The substitution of non-renewable biomass is allowed for in small scale methodology, but seems not yet fully undisputed;
– Carbon credits are awarded only after verification of proper performance. On a smaller scale, financial benefits may not live up to expectations.
– Preparation and monitoring costs and efforts are considerable

Therefore, one would be well advised to carefully weigh costs and benefits of developing the programme into a CDM project. Rather, the programme shall from the start ensure CDM compatibility, especially regarding quality management and monitoring and evaluation but embark up on CDM registration only once the programme itself is properly established.

Report on
the feasibility study of a national programme for domestic biogas in Ethiopia.

Section 5
Outline of the Ethiopia Biogas Programme.

1 Main features.

The Ethiopia Biogas Programme as proposed hereunder intends to lay out a robust foundation for the establishment of a commercially viable domestic biogas sector. Salient features of the programme would include:

Standardization of domestic biogas design, construction and after sales service.
The programme will produce concise manuals for appropriate installations and appliances, including manuals for construction, manufacturing and after sales service and the formulation of the related quality standards.

Introduction of a quality management system.
Precise control of the quality of construction, after sales and extension services will not only safeguard the investment of the farmer and enable the farmer to maximize the benefits of the investment. I will also level the playing field for aspiring biogas companies to operate on the emerging market. The quality management system will be compatible with quality assurance certification and CDM registration in a later stage.

Financing.
The programme proposes a flat rate subsidy scheme for participating farmers, reducing the initial investment with ~ 25%. In addition, and key to the long term success, the programme will support an investment credit facility in cooperation with existing micro-finance institutions.

Training
The programme will invest significantly in training. On the supply side of the market, to ensure that necessary dissemination skills are as much as possible available locally. And on the demand side, to make sure households understand the operation and maintenance of their plants sufficiently and families apply biogas and bio-slurry to their maximum advantage.

Study
The programme aims to study and document rural domestic energy practices in general and biogas user experiences in particular. The study results will be used to direct the programme and -on the medium term- to justify and direct continuation of a domestic biogas programme in Ethiopia.

Sectoral approach.
The programme will strongly promote an approach in which Government, non-government and private sector organizations, in a complementary fashion assume those programme functions that intrinsically fit to the character of their organization.

Institutional / organizational strengthening.
The programme intnds to invest heavily on developing the necessary indigenous organizational and institutional capacity within the biogas (sub) sector.

2 Goal and purpose.

The goal of the project is **to improve the livelihoods and quality of life of rural farmers in Ethiopia through exploiting the market and non-market benefits of domestic biogas**. By the end of the project:

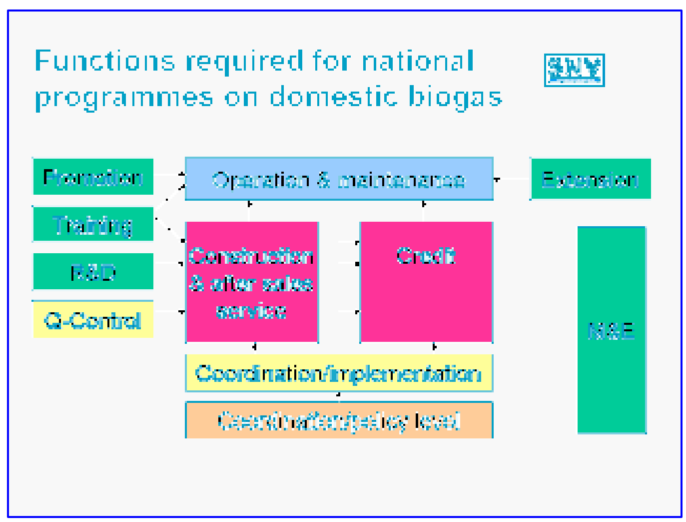
- 10,000 new biogas plants will be built nationwide;
- 95% of all new biogas plants will be connected to indoor cooking facilities;
- 80% of all new biogas plants have a double slurry pit[25] and;
- 50% of all new biogas plants will have toilets attached[26];

The purpose of the project is **to develop a commercially viable domestic biogas sector**. Therefore:

- At least 1 Biogas Construction Team is established in each Kebele in which the programme supports activities;
- New biogas plants are constructed in clusters of 50 to 100 installations per Kebele of 5 Woredas in 4 regions. As a result, communities in at least 150 Kebeles have access to the services of Biogas Construction Team;
- All plant owners have access to credit for biogas construction and 60% of biogas owners utilise it by the end of the project[27];
- A national vocational training institute will be identified that will act and biogas training and reference institute.

3 Programme components.

The focus of the programme shall be the biogas sector as a whole. Sector development implies the close cooperation of all relevant stakeholders (Government, Non-Government and private sector) in the sector at all levels (micro and macro). The chart indicates the main functions in a large-scale domestic biogas programme and its relations.



[25] For the proper application of bio-slurry as organic fertilizer, collection of the slurry would be a prime requirement. Double slurry pits enable to collect slurry, mix it with other organic material, and leave it for curing for a short period.

[26] It is acknowledged that 50% toilet connection in Ethiopia's context is a tall order. However, in view of the poor state of sanitation in rural areas in its health consequences, the programme should be committed to invest significantly in proper promotion. Technically, the programme will assure that all installations are equipped with a second inlet pipe to ensure attachment of a toilet at a later stage.

[27] The assumption is that at the end of the programme 60% of the installations (6000 plants) are constructed with credit assistance. This credit share will increase from 30% during the first year to 70% in the last programme year.

To support the project's purpose, objectives for each of the programme components have been formulated.

CN	Component	Objective
1	Promotion & marketing	To stimulate demand, informing beneficiaries and stakeholders on the benefits and costs of domestic biogas.
2	Financing	To lower the financial threshold and improve access to credit and repayment assistance, to facilitate easier access to domestic biogas for all potential clients, with particular emphasis on the poor, women and other disadvantaged groups.
3	Construction and After Sales Service	To facilitate the construction of 10000 domestic biogas plants and ensure their continued operation.
4	Quality Management	To maximise the effectiveness of the investment made by the biogas owners and to maintain consumer confidence in domestic biogas technology.
5	Training	To provide the skills for business people to run biogas SMEs and for biogas users to be able to operate their plants effectively
6	Extension	To provide the information to allow biogas users to effectively exploit all the benefits of biogas
7	Institutional Support	To maximise the ability of key biogas related institutions to provide the services and support required by the biogas sector to facilitate access to domestic biogas and the development of quality biogas products.
8	Monitoring and Evaluation	To identify project progress and impact on stakeholders/other aspects in order to facilitate knowledge transfer.
9	Research and Development	To increase knowledge about domestic biogas issues to maximise effectiveness, quality and service delivery of the biogas programme.
10	Programme management (National / Regional)	To support, coordinate and supervise the activities driving the development of a commercially viable biogas sector.

4 Expected results.

The table shows some of the main expected results. The detailed overview is provided in annex 5. Clearly, besides the environmental and energy aspects of domestic biogas, significant results can be expected in the socio-economic field and in training.

EBP expected results		
Biogas plant construction	**10,000**	[plants]
Energy		
Energy production	**197,960**	[GJ]
Power installed	**33,330**	[kW]
Environment		
GHG emission reduction	**40,400**	[t CO_2eq]
Fuel substitution		
Biomass	**59,166**	[t biomass]
Kerosene	**61**	[t]
Socio-economic		
Persons reached	**60,000**	[persons]
Workload reduction (women & children)	**2,020**	[pers years]
Exposure to indoor air pollution reduced	**30,000**	[women & children]
Toilets attached	**5,000**	[toilets]
Productive slurry use	**8,000**	[households]
Employment generation (direct)	**700**	[person years]
Training		
User training	**14,000**	[person days]
Professional training	**2,741**	[person days]

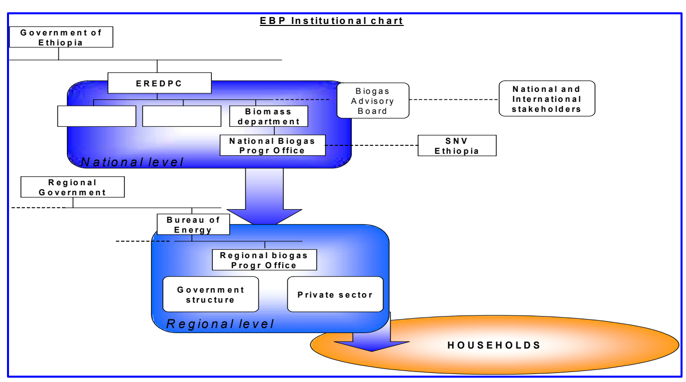
5 Actors & activities.

The contracting partners for the potential programme at the highest level would be the Ministry of Finance and Economic Development (MoFED) and the donor organizations. At regional level, contracting would be done with the Bureaux of Finance and Economic Development (BoFED).

Actor - activity	**Promotion & marketing**	**Investment financing**	**Constructio n and A.S.S**	**Quality Managemen t**	**Training**	**Extension**	**Institutional Support**	**Monitoring & Evaluation**	**Research & Developmen t**	**Programme Managemen t**
EREPDC		● (red)		● (red)		● (red)	● (red)	● (red)		● (red)
NBPO	● (red)	● (green)	● (green)	● (blue)	● (red)	● (green)	● (blue)	● (blue)	● (red)	● (blue)
Bureaux of Energy	● (green)	● (green)		● (green)		● (green)				
RBPO	● (blue)		● (green)	● (blue)	● (green)	● (green)	● (green)	● (green)		● (blue)
Bureaux of Agriculture	● (green)					● (blue)				
Kebele ext workers	● (green)	● (green)		● (green)		● (green)				
Regional MFIs	● (green)	● (blue)								
Biogas constr. teams	● (blue)		● (red)							
Selam VTC				● (green)	● (blue)				● (green)	

● (red) Initiating, primary responsible
● (blue) Executing
● (green) Assisting, supporting

The **Biogas Advisory Board** will accommodate representatives of all major programme stakeholders. The Board ensures the programme strategy matches relevant governmental policy (environment, rural development, energy) and facilitates a conducive and cooperative programme environment.



The Board advises / comments on (draft) programme guidelines, annual plans and reports and management response to programme audits and external evaluations.

The **Ethiopian Rural Energy Promotion and Development Centre** will take overall coordination and supervision responsibility. The Centre will be responsible to develop a productive rural energy network at national and regional level. The EREPDC ensures proper cooperation with regional level partners and tunes the (national) programme strategy with its other rural energy activities and similar activities of other actors.

The **National Biogas Programme Office** established within the EREPDC (possibly within the biomass department), will take operational responsibility. The NBPO will develop construction and after sales service manuals; develop corresponding quality standards and quality control procedures and training courses; implement quality control and conduct training. The NBPO will prepare annual and semi annual plans and reports.

Selam Technical and Vocational Centre will, together with the NBPO, implement the main training components of the programme. To that extent, STVC will provide training at “Technician” level, for staff of the BoEs and the RBPOs and training at “Construction” level, for the rural Biogas Construction Teams.

The **Bureaux of Energy** will have regional coordination and supervision responsibility. The Bureaux will develop a productive rural energy network at regional, woreda and kebele level. The BoE ensures proper cooperation with woreda and kebele level programme partners (Bureaux of Agriculture network, NGOs) and tunes the (regional) programme with its other rural energy activities and similar activities of other actors.

The **Regional Biogas Programme Offices**, established within the Bureaux of Energy, will take operational responsibility at regional level. The RBPOs will implement quality control, extension and training activities. The Offices will prepare regional annual plans and reports.

Biogas Construction Teams, “proto-” private biogas construction companies will be established under the programme, initially in each woreda of operation 5 to 10 teams. The BCTs, after training and certification, will be responsible for marketing, construction and after sales service of domestic biogas installations.

6 Activity schedule and budget outline.

Detailed activity schedules and budgets will be prepared on an annual basis by the NBPO, and proposed for advice to the Biogas Advisory Board. This outline suggests the boundaries of activities, scheduling and available budget. The full detail of the programme budget is provided in Annex 6.

General remarks to the activity schedule and budget:

- The direct investment costs, as covered by the farmers, are corrected for inflation, assuming an inflation rate of 5% per annum.
- The regional and national programme support costs are not corrected for inflation, as it is assumed that these cost will, to a large extend, be covered by (foreign) development aid funds. Experience learns that exchange rate development tends to correct inflation.
- The Biogas Support Offices, national and regional, are assumed to be integrated n the government structure. Budget rates are calculated accordingly.
- This schedule and budget merely serve to establish the "order of magnitude". Fine tuning should happen during the preparatory phase, together with the main implementing partner, in particularly while developing the Programme Implementation Document.

Foundation for this outline is the production forecast. The programme proposes to support the construction of 10,000 biogas plants over a period of 5 years. Production is planned in 4 regions: Amhara, Oromia, SNNPRS and Tigray. Tentatively, the production is evenly divided over the 4 regions. A survey at the start of the programme may indicate a shift in this division, depending on actual demand and marketing opportunities.

Initial production will be modest, but is expected to pick up as skills and awareness at both demand as well as supply side increase. To facilitate effective supervision, it will be crucial to construct in batches. Hence, for the first year the programme will stimulate to construct in one Kebele of one Woreda in each region in the first year. Regionally, the programme will thereafter gradually develop activities in maximally 5 Woredas, while continuing batch-wise construction.

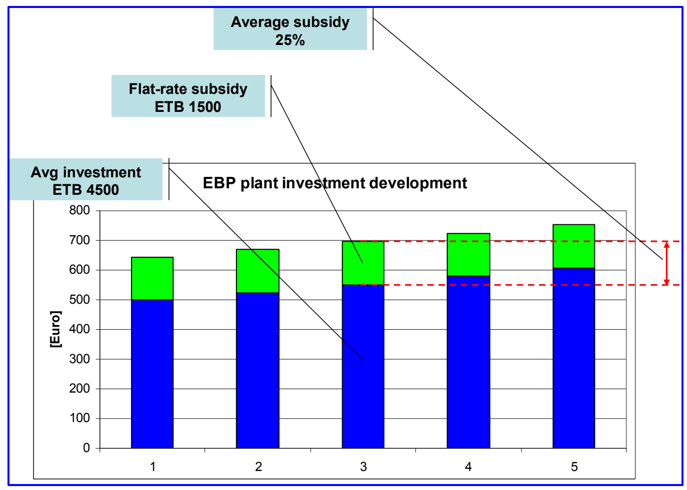
Region	Total	Distribution by years				
		1	2	3	4	5
Amhara	**2500**	50	200	500	750	1000
Oromia	**2500**	50	200	500	750	1000
SNNPRS	**2500**	50	200	500	750	1000
Tigray	**2500**	50	200	500	750	1000
Total project (*allocated*)	**10000**	**200**	**800**	**2000**	**3000**	**4000**
Production share/year	***100%***	*2%*	*8%*	*20%*	*30%*	*40%*

6.1 Subsidy.

As argued earlier, the Ethiopian circumstances would justify an investment subsidy component. Tentatively, a flat rate subsidy amount of ETB 1,500 (€ 144) is proposed. Further study should reveal the possibility of a two tier subsidy scheme, with a higher subsidy level (ETB 2,000) for poorer and/or more remote areas. The subsidy fund requirement of the programme will thus amount into € 1,441 million.

Annual subs requirement	1	2	3	4	5	[Euro] Total
# of plants	200	800	2000	3000	4000	10000
Subsidy requirement	28,818	115,274	288,184	432,277	576,369	1,440,922

The expectation is that the investment for the (modified) GGC 2047 fixed-dome biogas installation with a digester volume of 4 and 6 m^3, built in stone, will be under € 500 at 2006 price level. With the proposed subsidy of ETB 1500, the average investment for the farmer – corrected for inflation- will be € 435. The average subsidy amounts to 25% of the total investment

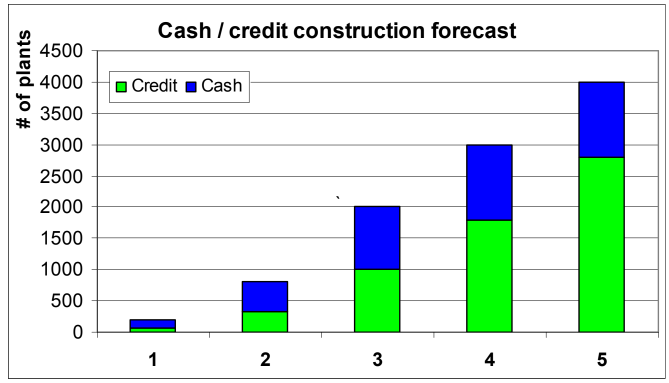


6.2 Direct investment.

For the programme, the total direct investment (10,000 biogas installations) will amount to € 5.788 million.

Direct investment EBP	*(inflation correction in farmer investment)*					[Euro]
	2006	2007	2008	2009	2010	total
Annual production biogas plants	200	800	2000	3000	4000	10000
Farmer investment (avg)	71,182	304,726	814,316	1,304,161	1,854,644	**4,349,028**
Investment subsidy (avg)	28,818	115,274	288,184	432,277	576,369	**1,440,922**
Total direct investment	**100,000**	**420,000**	**1,102,500**	**1,736,438**	**2,431,013**	**5,789,950**

Avg farmer investment / plant	435
Avg investment subsidy / plant	144
Total direct investment / plant	**579**



6.3 Credit.

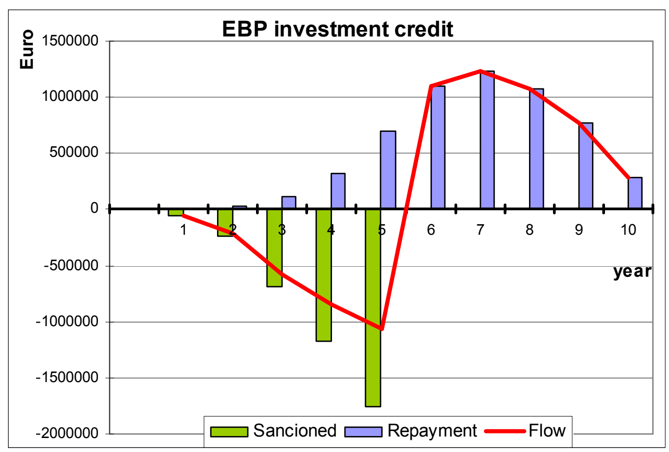
The remaining investment will -despite the subsidy- still be prohibitive for most rural farmers. Hence, a proper credit facility will prove crucial for the success of the programme.

In these preliminary calculations it is assumed that in the first year 30% of the households get a loan for the biogas investment. Subsequently, the credit share shall increase to 70% in the 5th programme year. As a result, at the end of the programme 60% of the participating households will have constructed their plant with credit assistance.

A "proper credit facility" has for these preliminary calculations been translated in a loan maturity of 5 years, interest rate of 12% per annum and a one year grace period. Of the total programme investment principal amount of € 2.631 million, the financing costs[28] will thus result in € 1.149 million.

Investment financing	1	2	3	4	5	[Euro] Total
Total prinicpal	21,354	121,890	407,158	782,497	1,298,251	**2,631,150**
Financing costs	9,331	53,259	177,903	341,902	567,255	**1,149,649**

Loan repayment loan will cover the sanctioned amount after the 6th year.



[28] Financing costs: accumulated interest cost over the entire maturity period.

6.4 The regional support budget.

The Regional Bureaux of Energy will play a fairly autonomous and pivotal role in the implementation of the programme in their respective regions. While being responsible for the implementation of the programme, they will depend heavily on networking / cooperation of other government (e.g. Bureaux of Agriculture) and non-government organizations (e.g. in the field of water and sanitation).

For that purpose, the government will employ at least two dedicated staff at regional level and make available proper accommodation. Together with other (part-time) BoE staff this unit will form the Regional Biogas Programme Office.

Summary Regional Support Budget		(total programme, not corrected for inflation)					[Euro]
		Budget					
# of regions:	4	1	2	3	4	5	total
1 Promotion & marketing		5,800	19,200	38,000	47,000	56,000	**166,000**
2 Quality management		1,635	6,840	17,850	29,025	41,700	**97,050**
3 Training		2,400	10,400	27,200	50,400	64,000	**154,400**
4 Extension		1,200	5,200	31,200	21,600	25,600	**84,800**
5 Operational expenses		45,600	37,600	37,600	19,200	19,200	**159,200**
Provincial Support Budget		**56,635**	**79,240**	**151,850**	**167,225**	**206,500**	**661,450**
Contingencies	**5%**	2,832	3,962	7,593	8,361	10,325	**33,073**
Total Provincial Support Budget		**59,467**	**83,202**	**159,443**	**175,586**	**216,825**	**694,523**
						Reg Sup / plant	69.45

Regional programme activities include promotion and marketing, quality management, training, and extension. The total regional budget amounts to € 695 thousand for the programme period.

6.5 The national support budget.

The Ethiopian Renewable Energy Development and Promotion Centre will, at federal level, take overall responsibility for the implementation of the biogas programme. The total programme budget for national support amounts to € 1.501 million.

Summary National Support Budget		(not corrected for inflation)					[Euro]
		Budget					
		1	2	3	4	5	total
1	Promotion & marketing	19,500	26,500	46,500	59,500	74,500	**226,500**
2	Finance	7,400	8,600	11,000	13,000	15,000	**55,000**
3	Construction & a.s.s	-	22,000	20,000	20,000	4,000	**66,000**
4	Quality assurance	13,342	6,018	5,572	11,658	10,944	**47,534**
5	Training	35,100	27,750	27,750	28,750	31,150	**150,500**
6	Extension	5,000	1,500	7,250	4,250	9,000	**27,000**
7	Institutional support	32,250	29,250	29,250	29,250	32,250	**152,250**
8	Monitoring & evaluation	14,000	24,000	26,000	24,000	26,000	**114,000**
9	Research & development	23,965	9,360	11,025	12,100	9,800	**66,250**
10	Project management	109,909	96,616	106,866	105,704	105,704	**524,800**
National Support Budget		**260,466**	**251,594**	**291,213**	**308,212**	**318,348**	**1,429,834**
Contingencies	5%	13,023	12,580	14,561	15,411	15,917	**71,492**
Total National Support Budget		**273,489**	**264,174**	**305,774**	**323,623**	**334,266**	**1,501,326**
National support bgt / plant							150.13

National support activities include promotion and marketing, (administration and channelling of) finance, (support of) construction and after sales service, quality assurance, training, extension, institutional support, monitoring & evaluation and research & development.

Within the national programme budget, a separate reservation has been made to refurbish existing biogas installations in the programme's area op operation. Non- or poorly functioning biogas plants are detrimental to promotion of the technology. Hence, the programme will provide support to those households that need assistance in updating their installation.

6.6 Technical assistance.

SNV may offer to provide technical assistance, foremost at national level, but –through the EREDPC- also on regional level. In this way, SNV would make available the experience of SNV's Biogas Practice Area to Ethiopia regarding large scale dissemination of domestic biogas.

Summary Technical Assistance		(not corrected for inflation)					[Euro]
		Budget					
	Description	1	2	3	4	5	total
1.01	Senior Technical Advisor (EUN)	115,200	96,000	76,800	57,600	38,400	**384,000**
1.02	Junior Technical Advisor (EUN)	-	84,000	70,000	56,000	28,000	**238,000**
1.11	Senior Technical Advisor (HCN)	16,800	16,800	16,800	16,800	16,800	**84,000**
1.12	Junior Technical Advisor (HCN)	12,000	12,000	12,000	12,000	12,000	**60,000**
1.21	Additional advisory services	6,000	6,000	6,000	6,000	6,000	**30,000**
1.22	Other support expenses	5,000	5,000	5,000	5,000	5,000	**25,000**
	Total Technical Assistance	**155,000**	**219,800**	**186,600**	**153,400**	**106,200**	**821,000**
					National Support Budget / plant		**82.10**

6.7 Budget summary.

A more detailed activity schedule and programme budget is provided in annex 6. The total budget amounts to nearly € 10 million for 5 programme years.

Summary project budget		(corrected for inflation)					[Euro]
		BP II summary project budget					
		2006	2007	2008	2009	2010	total
1a	Farmer investment	71,182	304,726	814,316	1,304,161	1,854,644	**4,349,028**
1b	Credit financing costs	9,331	53,259	177,903	341,902	567,255	**1,149,649**
1c	Investment subsidy	28,818	115,274	288,184	432,277	576,369	**1,440,922**
2a	Regional support *(RBPO)*	59,467	83,202	159,443	175,586	216,825	**694,523**
2b	National support *(NBPO)*	273,489	264,174	305,774	323,623	334,266	**1,501,326**
2c	Technical assistance	155,000	219,800	186,600	153,400	106,200	**821,000**
	Total project	**597,287**	**1,040,434**	**1,932,219**	**2,730,949**	**3,655,558**	**9,956,447**

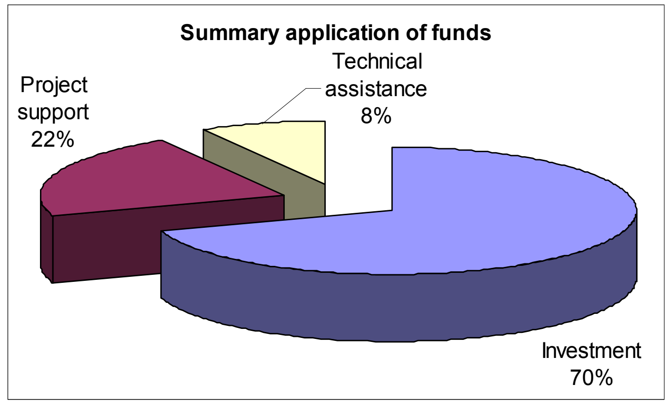
6.7.1 Application of funds.

Investment, for the construction of 10000 installations, takes 70% (€ 6.9 million) of the total programme costs.

The remaining 30% (€ 3 million) will be applied for programme support. Divided over the 4 participating regions, € 695 thousand will be applied for programme support at regional level and € 1.5 million is budgeted for national support costs.

SNV-Ethiopia's contribution for technical assistance will amount to € 821 thousand.

Application of funds		[Euro]		[%]
1	**Investment**			
1a	Farmer investment	4,349,028	63%	
1b	Credit fiancing costs	1,149,649	17%	
1c	Investment subsidy	1,440,922	21%	
	Total investment	**6,939,599**		70%
2	**Programme support**			
2a	Regional support RBPO	694,523	23%	
2b	National support NBPO	1,501,326	50%	
2c	Technical assistance	821,000	27%	
	Total project support	**3,016,848**		30%
	Total application	**9,956,447**		



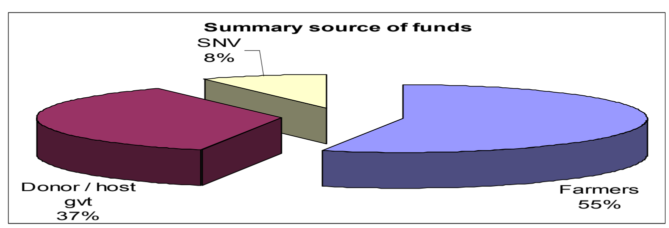
6.7.2 Source of funds.

The lion share of the funds, 55% or € 5.5 million, is sourced by the participating farmers either directly but more likely indirectly, through the repayment of biogas loans. The farmers' share covers investment and investment financing costs, minus the subsidy component.

Donor(s) and the Ethiopian Government are proposed to provide funds for the subsidy component (€ 1.4 million) and programme support costs (€ 2.2 million).

A proposal for a division of the contributions by the partners will be subject to further negotiations during the development of the Programme Implementation Document.

Source of funds		[Euro]		[%]
a	**Farmers**			
a1	Farmer investment	4,349,028	79%	
a2	Credit financing costs	1,149,649	21%	
	Total participating farmers	**5,498,676**		55%
b	**Donor / host government**			
b1	Investment subsidy	1,440,922	40%	
b2	Regional support	694,523	19%	
c1	National support	1,501,326	41%	
	Total donor / host gvt	**3,636,770**		37%
c	**SNV**			
d1	Technical assistance	821,000		
	Total SNV	**821,000**		8%
	Total source	**9,956,447**		



7 Opportunities and risks.

Conditions in Ethiopia pose particular opportunities and threats for a large scale biogas programme.

In general a biogas programme fits well into the latest insights regarding sustainable development. Opportunities include access to funding and cooperation with similar initiatives.

Threats can be defined in the climatic conditions, poverty and agricultural customs and the political situation in the region.

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7.1 Opportunities.

7.1.1 UNDP-GEF co-funding:

The UNDP administered Global Environment Facility in Ethiopia would consider co-financing of a national biogas programme. The programme so far has little activities related to energy, both in its core programme or the GEF. Recent policy expresses increased interest in focussing on renewable energy, including:

- RE policy issues,
- Institutional capacity strengthening
- Community level solutions.

The GEF operates in a one-on-one co-financing facility in three steps. Submission for co-funding of programme identification (PDF A) and formulation (PDF B) and possibly implementation (PDF C) should be considered.

7.1.2 Financial support of the Netherlands Government:

A domestic biogas programme for Ethiopia would fit into the Netherlands' policy to:

- provide 10 million people in developing countries with safe, reliable and affordable sources of domestic energy by 2015. Domestic energy is a mainstay for social and economic development.
- provide 50 million people in developing countries with clean drinking water and proper sanitary facilities by the year 2015. Clean drinking water and proper sanitary facilities are a pre-condition for a healthy and productive society.

7.1.3 Integration with the SNV BOAM programme.

SNV's "Support to Business Organizations and Access to their Markets" (BOAM) aims to strengthen the capacity of service providers in specified agricultural value chains (honey and beeswax; milk and dairy products; edible oils and oilseeds; and pineapple). The biogas programme will benefit from the experiences and relations gained from SNV's activities, particularly in the milk and milk products chain. In the medium turn, experiences in e.g. Nepal show considerable mutual benefits may be derives from cooperation within the dairy sector.

7.2 Risks.

7.2.1 Recurring droughts will hamper the implementation of any programme:
This is a considerable risk in particular for a biogas programme, where steady water supply is a crucial requirement. The risk can be (partially) mitigated by including post draught programme component to reactivate dried-up biogas installations

7.2.2 The feed basis for livestock is declining:
Partially –but not uniquely- in relation with the point above, the natural resource base is increasingly unable to provide sufficient feedstock for large (in and output extensive) cattle herds. Continuation of this practice will result in further degradation of the environment and eventually "pull the plug" of small scale integrated agriculture on the highlands.

Livestock keeping practices
It should be noted that environmental management in rural Ethiopia is gradually including more "cut and carry" and "area closure" approaches. In tandem, extension services promote less, better fed and improved breed cattle which is more productive and less threatening for the environment. This development will actually be an opportunity for small scale integrated agriculture and, thus, for domestic biogas.

7.2.3 Political instability:
As argued earlier, Ethiopia after the last elections has lost some of its political stability. Furthermore, placed in the politically volatile Horn of Africa, Ethiopia's situation cannot be taken in isolation. Although the situation currently seems normalized, unfavourable developments may result in reluctance of donors to (co-) finance a larger programme, and may complicate implementation later on.

7.2.4 Gender inequality:
A significant share of (in particular the non-formal) advantages of domestic biogas will benefit women in particular. Women seem, however, to have a minor role in investment decisions of the farming household. Men, hence, may decline to invest in biogas as they do not take the full scope of benefits in consideration.

Terms of Reference (final) for

Study on the feasibility of a national programme for domestic biogas in Ethiopia

1. Introduction and background

The Deputy Director of DGIS/DMW, Mr. Paul Hassing, requested the Coordinator of the Biogas Practice Team (BPT) of SNV, Mr. Wim van Nes, to look into the possibilities for a biogas programme in Ethiopia. This request builds on a study made by SNV/Ethiopia in 2004 in the field of renewable energy which included the potential use of biogas. Also the First Secretary of the Royal Netherlands Embassy (RNE) in Addis Ababa, Mrs. Janny Poley, showed interest in this direction. This document presents the Terms of Reference (ToR) for such study.

2. Objective of the study

The objective of the study is to thoroughly assess the feasibility to set-up and implement a national biogas programme in Ethiopia.
More specifically, the study will address the following areas:

- Country background including agricultural & livestock sector, energy demand and supply, energy policy and plans;
- History of domestic biogas;
- Potential demand for domestic biogas;
- Possible institutional set-up for a national biogas programme; and
- Outline for a national programme on domestic biogas.

See Annex I for a tentative table of contents of the study report.

3. Activities and methodologies

The following activities and methodologies are proposed:

E. Preparation of a mission to Ethiopia by collecting secondary information, contacting key respondents and informants in Ethiopia and abroad, and drafting checklists for biogas plant visits and interviews;
F. Mission to Ethiopia to visit domestic biogas plants constructed in the past, to meet with key respondents and informants for interview and discussion. The mission shall include a workshop to discuss with the main stakeholders the roles of the different actors in Ethiopia and the outline of a possible national biogas programme;
G. Formulation of the draft study report and submission for comment to SNV/Ethiopia, members of the Biogas Practice Team (BPT) of SNV, RNE in Addis Ababa and DGIS/DMW.
H. Submission of the final study report by incorporating the comment from SNV/Ethiopia, members of the BPT, RNE/Addis Ababa and DGIS/DMW.

4. Time schedule

The mission to Ethiopia shall be completed within a period of three weeks starting mid-March 2006. The draft report shall be submitted before 30 April 2006. SNV/Ethiopia, members of BPT, RNE/Addis Ababa and DGIS/DMW will provide within 10 working days comment on the draft report. After that, the final study report will be presented within five working days.

5. Required budget and proposed financing

The costs of this study will mainly consist of expenses for travelling and DSA of the team members, a consultancy fee for a local expert and some other local expenses if deemed required for example for additionally required local consultancies. All these costs will be borne by SNV/Ethiopia. Once the composition of the team is known (see 7), a budget proposal will be prepared by the team leader and presented to SNV/Ethiopia for approval.

6. Expected output

The report on the feasibility study shall be well-structured and clearly written in English not exceeding 50 pages excluding annexes and provide informed recommendations on the possibilities to set-up a national programme on domestic biogas in Ethiopia. Annex I provides a tentative table of contents for the report.

7. Composition of the team

The mission team shall consist of three members:
- Team leader to be appointed from the BPT of SNV;
- Advisor from SNV/Ethiopia; and
- Local Expert in the field of renewable energy.

8. Further arrangements

Prior to departure to Ethiopia, the team leader will after consultation with SNV/Ethiopia and RNE/Addis Ababa come up with an itinerary for the mission. The mission team is free to discuss any matter concerning the assignment with any institution or individual, but is not authorised to make any official commitments on behalf of SNV, RNE/Addis Ababa or DGIS/RNE.

9. References

– Ethiopia: Building on Progress: A Plan for Accelerated and Sustained Development to End Poverty (PASDEP). Ministry of Finance and Economic Development. October 2005.
– Identification Study on Renewable Energy and Energy Efficiency in SNNPRS and Ethiopia. Dr. Getachew Eshete et al. May 2004.
– Email correspondence with
    – Mrs Janny C. Poley, First Secretary RNE Horn of Africa Programme
    – Mr. Rem Neefjes, PC SNV Ethiopia
    – Mr. Christopher Kellner, Senior Advisor Biogas, SNV Nepal.

Wim J. van Nes
Leiden, 27 January 2006

Tentative table of contents for the report on the feasibility study

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    - Required functions/services (promotion, operation & maintenance, construction & after sales service, provision of micro-credit, training, R&D, quality control, extension (use of bio-slurry), monitoring & evaluation (external), coordination at implementing level, coordination at policy level)
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    - Required TA
    - Assumptions and risks
7. Conclusions and recommendations
8. References

Annexes:
- ToR
- Itinerary of the mission
- Contact details of visited organisations and individuals
-

The information provided in this annex is largely sourced from:

> Environmental and social analysis food security project No. ENIBER 2001 by Metaferia Consulting engineers, Addis Abeba for the Federal Democratic Republic of Ethiopia, Ministry of Economic Development and Cooperation.

Unfortunately, the team did only managed to lay hands on part of the full report. As a result, the information hereunder provided does not have the same level of detail for all four regions

1 Amhara Regional State.

1.1 Location and Topography.

The Amhara National regional state extends from 9 to 130 45'N and 36 to 40°3'E. It is bounded by Benshangul and the Sudan in the West, Oromia in the South, Afar in the East and Tigrai in the North. The region covers a surface area of 170,152 km^2 and occupies $1/6^{th}$ of the country's total landmass.

The Amhara Region constitutes ten administrative zones (North Shewa, East Gojam, West Gojam, North Gonder, South Gonder, North Wollo, South Wollo, Oromia (Kemissie), Awi and Wag Hamra Zones) and 105 Woredas. 48 Woredas are earmarked as food deficit Woredas.

The region is affected by severe land and soil degradation, recurring drought, fragmented farm plots, (0.7 ha/HH,) high population, low literacy, and with poor delivery of research technology and extension support.

The central highlands of Ethiopia, of which Amhara Region is the major part, under went several crucial deformations during the tertiary period. This resulted in the appearance of large openings e.g. fissures, rents and the production of prominent plateau, hills and mountains. Those diversified geological formations produced complex and mosaic landscapes which made the region a center of diversity and variability for various biological life and physical structures. The highlands, between the two major massifs, Tekeze Gorge in the north and Abay Gorge to the south and the Rift valley escarpment in the east, are an important watershed and source of major national and international rivers.

1.2 Population and Settlement.

According to the 1994 census the population of the region is estimated at 14.4 million people (7.4 million male and 7 million female). About 88% of the population lives in rural areas. Regional population density ranges from 136.4 persons (East Gojam) to 41.5 persons /km^2 (North Gondar). The average is about 82.5 persons/km^2. The census has also indicated that the proportion of the population under the age of 15 is 49.3%, which is attributed to high fertility rate and declining infant under 5 mortality rate.

The high proportion of the younger population combined with the aged (4.8%) poses a very high degree of dependency. More than 85% of the total population live in the highlands where the climate is mild, the soils are productive and human and livestock pests and diseases are relatively absent. The majority is rural with only 12% of the population residing in urban areas.

1.3 Climate and Agro-ecology.

The Region exhibits wide altitudinal ranges, from 600m at Metema (Sudan border) to 4620 masl, the peak of Ras Dashen. The amount of rainfall per annum varies from 200mm at Qobbo to 2,000mm at Awi (Banja, and Guang Woredas). The single growing period in the eastern and southern parts of the Region is respectively 45-90 and 60-120 days long. The Belg growing highlands' length of growing period (LGP) is 120 days at Wag Hamera and 200 days at Awi (Banja).

The Amhara Region has ten major and fairly homogenous agro-ecological zones (AEZs). The major part of the region (37%) lies within the tepid to moist zone. This agro-ecological zone is predominantly located in the central part, where there is high potential for crop production. Moisture deficit areas are found in the hot to warm arid or hot to warm sub-moist agro-ecological zones (Wollo and Gondar zones).

1.4 Soils and Soil Erosion.
There are about twelve distinct soil types in the region. Depressions and flat plains are mainly covered by black clay soils (Vertisoils). Undulating to gently rolling areas are characterized by dark reddish to brown colored deep soils (Luvisoils, Nitosoils and Acrisoils). The mountainous and degraded landscapes of most parts of Wollo and North Gondar are dominated by shallow and stony soils. The major alluvial plains in the east are predominantly Fluvisoils and Vertisoils with some saline and sodic traces. The highlands of Amhara suffer from severe soil erosion and degradation.

1.5 Land Use and Cover.
There is no updated data on land use/cover of the region. Climate, topography and population are the main influencing factors both for land use and cover types of the region. There are twenty-four mapped land use/land cover types derived from eleven major classes. From the available data, about 53.5% of the total regional area is under cultivation, 40% is covered by bushes/shrubs and open grass lands, 0.8% is open woodlands; 0.4% swamps; 0.8% Afro-alpine vegetation; 2.2 % rocky and shrubs & grasses; the riparian vegetation occupies 0.2% and the remaining are water bodies and bare lands.

1.6 Water Resources.
About 70% of the Region suffers from high water erosion. Most of the rivers cut deep gorges and many of them are seasonal. Abay, Tekeze and Awash tributaries are mainly from the Amhara highlands. Of all the rivers, only Abay is used to generate hydropower at several natural falls.

The regional survey indicated that about 250,800ha is suitable for irrigation and 120,000ha can be developed by micro-dams and river diversions. At present 15.5% (40,000 ha) has been brought under irrigation, 97% of these by traditional means.

Prominent friable red and brown clay soils on relatively flat land in Gojam and Awi are potential crop farming zones and are considered as food self-sufficient areas. The bottom wet lands like Woreta/ Fogera plains, Chefa-Borkena and Qobbo Valley are crossed by several rivers and are considered as potential irrigable and rice production areas.

Potable safe water distribution is an unresolved development problem and closely related to gender issues. Only 10.3% of the population receives clean water and substantial numbers of people walk 5-7 km to fetch water.

1.7 Forest Resources.
There are four major types of forests including natural forests, plantations, farm forests and Acacia woodlands. The Region has an estimated 80,000ha of natural forest, 73,000ha-plantation forest; 25,000 ha farm forest and more than 600,000ha of Acacia woodland (mostly incense, gums and A. Abyssinica, A.Nilotica, etc.). A report on forest ownership in the region indicates that 94%, 3% and 3% is owned by state, community and private farms, respectively.

1.8 Energy.
Biomass from wood, coal, cow dung and crop residues are the main energy sources, accounting for 99% of the total fuel needed for domestic use. Alternative energy sources like wind, solar, earth-coal and methane (bio-gas) gas are under study.

1.9 Wildlife.
There are many endemic mammals and birds in the Region. The Semen Mountain National park is known for a number of rare wild life including Walya Ibex, Abyssinian Wolf, Chelada Baboon, Minelik bush buck, Serine birds, etc. Low land animals are widely distributed at Metema and Quara areas and some in Bati and Woredas bordering the Afar Region. Lake Tana, L.Hayik, Ardibo, May Bara and Gulbo are some of the lakes (water bodies) that inhabit fish and other aquatic life.

1.10 Farming System and Crop Production.
The dominant farming system in the region includes cereal growing, oxen cultivation and mixed farming where livestock production is undertaken complimentary to crop production. Crop production is mainly

rain-fed, which in some places entails uncertainty due to the erratic nature of the rainfall. The major crop types include cereals, pulses, oil-crops and tubers. Barley, wheat, teff, maize, sorghum, millet, faba bean, peas, chickpeas, vetch, lentils, linseed, noug, sesame and oats (wild type) are widely grown in the different agro-ecological zones of the region.

Cattle constitute 70% of the livestock population, and many of them are highland and 'senga' types. The Fogera types, around Lake Tana, are potential milk yielder breeds. Sheep (highland sheep with fur) at Debre Birhan; Amhed Guya and the Menz and Awassi types are potential wool type breeds in the Region. Equines (horses, mules, sinar donkeys from Metema and camels) are commonly found in the Region.

Hides and skins are mostly used at home, with only small amounts reaching the market. Moreover, there is no processing plant in the region. Veterinary service is poor in the highlands. Due to limitations in accessibility, periodic vaccination for epidemics and sporadic diseases is greatly hampered.

1.11 Health Services.
Health service in the region is very low, especially in the rural areas. Facilities are inadequate and there is an acute shortage of health personnel as related to the large population of the region. Currently, there are 10 hospitals, 41 health centers and 446 clinics covering about 30% of the population needs. The population suffers from various diseases such as malaria, tuberculosis, intestinal parasites, skin and eye diseases, diarrhea, etc. In recent years, malaria has become a major cause of morbidity and socio-economic problems. It is estimated that about 75% of the region is prone to malaria, affecting more than 64% of the region's population. Women and children are among the most vulnerable groups of the population.

1.12 Water supply.
Only 10.3% of the total population of the region has access to safe water from properly constructed facilities. Safe water coverage in rural areas is in much worse condition. Over 97% of the rural population has no access to potable water.

Women are responsible for fetching water to the household. In many cases they travel long distances (5-7km) in search of water.

1.13 Education.
Regional reports indicate that between 40 and 50% of the total population can not read and write. Only 13% of the estimated school age children attend schools. There are 2,506 primary schools, 228 junior and 76 senior secondary schools.

The primary schools enroll about half a million students, which account for about 18% of the total primary school age children. The junior and senior secondary schools enroll only 8.3% and 5.4% of the total population (between 15 and 18 years of age), respectively.

Technical and vocational schools are few, three in number, with a capacity of 700 students at a time. These institutions train middle level manpower in the fields of mechanics, electricity and commerce. Community skill training is also given in 114 centers although many of these centers were ruined and looted during the transition period to the new Government, ten years ago.

There are also three teacher training and three higher training institutes in the region. However, all the schools and institutes lack adequate facilities, tools, equipment and qualified instructors.

1.14 Access Roads.
Road access within the region is limited. In most cases pack animals and human porterage are the major forms of transport. The total length of all-weather road is about 4,339km. Of this total, only 590km (13.6%) is asphalt and the remaining is surfaced with gravel. There are also feeder roads constructed by the community and NGOs. In general, current data indicate that road/access density is about 8km/1,000km^2. Many of the roads lack periodic maintenance and upgrading.

1.15 Cultural Heritage.
There are many historical and cultural sites in the Region that are tourist attractions. The Lalibela rock hewn churches, Gonder Castles, Mesela Mariam and Ankober Palaces, Tisesat Fals and the islands in Lake Tana are the major cultural heritage sites. Limalimo and Tekeze gorges, Ras Dashen and Semien Park, Wofwasha (birds), Gussa-ecology (Menez) and Dessie-Bati areas are also tourist attractions.

1.16 Income.
Average annual income per household is Birr 1,500 (for a household of 4.3 persons) and per capita income is Birr 350. About 32% of the households are without oxen. The average land holding in the highlands and the lowlands is 0.70 ha and 1.75 ha, respectively.

2. Tigray Regional State

2.1 Location and Topography.
The Regional State of Tigray is situated in the northern part of the country with a total area of 50,230 km2. It has a common boundary with Eritreya in the north, with the Sudan in the west, with Amhara Region in the south and with the Afar Region in the east. It extends from 120 15' to 140 50' North Latitude and from 360 27' to 390 59' East Longitude (TFAP, 1996).

The region is divided into five administrative zones (Western, Central, Eastern, Mekele and Southern Zones). It has 35 Woredas, 603 development centers (Tabias) and 2,272 kushets. Tabias are the main development centers, which are the basic units of the administrative structure.

Tigrai exhibits three distinct topographical zones; the central highlands, the north- western lowlands and the eastern lowlands. The central highlands are an extension of the central highlands of the country with an elevation of between 1,500 and 3,200masl, the highest peak being 3,900masl. As this ecological zone is safe from malaria and most other diseases, population density is very high, which through time led to degradation of the natural resources. The northwestern lowlands are sparsely populated and have soils that are less eroded and exploited. Close to the Sudanese border, elevation is as low as 500masl. Malaria and livestock diseases are more prevalent in this zone. The eastern escarpment falls steeply from the plateau of 2,900masl to the depressions in the Afar Region.

2.2 Population and Settlement.
The total population of the region in 1994 was 3.13 million (about 3.85 million in 2001), of which 1.54 million were males and 1.59 million females. The urban population was 468,478. The average household size was 4.3 persons. The proportion of children under the age of 15 was about 44.8%, the age group of 15-64 51.2%, and the population aged 65 years and over about 4%. The literacy rates for urban and rural areas were 57% and 14%, respectively (TGSA, 1996/97).

Seventy eight percent of the population of the 15-64 age groups is economically active and 1,226,970 persons are employed in various sectors of the economy. The rate of unemployment for the total population of the region, by sex, is 1.5% and 1.7% for males and females, respectively. Fertility rate is 5.4% for the region. Estimated infant mortality rate is 123/ 1000 births and life expectancy is 49 years.

The larger proportion of the population is concentrated in the highlands, mainly in the eastern part. The western lowlands are sparsely populated. The settlement pattern is in scattered villages with a limited number of houses in each village. The pattern poses problems to provide services like health, schools, water supply, electricity and communications. There is also lack of well-developed rural centers, small and middle sized towns, which can perform necessary functions for the rural hinterland.

2.3 Climate and Agro-ecology.
There is a marked variation in rainfall distribution from east to west. The mean annual rainfall in the region varies from less than 200mm in the extreme east, bordering the Danakil Depression, to over 1,900mm in the southwestern part of the region. The rainy season is mainly between June and September. However,

just south of Mekele and southward along the eastern part of Tigrai highlands, the short rains prevail, which last 45 to 65 days.

The mean annual rainfall and the length of the growing period increases considerably when one moves from lower to higher altitudes and from east to west. The length of the growing period varies from 120 days in the western part to 90 days along the Eastern Escarpments and eastern low lands (TRBIMPP, 1997/98).

The mean temperature in the lowlands of Tigrai is 25^0c. In the eastern part, along the foot slopes of the great escarpment, separating the lowlands from the highlands, the temperature ranges from 25 to 28^0c. Also, in the extreme western part of theregion, where altitude falls below 1000masl and along the Tekeze River, mean temperature is about 25^0c. Temperature of 15 to 18^0c is restricted to the ridges of the highlands, which run west east from Inda Silassie to Adigrat, and the upper slopes of the escarpment.

According to TAFP's 1996 survey, there are four main agro-ecological zones identified in the region. These include:

- hot to warm arid lowlands (found mainly in the eastern part of the region below 1,400 masl);
- hot to warm semi-arid lowlands and plateau remnants (found on the extreme western of the region between 500-1600 masl);
- hot-to warm sub-moist lowland and plateau remnants (found in the south-western part of the region and along the western part of the eastern escarpment); and
- tepid to cool sub-moist low to high altitude, which occupies the central and north western part of the region with altitude varying from 1000 to 3000masl.

2.4 Soil and Water Conservation.

Farmers in the region are aware of the environmental degradation, which takes place in their farmland and surroundings. Farmers are participating in problem identification, planning, implementation and evaluations of various types of soil and water conservation. They fully participate in SWC measures not only to get food aid, but because they have understood the long-term benefits of SWC measures on their farmland and surroundings.

Soil and water conservation activities have included planting trees around gullies to stabilize the check dams. The most significant biological conservation measures accomplished include the establishment of area closures. In the region, excluding the southern zone, about 143,016 hectares of uncultivated and overgrazed hillsides are enclosed (TFAP, 1996).

2.5 Land Use.

There is no recent information on land use/land cover of the region. However, previous studies indicate the following. Cultivated land (including commercial farms, intensively and moderately cultivated smallholdings) accounts for 64%. Disturbed high forest, dense and open woodlands occupy about 7%. Open bushes and grassland account for 17%. The remaining are water bodies and waste lands.

2.6 Water Resources.

Major river basins include Tekeze and Mereb, which drain a combined catchment area of over 37,037km2 within the region. The Mereb River basin alone drains most of northern part of the region. The Lailay Adiabo, Mereb-Leha, Medabay Zana and Enticho watersheds are included in this basin. The area coverage of this basin is about 5,899km^2. Lake Hashenge is a large water body in the Southern Zone with an area of 20km^2, is inhabited by fish and other aquatic life.

2.7 Forest Resources.

The available information on the amount of forest resources in the region is very limited and inconclusive. The estimate made by the regional Agricultural Bureau puts the total forest land at approximately 0.3% of the regional area. An estimate made by SAERT (1994) indicates that about 154,000ha of land is covered by vegetation.

The long history of intense human settlement has left an extremely degraded landscape. Most of the climax vegetation, especially on the highlands, has been transformed to grass and shrubs vegetation. However, there is an indication from the remnant vegetation that the highland areas, above 2,000m, were covered by Podocarpus gracilior, Olea africana, Cord/a africana and highland Acacia of various types. The lower valleys and the western lowlands were covered with deciduous woodlands and shrub-lands mostly dominated by species like Acacia spp., Boswellia spp., etc. At present, severe fuel wood scarcity prevails in almost all areas of the region, more in the highlands than in the lowlands, and better in localities close to forest degraded wood lands compared to the predominantly clear agricultural landscapes.

2.8 Farming System and Production.

The general farming system is single cropping, oxen cultivation, mixed farming where livestock husbandry is complemented by crop production. Crop production is mainly under rain-fed conditions. The major types of crops produced in the region are cereals, pulses and oil crops. The main crops are teff, barley, wheat, millet, finger millet, sorghum, maize, chickpeas, broad beans, vetch, peas, linseed, lentils noog and sesame. The average yield of crop in the region is 5.3 quintal per ha. The average yield for cereals, pulses and oil crops is 6.9, 3.7 and 3.7 quintals/ha, respectively.

The region has a total livestock population of 2,533,047 TLU. Of the total livestock population, 3,040,712, 1,465,693 and 935,337 are cattle, goats and sheep, respectively. Equines are important pack animals in transporting input and output to rural and urban markets. They are also important in human transport (horses & mules). Among the equines, donkeys stand first in quantity with a total number of 303,405 followed by mules (10,417) and horses (5,110). There are also camels (13,661) and poultry (3,765,276). The region produces significant amounts of good quality honey from 164,580 colonies of beehives (ILCA 1990).

2.9 Health Services.

There are two higher hospitals, four zonal hospitals, six zonal clinics, fifteen health centers, fifteen health stations and eighty heath posts (TRBH 1999/2000). About
2,538 medical and management personnel of various levels of professions staff these establishments. Besides these health institutions, there is a nursing school in
Mekele, with a capacity of graduating about 31 nurses each year. Other medical infrastructures such as pharmacies, drug shops and rural drug vendors (run by both government and the private sector) are also prevalent. The main diseases in the region are malaria, acute respiratory infections, infections of skin, gastritis, helmintus and genito urinary system problems (TRBH 1999).

2.10 Water Supply.

Only 13.9% of the region's population has access to piped water supply. About 7.5% has access to protected sources. The remaining population use water from unprotected wells and rivers/ponds.

2.11 Education.

According to the Bureau of Education (1999/2000), there were about 289,319 students from grade 1 to grade 6 in governmental and 9,503 students in non- governmental schools. In addition to this, there were about 27,131 students from grade 7 to 8 in government and 1,713 in non-governmental schools. Similarly, the number of students from grade 9 to grade 12 in governmental and non-governmental schools was 16,213 and 546, respectively. Moreover, there are about 7 colleges/universities in the region enrolling 1,663 students (BETR 1999). Besides this normal educational program, there is a program of literacy for the adult population. So far, 12 rounds of literacy campaigns have been undertaken and 136,587 males and 74,520 females have participated in these rounds (BETR 1999/2000).

2.12 Access Roads.

The region has a network of 14,739km of access road that connect zones and
Woredas. Of the total length, 741km is main road, 590km all-weather road and about 13,400 dry-weather roads.

2.13 Cultural Heritage.
There are a number of cultural heritages that are very much impressive to both national and international visitors. These include, among others, the obelisks of Axum, the churches of Debre Damo and Abrha Woatsebha, and the historical mosque of Negash.

3. Oromia National Regional State.

3.1 Location and Topography.
The Regional State of Oromia extends from the southeastern border with Kenya across the center to the border of the Sudan. Its estimated area is about 353,690 km^2. Oromia constitutes about 32% of the total area of the country. It has physical contacts with all the Regional States of the country except Tigrai.

Oromia is bordered on the North by Afar, Amhara and Benishangul-Gumuz National Regional States, on the South by Kenya, on the East by Somali Regional State and on the West by Sudan and Benishangul-Gumuz Regional states. In the south, it borders the National Regional States of Southern Nations and Nationalities and Gambela.

The topography of Oromia includes high and rugged mountain ranges, undulating and rolling plateaus, panoramic gorges and deep incised river valleys and rolling plains. The altitude ranges from about 500 masl. in the Rift Valley to about 4,200masl at Batu Mountain, the highest peak in the region. Over three fourths (75.9%) of the region lies between 1,000 and 2,500 masl.; 17% below 1000 masl. and the remaining 7.1 % fall in altitudes above 2,500 masl.

Thirty percent of the land of the region is estimated to have a slope gradient of below 0.5%, which includes the low plains, river and rift valley floors. Five percent of the landmass of the region, having slope gradient of above 15%, is characterized by severe erosion risks. About 65% of the region is potentially utilizable from the viewpoint of good surface drainage and low risks to soil erosion.

3.2 Population and Settlement.
According to the 1994 census report of the Central Statistics Authority (CSA), the total population of Oromia Regional State, in July 2000 was projected to 22.3 million. Out of this population about 89 % are living in rural areas and the remaining 11 % in urban areas. Of the economically active population 92.2% are engaged in agriculture, 1.3 % in manufacturing and construction, and 6.5 % in service and related sectors. Sixty percent of the GDP is from agriculture.

3.3 Climate and Agro-ecology.
As already mentioned, having varied ranges in elevation, the region is characterized by diverse climatic conditions, ranging from hot tropical low lands to warm and cool temperate highlands. Mean annual temperature for the region is about 19.3^{0}C, with mean annual maximum of over 30^{0}C in the lowlands to less than 10^{0}C in the cool highlands. Areas of extreme temperature include the lowlands of Borena and Hararghe (above 30^{0}C) and Bale massifs (less than 10^{0}C).

Highland Oromia attracts heavy precipitation particularly in the summer from moisture-laden southwest tropical monsoon winds that cross the Atlantic Ocean. Over a quarter of the region receives 800-1200mm of rainfall (mean annual), while its arid lowlands and wet highlands receive mean annual of less than 800mm and over 1,600mm, respectively. In these areas, especially in the arid and semi arid portion of the region, rainfall variability is so high that it seriously affects crop production. Late onset and early cessation of rains causes heavy damages on crop and livestock production. It is estimated that, in the highlands, rainfall can reduce production by 50% while in the lowlands the reduction could be as high as 70 to 90% of the normal average.

3.4 Geology and Soils.
The geology of the region is characterized by the existence of considerable crystalline basement, basalts and sediments and sedimentary rocks. Rocks of the crystalline basement complex cover about 21.3% of

the region. Almost half of the regional surface cover is Cenozoic basalts and sediments, while 28.8% is of old Mesozoic sedimentary rock cover.

Soils of volcanic origin dominate the central high plateau of the region. The soils include Cambisols, Phaeozems, Luvisols and Vertisols. Except the Vertisols, which are constrained by poor drainage, the others are mostly utilized for cropping. Other major soil units of significant coverage include Acrisols and Nitosols, both characterizing the western section of the western sub region and the northern Borena area. Soils of arid climate, gypsic soils, occur in the rift valley system and the lowlands of eastern sub region.

3.5 Land Use.

The land use/cover- of the region is 14% cultivated area; forests, bush and woodlands constitute 25% and grazing areas occupy about 32% of the total area. The remaining areas include infrastructure and settlements, water bodies, mountains and steep slopes and wastelands.

3.6 Forest Resources.

Oromia is endowed with vast areas of forest resources. The total forest area of the region is estimated at 29,000km2. Of this total area, about 50% is natural high forest, 2.3% plantations and the remaining are other types (woodlands, bushes etc.).

3.7 Wildlife.

The region is home for various types of wildlife. There are a number of national parks (Awash, Bale Mountains and Abjata Shala), sanctuaries (Babile and Yavelo), game reserves (Bale and Awash West) and controlled hunting areas (Borena, Bale, Chercher / Arba Gugu, Segen and Awash West) covering some 97,667km2.

3.8 Farming System and Crop Production

Agriculture is the main stay of the regional economy. It accounts for the larger portion of the regional GDP and 92.2% of employment. Small holder producers contribute over 95 % of the total agricultural production. Though the agricultural potential of the region is considered significant, its performance is low because of land fragmentation, population pressure, low level of technological advancement in the sector, poor infrastructure development, high dependence on rainfall and environmental degradation including serious soil erosion, deforestation, desertification and loss of soil fertility.

3.9 Health Services.

Health coverage of Oromia region is about 46 %. This means that the majority of the population has no access to modern health services of any kind. Infant mortality is as high as 118 per 1000 live births. The coverage of vaccination in the region is about 66%. The health coverage of drought prone areas is even lower because of shortage of infrastructure and other socio-economic problems.

Water born and water related diseases are the major health problems of the region. Among these, malaria, helementhiasis and diarrhoea dominate. Malaria is the most prevalent health problem of the region. It occurs in all the areas below 2000 masl, and was the first amongst the top ten diseases registered in several health centers of the region, in the year 2000. The major types of malaria parasites commonly found in Oromia regional state are Plasmodium vivax and Plasmodium falciparium.

Other intestinal parasites are the ones mainly associated with poor quality of drinking water, unsanitary living environment and poor personal hygiene, which are common in the region. The major intestinal parasites frequently encountered are Amoebae, Ascaris, Gardia & tapeworm. Upper respiratory tract infections, Pneumonia, Subcutaneous tissue infections and skin infections are also common in the region.

3.10 Water Supply.

In the year 2000 about 24.8% of the rural and 83% of the urban population had access to clean potable water. This makes a total of 30.1% of the population with access to potable water in the region.

3.11 Education.

Though education services have been improving over the last six years, still most of the population has no access to education facilities. Enrolment rates in primary schools (1-8) are only 52% and only 22.4% of the population are able to read and write.

3.12 Road infrastructure.

Poor road net work and transport facilities are one of the factors for food insecurity. The average road density in Oromia is estimated to be 25.8 km per 1000 km^2 of land and 0.48 km per 1000 population (1996), but much lower in drought prone food insecure areas. For example the road density per thousand population for East and West Hararge, North Shewa and Arsi is 0.24, 0.23, 0.4 and 0.42 km/1000 persons respectively.

The existing road net work is mostly concentrated in the more productive zones of the central and Western parts of the region, which are assumed to be areas of high economic importance. The poor network in drought prone areas makes delivery of food aid extremely difficult and farmers obliged to carry their produce to market places by pack animals or humans. This severely constrains the total farm production that can be marketed and adds substantially to the cost of farm inputs and prices of other consumption

4. Southern Nations and Nationalities Peoples Regional State.

4.1 Location and Topography.

The Southern Nations, Nationalities and Peoples Regional State (SNNPRS) is located in the Southern and South-western part of Ethiopia, bordering with Kenya in the South, Sudan in the Southwest, Gambella Region in the Northwest and Oromia Region in the North and East. The Region lies roughly at 4027'-8030' latitude N and 34021'-390 11' longitude E. It is a region of immense ecological and cultural diversity.

The SNNPR occupies about 113,539 km^2 and accounts for about 10% the total area of the country. There is a wide variation of altitude in the region, which ranges from about 380masl at Lake Turkana to about 4,210masl at Mount Guge in North Omo.

Administratively, the SNNPR is divided into 12 Zones and 77 Woredas. Seven of the woredas are Special Woredas, which directly report to the regional government.

4.2 Population and Settlement.

According to the 1994 Population and Housing Census of Ethiopia, the population of the region was 10,377,028, and it is estimated to reach 12,880,801, in the year 2001. About 92% of the population lives in rural areas and the remaining 8% in urban areas. Eighty percent of the region's population lives in the highland areas that account only for 40% of the regional total area. The remaining 20% are pastoralists and agro-pastoralists occupying the semi-arid and arid southern lowlands. The average population density of the region was about 97.5 persons per kM^2 in 1997.

4.3 Climate and Agro-ecology.

The rainfall intensity, duration and amount increase from south to northeast and north-west. The mean annual rainfall for the region ranges from 400mm to 2,200mm. Temperature is usually inversely related to altitude. As a result of this, it decreases from south to northeast. The mean annual temperature of the region, in general, ranges from 15^0c to 30^0c. Agro-climatically, the region can be classified as including Dega, Woina Dega and Kolla agro-climatic zones.

4.4 Farming System and Crop Production.

The agricultural production of the region includes both food crops and cash crops. Root crops such as cassava, yam, taro, and sweet potato are predominantly found in the Woina Dega agro-climatic zone. Cash crops such as coffee, cotton, and spices occupy an important place of the region's economy.

The region has an estimated population of 7.7 million cattle, 2.2 million sheep, 2 million goats and 1.3 million equines, approximately 1.14 animals per person.

The Agricultural Bureau of the region has aims at increasing productivity per unit of land, while minimizing the dependency on rainfall by shifting towards water harvesting and irrigation development. It also focuses on the introduction of high yielding, disease and pest resistant crops.

4.5 Health Services.

The major health problems of the region are various types of infectious diseases. As the morbidity statistics reported by hospitals and health centers in the region indicate, malaria is the leading cause of morbidity, accounting for about 11.3% of all outpatients in 1999/2000 (1992 E.C).

Pneumonia, helminthiasis (intestinal parasites), upper respiratory tract infections, dysentery and infection of skin and subcutaneous tissue are among the main causes of outpatient visits. The majority of the health problems are water related diseases that are transmitted by drinking contaminated water, or due to lack of safe water for personal hygiene or through aquatic insects that depend on water for their breeding. The top five causes of deaths (as recorded in 1999/2000) are malaria (19.5%), TB (15.0%) pneumonia (15.8%), accidents (5.2%) and tetanus (3.2%). Gastro-enteritis and colitis, meningitis, dysentery, chronic rheumatic heart disease, malnutrition and anemia are also among the causes of deaths in the region.

Malaria is by far the most important health problem in the region. It is well recorded that areas below 2,000m altitude are malarious, and short-lived transmission occurs even above 2,000m where the microclimate is favorable. Most parts of the 12 administrative zones and the 7 special Woredas of the region have endemic malaria transmission. Many Woredas of the region are also annually affected by epidemic of the disease. For example, about 146,100 people living in 101 Kebeles in 25 Woredas were affected by a malaria epidemic in 1999/2000. The entire 32 'Chronic food deficit' Woredas of the region are known to be endemic for malaria.

Public health infrastructure of the region includes 12 hospitals (10 governmental and 2 non-governmental), 95 health centres (91 governmental and 4 non-governmental),366 clinics (310 governmental and 56 non-governmental), and 263 health posts. In addition, there are 109 private clinics and 91 other governmental clinics (other than the regional health bureau). Furthermore, there are 31 pharmacies, 43 drug shops and 478 rural drug vendors in the region. In 1999/2000 there were 2,814 health personnel including 215 physicians, 792 nurses, 133 sanitarians, 10 pharmacists, 30 health officers, 1447 health assistants, 41 pharmacy technicians, 104 laboratory technicians, 6 biologists and 23 X-ray technicians.

4.6 Access Roads.

Shortage of reliable road infrastructure is one of the major bottlenecks for socio-economic development in the region. In 1999, the total length of all weather roads in the region was about 4,949km. Of this, about 4,512 km was gravel, and the remaining 437km asphalt. All weather road density of the region is about 43.5km per 1000 km^2.

The Regional Rural Road Authority has recruited a consulting firm to carry out a regional master plan study for road networking and prioritize future road construction and maintenance programs to effectively utilize the resources.

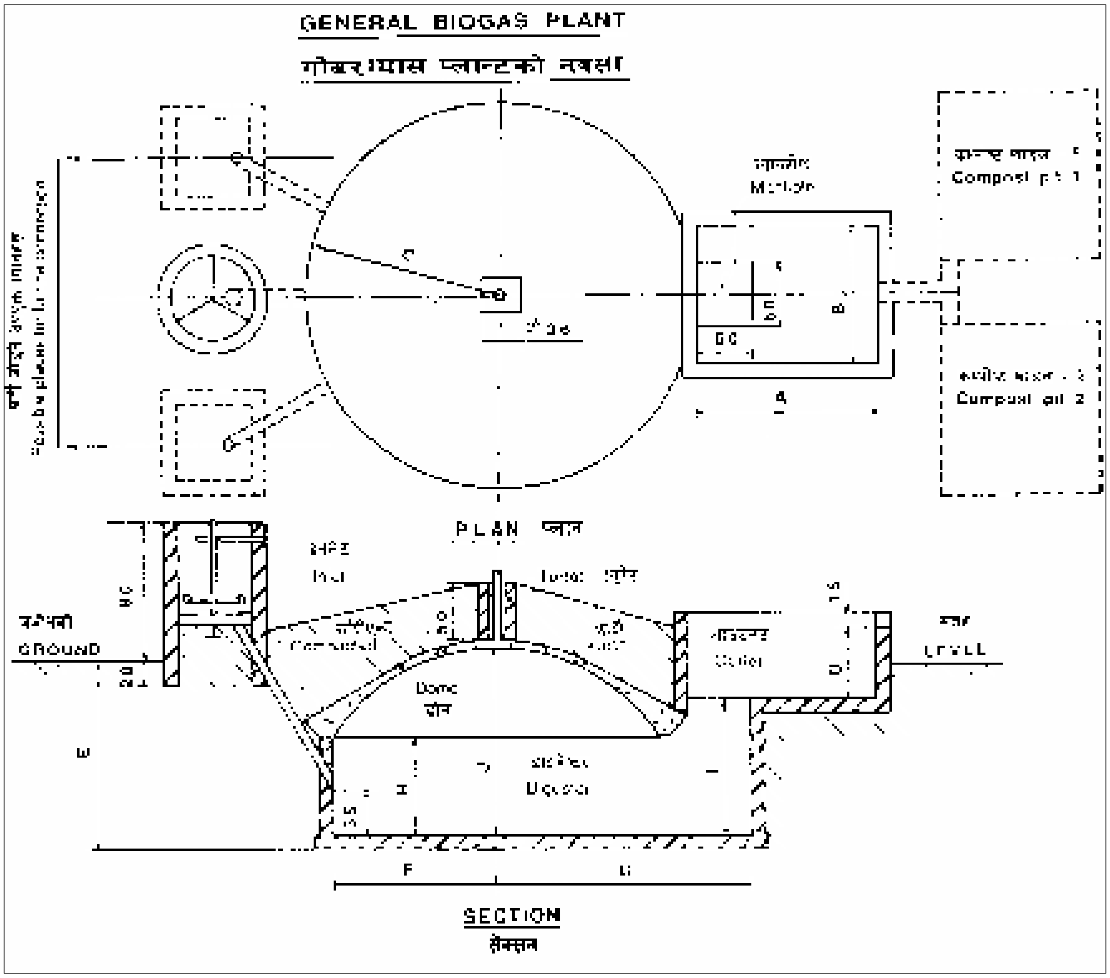
Of the 32 chronic food deficit Woredas considered in this study, 25 Woredas have all weather road network while the remaining 7 Woredas (Kemba, Zala, Ubamale, Dita Deramalo, Selamago, Maenit, Surma and Dizi) do not have reliable all weather roads. The Woredas located in Wolayita and Gamo Gofa zones have relatively good road networks.

CONSTRUCTION MANUAL

FOR

GGC 2047 MODEL BIOGAS PLANT

Plan of Biogas Model 2047



Dimensions of Biogas plant GGC 2047 in cm

Size	4 m^3	6m^3	8m^3	10m^3	15m^3	20m^3
A	140	150	170	180	248	264
B	120	120	130	125	125	176
C	135	151	170	183	205	233
D	50	60	65	68	84	86
E	154	155	172	168	180	203
F	102	122	135	154	175	199
G	185	208	221	240	261	288
H	86	92	105	94	115	115
I	112	116	127	124	132	137
J	151	160	175	171	193	203

Introduction:

The success or failure of any biogas plant mainly depends upon the quality of construction works. To come to a successfully constructed biogas plant, the mason should not only respect the dimensions as indicated on the drawing but also follow the correct construction method. Hereunder, in a step by step fashion, the right construction method of the 2047 design GGC model bigots plant is given.

1. Different Sizes of Plant:

The table below gives some relevant data about these six different sizes of biogas plants.

+ Size of plant m3	Daily Fresh Dung (Kg)		Daily Water (litre)		Approx. No. of Cattle Required
	Hill**	Terai*	Hill**	Terai*	
4	24	30	24	30	2 - 3
6	36	45	36	45	3 - 4
8	48	60	48	60	4 - 6
10	60	75	60	75	6 - 9
15	90	110	90	110	9 - 14
20	120	150	120	150	14 and more

+ Plant size is the sum of digester volume and gas storage
** Based on a hydraulic retention time of 70 days
* Based on a hydraulic retention time of 55 days

A biogas plant consists of five main structures or components. The required quantity of dung and water is mixed in the inlet tank and this mix in the form of slurry is allowed to be digested inside the digester. The gas produced in the digester is collected in the dome, called as the gas holder. The digested slurry flows to the outlet tank from the digester through the manhole. The slurry then flows through the overflow opening to the compost pit where it is collected and composted. The gas is supplied to the point of application through the pipeline.

Before deciding the size of plant, it is necessary to collect dung for several days to determine what is the average daily dung production. The amount of dung daily available helps in determining the capacity of the plant.

The important point to be considered is that size of plant has to be selected on basis of the available dung not the family size.

If a plant is underfed, the gas production will be low. In this case, the pressure of the gas might not be sufficient to displace the slurry in the outlet chamber. This means that the amount of slurry fed into the digester is more than the amount of slurry thrown out from the outlet. This will cause the slurry level to rise in the digester, gas holder and it may eventually enter to the gas pipe and sometimes to the gas stove and lamp while opening the main valve. Therefore, the slurry should always be fed according tot he prescribed amount as indicated in the above table.

2. Construction Materials:

If the construction materials to be used in the plant construction such as cement, sand, aggregate etc. are not of good quality, the quality of plant will be poor even if design and workmanship involved are excellent. In order to select these materials of best quality, their brief description regarding the specifications has been given hereunder.

a) **Cement:** The cement to be used in the plant construction has to be of high quality portland cement from a brand with a good reputation. It must be fresh, without lumps and stored in a dry place. Bags of cement should never be stacked directly on the floor or against the walls but wooden planks should be placed on the floor to protect cement from dampness.

b) **Sand:** Sand for construction purpose must be clean. Dirty sand has a very negative effect on the strength of the structure. If the sand contains 3% or more impurities, it must be washed. The quantity of impurities specially the mud in the sand can be determined by a simple test using a bottle. This is called the “bottle test”. For this test, small quantity of sand is put in the bottle. After this, water is poured in and the bottle is stirred vigorously. The bottle is then left stationary to allow the sand to settle down. The particles of sand are heavier than that of mud so it settles down quickly. After 20 - 25 minutes, the layer of mud verses sand inside the bottle are measured. Coarse and granular sand can be used for concreting work but fine sand will be better for plastering work.

c) **Gravel:** Gravel should not be too big or very small. It should not be bigger than 25% of the thickness of concrete product where it is used in. As the slabs and top of the dome are not more than 3” thick, gravel should not be larger than 0.75” (2 cm) in size. Furthermore, the gravel must be clean. If it is dirty, it should be washed with clean water.

d) **Water:** Water is mainly used for preparing the mortar for masonry work, concreting work and plastering. It is also used to soak bricks/stones before using them. Besides these, water is also used for washing sand and aggregates. It is advised not to use water from ponds and irrigation canals for these purposes as it is usually too dirty. Dirty water has an adverse effect on the strength of the structure, hence water to be used must be clean.

e) **Bricks:** Bricks must be of the best quality locally available. When hitting two bricks, the sound must be clear. They must be well baked and regular in shape. Before use, bricks must be soaked for few minutes in clean water. Such bricks will not absorb water (moisture) from the mortar afterwards.

f) **Stones:** If stones are to be used for masonry work, they have to be clean, strong and of good quality. Stones should be washed if they are dirty.

3. Construction Site Selection:

The following points should be kept in mind when deciding on a site for biogas plant construction:

- For proper functioning of the plant, the right temperature has to be maintained in the digester. Therefore, a sunny site has to be selected.
- To make plant operation easy and to avoid wastage of raw materials specially the dung, the plant must be as close as possible to the stable (cattle-shed) and water source. If the nearest water source is at a distance of more than 20 minutes walk, the burden of fetching water becomes too much and no plant should be installed in such places.
- If longer gas-pipe is used the cost will be increased as the pipe is expensive. Furthermore, longer pipe increases the risk of gas leakage due to more joints in it. The main valve has to be opened and closed before and after use. Therefore, the plant should be as close as possible to the point of use so that the above problems are eliminated.
- The edge of the foundation of the plant should be at least two metres away from the house or any other building to avoid risk of damages.
- The plant should be at least 10 metres away from the well or any other under-ground water sources to protect water from pollution.
- Sufficient space for compost pits should be available.

4. Digging and Pit Depth:

When a suitable site is selected, a small peg has to be stuck in the ground at the centre spot of the digester. A cord has to be attached to this peg with the length indicated on the drawing under dimension "C". Now this cord is the radius of the digester pit and the circumference can be decided by moving the edge of the cord on circular fashion. The pit depth is indicated on the drawing under dimension "E". The excavation work should only be started after deciding the location of manhole and outlet tank. The pit walls should be as vertical as possible and, most important, the pit bottom must be levelled and the earth must be untouched.

While digging, excavated soil should be thrown at least one foot away from the lay-out, so that it does not fall inside the pit when the construction work is in progress. After digging the pit, a suitable arrangement must be made for the inlet pipe(s).

If because of hard rock or under ground water, the right depth cannot be achieved, the pit has to be made as deep as possible, while after completion of the structure some protective measures have to be constructed so that the walls of outlet and dome is supported well from outside. (see chapter 10)

5. Construction of Round-wall

At the centre of the pit, a straight rod or pipe (the 0.5" GI gas-pipe) must be placed in an exact vertical position. At ground-level, a heavy pole or pipe has to be placed horizontally over the centre of the pit. The vertical pipe can now be secured to the horizontal pipe or pole. After securing, the vertical pipe has again to be checked whether it is still in the right position.

A string or wire can now be attached to the vertical pipe. The length of this wire can be found on the drawing under the dimension “F”. One cm has to be added to this length to allow space for plastering. Every brick or stone which is laid in the round-wall has to be exactly F + 1 cm away from the vertical pipe.

After deciding the radius of digester, the round-wall is started to be constructed. The first row of bricks must be positioned on their sides so that a 4.5” high 9” wide base is made. It is essential that first row is placed on a firm, untouched and level soil. The next rows of bricks can be positioned on their lengths so that the wall thickness becomes 4.5”. It is not necessary to make pillars in the wall but the backfilling between wall and pit-side must be compacted with great care. This backfilling has to be done in the morning before starting the construction work. Earth should be well compacted by adding water and gentle ramming all along the circumference of the digester. Poor compaction will lead to cracks in round-wall and dome.

If stone is used for the construction of round-wall, the wall should rest against the pit-side as it is difficult to have proper backfilling because of the irregular shape of the outside of the stone wall. The cement mortar used can be 1 cement - 4 sand to 1 cement - 6 sand depending on the quality of the sand.

The height of the round-wall can be found on the drawing under dimension “H” when measured from the finished floor. The dung inlet pipe and toilet pipe must be placed in position when the round-wall is 35 cm high. To reduce the risk of blockage, the inlet pipe(s) must be placed as vertical as practically possible. Exactly to the opposite of the dung inlet pipe, a 60 cm wide opening must be left in the round-wall which acts as manhole. The digested slurry also flows out to the outlet tank through this opening. The inlet pipe from the toilet should be placed as close as possible with the dung inlet pipe with a maximum distance of 45 degrees from the dung inlet on the dung inlet-centre manhole line (hartline).

When the round-wall has reached the correct height, the inside must be plastered with a smooth layer of cement mortar with a mix of 1 cement - 3 sand. The digester floor can be made from bricks or small stones with plaster in cement mortar.

6. Dome Construction:

When the construction works of round-wall as described above is completed, then the dome has to be constructed. Before filling the pit with earth to make the mould for the dome, backside of the round-wall should be filled with proper compacted backfilling. If this is not done, the pressure of the earth for the mould can lead to cracks in the round wall.

- On the vertical centre pipe, a mark has to be made at a distance “J”, as given in the drawing, from the finished floor. The compacted earth has to reach this level. The vertical pipe can now be removed by pulling it upwards. It has to be replaced by a shorter 0.5” dia. pipe, approx. 0.5 metres length in the earth exactly at the same spot. Now the template should be used to make the shape of the dome. The top of the round-wall must be clean when the template is in use. The template can be checked by making sure the top is horizontal and the side exactly vertical. Furthermore, the part of the template that touches the round-wall must be in the same position all over the round-wall.
- It is important that the earth of the mould is well compacted. If the earth is further compressed after casting the dome, by its own weight and that of the concrete, it can lead to cracks in the dome. When the earth mould has the exact shape of the template, a thin layer of find sand has to be spread on the mould-top by gently patting it on the surface. Any excess sand or soil that falls on the round-wall has to be removed. The earth used for the mould has to be damp to prevent dry earth from soaking up water from freshly concrete.
- Before starting the casting work, enough manpower and construction materials like sand, gravel, cement and water has to be collected on the site. The casting has to be done as quickly as possible and without interruptions as this will negatively affect the quality of the cast. A constant, adequate supply of concrete (mix: 1 cement, 3 sand, 3 gravel) must be made for the mason. No concrete older than 30 minutes should be used.
- A special care should be taken to maintain the thickness of dome while casting, i.e. the thickness; in and near the edges should be more than the thickness in the centre. for 6, 8, 10 & 15 cubic metres plants, the thickness in the edge should be 25 cm whereas thickness in the centre should be 7 cm. Similarly, for 4 and 20 cubic metres plats, the thickness in the centre should be 7 & 9 cm respectively and the edge should be 22 and 28 cm respectively.
- The small pipe on the top of the mould must be left in place till the main gas pipe is installed. This is to make sure that the main gas pipe is exactly in the centre.
- Already during the casting, the concrete has to be protected against strong sunlight by covering it with jute bags or straw mats. This protection has to be left in place for at least one week. The day after the casting, the turret must be made.

Any delays can lead to leakage between main gas pipe and dome. Also from the day after the casting onwards, the dome has to be sprinkled with water 3 to 4 times a day which is known as ‘curing’. After approximately one week, depending on the temperature, the earth of the mould can be removed through the manhole. When all earth is removed, the inside of the dome, has to be thoroughly cleaned with a brush and clean water.

On the clean surface the following plaster coats have to be applied to make the dome gas-tight.

a) Cement - water flush.

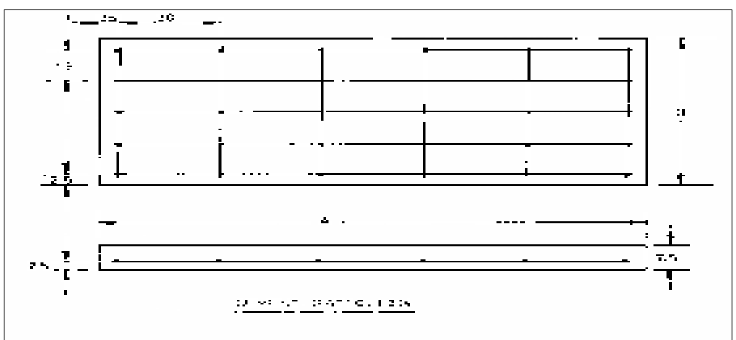
b) 10 mm layer, 1 cement - 2 sand, plaster.
c) 5 mm layer, 1 cement - 1 sand, punning.
d) Cement/acrylic emulsion paint coating, 1.5 paint - 20 cement.
e) Cement/acrylic emulsion paint coating, 1 paint - 2 cement.

A plaster coat must be at least one day old before the next layer can be put on. When a layer of plaster is applied, the work must be executed with the greatest care and without interruptions. The well - functioning of the plant is very much depending on the gas tightness of dome.

Construction of Outlet Chambers:

To construct the outlet tank, excavation has to be done just behind the manhole. The level of excavation can be measured from the digester floor by taking the dimension "I" minus the thickness of the digester floor. The earth behind the manhole and under the outlet floor has to be very well compacted otherwise cracks will occur.

- The inside dimensions of the outlet can be found on the drawing under A, B and D. The distance from the digester floor to the outlet floor is given by the dimension "I".
- It is important that these dimensions should be accurate as they determine the useful capacity of the gas holder. For the same reason the outlet floor and the top of the walls have to be in level. The walls have to be vertical and finished with a smooth layer of cement plaster (mix: 1 cement - 3 sand). On the outside, the walls have to be supported with sufficient earth body upto the overflow level. This again is to avoid cracks.



Plant Size (m3)	Slab Size Length (cm)	Width (cm)	No of slab	Diameter of Rod (mm)	Required Rod (kg)
4	145	55	3	8	10.50
6	145	58	4	8	10.50
8	155	63	3	8	13.50
10	150	66	3	8	13.50
15	150	68	4	8	15.00
20	201	72	4	10	[illegible]

The outlet tank should be on a slightly higher elevation than the surrounding so that there are no chances of water running into the outlet during the rainy season.

At the same time of dome casting, the concrete slabs for the out let should be constructed. It is easy to make some additional concrete at this time, and the slab will be well cured before they are placed on the outlet. The slabs must be 3" thick with proper reinforcement at 1" from the bottom side. The slabs must be of such size that they can be

handled by 4 - 5 men without great difficulty.
The surface on which the slabs are cast, has to be flat and clean. Special care has to be taken for the compaction of the concrete, as small holes will expose, the steel reinforcement to corrosive vapour coming from the slurry in the outlet and will cause the corrosion which may ultimately lead to the slab collapse. Hence, if holes are formed in the slab these should be blocked with plaster layer. The outlet cover slabs are essential to protect people and animals from falling inside and to avoid excessive vaporization of the slurry in dry season.

For all slabs:

1. Thickness : 3” (7.5 cm)
2. Cover : 1” (2.5 cm)
3. C/C spacing (longitudinal) : 6” (15 cm)
4. C/C spacing (cross sectional) : 1’ (30 cm)
5. Concrete ratio (cement:sand:gravel) : 1:2:4
6. Curing period : One week

Note: Casting should be done on a levelled surface and plastic sheets or empty cement bags should be used as bed sheets.

8. Construction of Inlet pit:

The inlet pit is constructed to mix dung and water. This can be constructed with or without a mixing device. Installation of mixing device is preferable not only because it makes plant operation easier for the user but also because it improves the quality of mix. When a mixer is installed it has to be firmly attached to the structure, easy to operate, effective in the mixing process and steel parts in contact with the dung are to be galvanised.

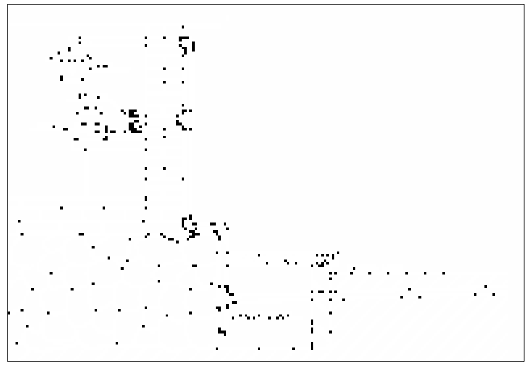
The top of the structure should not be more than one metre high nor less than 50 cm from the ground level and both inside and outside of the pit has to be covered with a smooth layer of plaster (mix: 1 cement - 3 sand).

The bottom of the tank, must be at least 5 cm above the outlet overflow level. The position of the inlet pipe in the floor must be such that pole or rod can enter through it without obstructions. For the same reason the inlet pipe must be without bends.

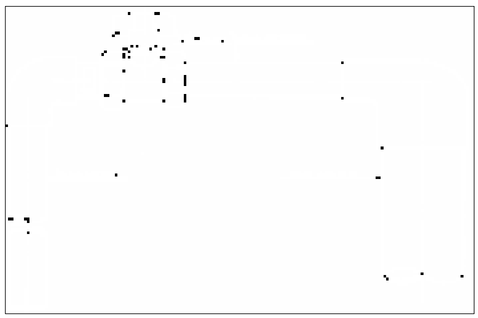
Even though mixing devices is not installed, the inlet pit should be round in shape as this is more economical material-wise and easier for hand mixing.

In case of toilet attachment to the plant it is better to construct without siphon or trap as the pan with siphon needs more water which may result excess water inside the digester. It is also not possible to de-block the pipe when the toilet has a trap. The toilet should not be farther than 45 degree from the hartline. Additionally, the toilet pan level should be at least 15 cm above the outlet overflow level.

9. Lay-out of Pipeline:



The gas pipe conveying the gas from the plant to users point is vulnerable for damages by people, domestic animals and rodents. Therefore, only light quality galvanised iron pipe should be used which must be, where possible, buried 1 foot below ground level. Fittings in the pipeline must be sealed with zinc putty and Teflon tape. Any other sealing agent, like grease, paint only, soap etc. must not be allowed. To reduce the risk of leakage, the use of fittings, specially



unions, should be kept to a necessary minimum. No fittings should be placed between the main gas valve and the dome gas pipe.

The biogas coming from the digester is saturated with water vapour. This water vapour will condense at the walls of the pipeline. If this condensed water is not removed regularly, it will ultimately clog the pipeline. Hence, a water drain has to be placed in the pipeline. The position of the water drain should be inclined below the lowest point of the pipeline so that water will flow by gravity to the trap. Water can be removed by opening the drain. As this has to be done periodically the drain must be well accessible and protected in a well-maintained drain pit.

For connecting burners with gas pipeline, use of transparent polyethylene hose must be avoided. Only neoprene rubber hose of the best quality should be used.

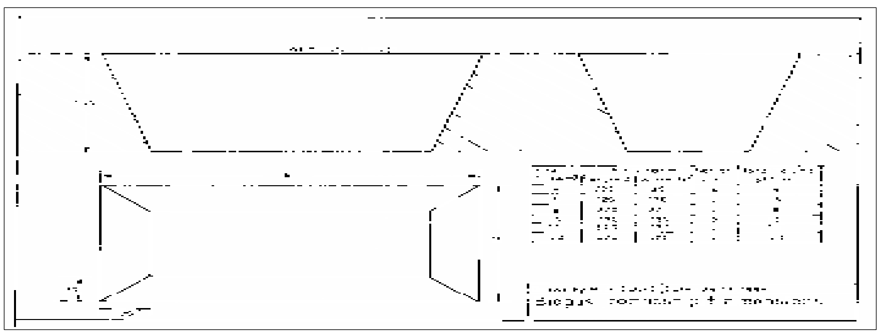
As soon as there is gas production, all joints and taps must be checked for leakage by applying a thick soap solution. If there is leakage the foam will either move or break.

10. Compost Pits:

Compost pits are an integral of the biogas plant: no plant is complete without them. a minimum of 2 compost pits must be dug near to the outlet overflow in such a way that the slurry can run freely into the pits. Enough earth body must remain however, at least 1 metre, between the pits and the outlet chamber to avoid cracking of the chamber walls. The total volume of the compost pits must be at least equal to the plant volume.

To make a potent and easy to use as fertiliser, the compost pits should be filled with agricultural residues together with the slurry from the plant.

The earth coming from digging the compost pits can be used for backfilling of the inlet and outlet chamber and for top filling over the dome.

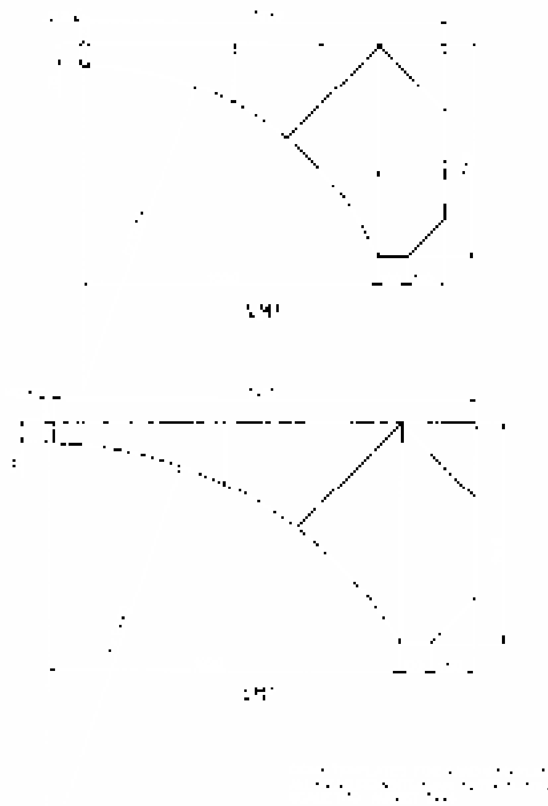


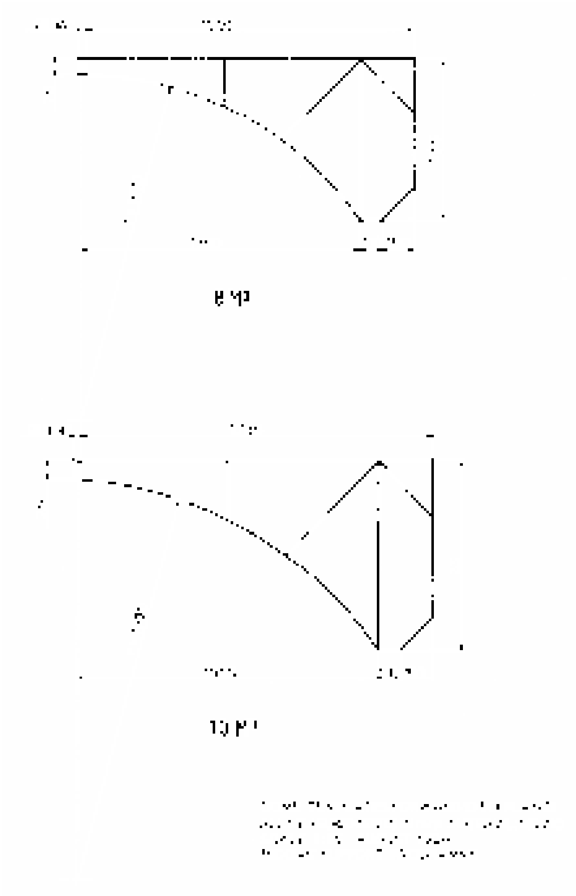
For proper insulation during the cold season and as counter-weight against the gas pressure inside, a minimum top filling 40 cm compacted earth is required on the dome. If e.g. because of high ground water table, the plant is not positioned deep enough, the top filling will be prone to erosion due to wind and rain. In these cases, proper protection, i.e. with a dry stone circular wall, has to be applied.

Notes:

1. Length and width mentioned in the above table can be changed according to the space available without changing the volume of the pits.
2. If possible Length, Width should be doubled.
3. Depth of the pit should not exceed 1 metre (100 cm) due to safety reason.

If the concerned mason and plumber strictly follow the above described instructions during the construction phase, the complete plant will be of high quality. Hence, the plant owner will be benefited ultimately from the investment and positive return will be achieved as per the expectations. This again will persuade his relative and neighbours to install a biogas plant as well, while a poorly constructed plant will do harm to the reputation of biogas technology.





Dome templates 4 6 8 & 10 M^3

Annex 4
Expected results

Activity	Rate	Unit	1	2	3	4	5	Total	
Biogas plant construction	*annual*	[# of plants/yr]	200	800	2000	3000	4000	**10000**	[plants]
	cumulative	[# of plants]	200	1000	3000	6000	10000		
Energy									
Energy production	9.80	[GJ/plant/yr]	1960	9800	29400	58800	98000	**197,960**	[GJ]
Power installed (nett)	1.65	[kW_{th}/plant]	330	1650	4950	9900	16500	**33,330**	[kW]
Environment									
GHG emission reduction	2	[tons CO_2 eq/plant/yr]	400	2000	6000	12000	20000	**40,400**	[t CO_2eq]
Fuel substitution									
Biomass									
Agricultural residue	0.45	[tons agric res/plant/yr]	90.6	453	1359	2718	4530	**9,151**	[t]
Dung cake	0.63	[tons dungcake/plant/yr	125.6	628	1884	3768	6280	**12,686**	[t]
Fuelwood	1.76	[tons fuelwood/plant/yr]	351.6	1758	5274	10548	17580	**35,512**	[t]
Charcoal	0.01	[tons charcoal/plant/yr]	1.8	9	27	54	90	**1,818**	[t]
Total biomass	2.93	[tons biomass/plant/yr]	**585.8**	**2929**	**8787**	**17574**	**29290**	**59,166**	[t biomass]
Fossil									
Kerosene	0.003	[tons/plant/yr]	0.6	3	9	18	30	**61**	[t]
Socio-economic									
Persons reached (female)	3	[pers/biogas hh]	600	2400	6000	9000	12000	**30,000**	[women]
Persons reached (male)	3	[pers/biogas hh]	600	2400	6000	9000	12000	**30,000**	[man]
Workload reduction (women & children)	0.1	[pers-year/plant/yr]	20	100	300	600	1000	**2,020**	[pers years]
Exposure to indoor air pollution reduced (w	3	[pers/biogas hh]	600	2400	6000	9000	12000	**30,000**	[women & children]
Toilets attached	50%	[connection rate]	100	400	1000	1500	2000	**5,000**	[toilets]
Productive surry use	80%	[inclusion rate]	160	640	1600	2400	3200	**8,000**	[households]
Employment generation (direct)	0.07	[pers-year/plant]	14	56	140	210	280	**700**	[person years]
Training									
User training									
Pre construction training (female)	0.2	[pers-day/plant]	40	160	400	600	800	**2,000**	[person days]
Pre construction training (male)	0.3	[pers-day/plant]	60	240	600	900	1200	**3,000**	[person days]
Post construction training (female)	0.4	[pers-day/plant]	80	320	800	1200	1600	**4,000**	[person days]
Post construction training (male)	0.1	[pers-day/plant]	20	80	200	300	400	**1,000**	[person days]
Bio-slurry extension (female)	0.2	[pers-day/plant]	40	160	400	600	800	**2,000**	[person days]
Bio-slurry extension (male)	0.2	[pers-day/plant]	40	160	400	600	800	**2,000**	[person days]
Total User Training	1.4	[pers-day/plant]	**280**	**1120**	**2800**	**4200**	**5600**	**14,000**	[person days]
Professional training									
Project management & administration	0.003	[pers-day/plant]	1	3	7	10	13	**33**	[person days]
Biogas technology	0.054	[pers-day/plant]	11	43	108	162	216	**540**	[person days]
Biogas technology refresher	0.027	[pers-day/plant]	5	21	53	80	107	**267**	[person days]
Biogas construction	0.090	[pers-day/plant]	18	72	180	270	360	**900**	[person days]
Biogas construction refresher	0.053	[pers-day/plant]	11	43	107	160	213	**533**	[person days]
Operation check	0.040	[pers-day/plant]	8	32	80	120	160	**400**	[person days]
Biogas extension	0.007	[pers-day/plant]	1	5	14	20	27	**68**	[person days]
Total professional training	0.274	[pers-day/plant]	**55**	**219**	**548**	**822**	**1096**	**2,741**	[person days]

1 Production planning

Production per Region / Woreda per year

Region	Woreda	Total	Distribution by years 1	2	3	4	5
Amhara	1	**600**	50	100	100	150	200
	2	**500**		50	100	150	200
	3	**500**		50	100	150	200
	4	**450**			100	150	200
	5	**450**			100	150	200
	Total region	**2500**	**50**	**200**	**500**	**750**	**1000**

Region	Province	Total	Distribution by years 1	2	3	4	5
Oromia	1	**600**	50	100	100	150	200
	2	**500**		50	100	150	200
	3	**500**		50	100	150	200
	4	**450**			100	150	200
	5	**450**			100	150	200
	Total region	**2500**	**50**	**200**	**500**	**750**	**1000**

Region	Province	Total	Distribution by years 1	2	3	4	5
SNNPRS	1	**600**	50	100	100	150	200
	2	**500**		50	100	150	200
	3	**500**		50	100	150	200
	4	**450**			100	150	200
	5	**450**			100	150	200
	Total region	**2500**	**50**	**200**	**500**	**750**	**1000**

Region	Province	Total	Distribution by years 1	2	3	4	5
Tigray	1	**600**	50	100	100	150	200
	2	**500**		50	100	150	200
	3	**500**		50	100	150	200
	4	**450**			100	150	200
	5	**450**			100	150	200
	Total region	**2500**	**50**	**200**	**500**	**750**	**1000**

Region	Total	Distribution by years 1	2	3	4	5
Amhara	**2500**	50	200	500	750	1000
Oromia	**2500**	50	200	500	750	1000
SNNPRS	**2500**	50	200	500	750	1000
Tigray	**2500**	50	200	500	750	1000
Total project (*allocated*)	**10000**	**200**	**800**	**2000**	**3000**	**4000**
Production share/year	***100%***	*2%*	*8%*	*20%*	*30%*	*40%*

		Distribution by years 1	2	3	4	5
Cum # of Wor / Reg	5	1	3	5	5	5
Cum # of Wor / project	20	4	12	20	20	20
Number of Regions	4					
Avg prod / Woreda		50	67	100	150	200
Avg prod / Region		50	200	500	750	1000

2 Subsidy levels.

Subsidy levels EBP					
			rates		
	Subsidy level	ETB	Euro	USD	share
1	Regular	1,500	144.09	171.43	100%
2	High	2,000	192.12	228.57	0%
	Avg subsidy	**1,500**	**144.09**	**171.43**	100%

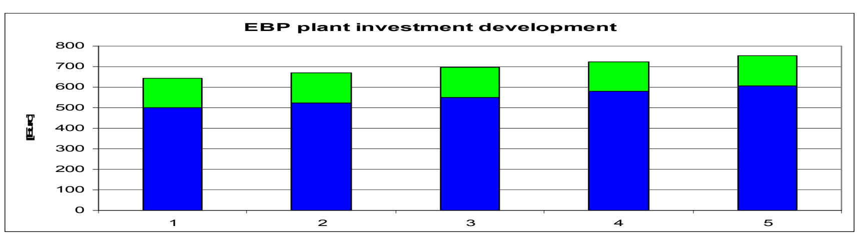
Annual subs requirement	1	2	3	4	5	[Euro] Total
# of plants	*200*	*800*	*2000*	*3000*	*4000*	*10000*
Subsidy requirement	28,818	115,274	288,184	432,277	576,369	1,440,922

3 Direct investment.

Investment costs / plant	1	2	3	4	5	[Euro] AVG
Plant investment costs	**500.00**	525.00	551.25	578.81	607.75	579.00
Investment subsidy	**144.09**	144.09	144.09	144.09	144.09	144.09
Farmer investment	**355.91**	**380.91**	**407.16**	**434.72**	**463.66**	**434.90**
Subsidy share:	*29%*	*27%*	*26%*	*25%*	*24%*	*25%*

Direct investment EBP *(inflation correction in farmer investment)*	2006	2007	2008	2009	2010	[Euro] total
Annual production biogas plants	*200*	*800*	*2000*	*3000*	*4000*	*10000*
Farmer investment (avg)	71,182	304,726	814,316	1,304,161	1,854,644	**4,349,028**
Investment subsidy (avg)	28,818	115,274	288,184	432,277	576,369	**1,440,922**
Total direct investment	**100,000**	**420,000**	**1,102,500**	**1,736,438**	**2,431,013**	**5,789,950**

Avg farmer investment / plant	435
Avg investment subsidy / plant	144
Total direct investment / plant	**579**



4 Investment credit.

Investment costs / plant	1	2	3	4	5 [Euro]
Farmer investment (avg)	**355.91**	**380.91**	**407.16**	**434.72**	**463.66**

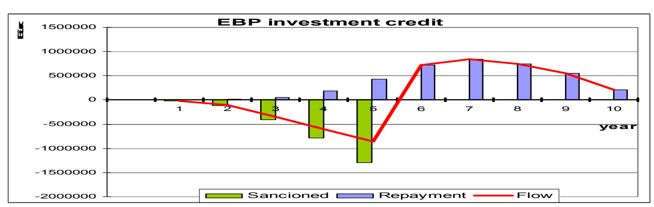
Estimated # of credit plants	1	2	3	4	5	[# of plants] Total
Construction	*200*	*800*	*2000*	*3000*	*4000*	*10000*
Est investment share requested	30%	40%	50%	60%	70%	
# of credit plants	**60**	**320**	**1000**	**1800**	**2800**	***5980***
Credit	60	320	1000	1800	2800	***5980***
Cash	140	480	1000	1200	1200	***4020***
Total	200	800	2000	3000	4000	***10000***

Proposed credit conditions		
Interest rate	12%	[% per year]
Maturity	5	[year]
Grace period	1	[year]

Credit costs per plant	1	2	3	4	5 [Euro]
Principal	- 355.91	- 380.91	- 407.16	- 434.72	- 463.66
Interest over grace period	- 42.71	- 45.71	- 48.86	- 52.17	- 55.64
PMT (annual)	117.18	125.41	134.05	143.12	152.65
Total repayment (end of year 5)	**511.42**	**547.34**	**585.06**	**624.67**	**666.25**
Financing costs	155.51	166.43	177.90	189.95	202.59

Investment financing	1	2	3	4	5	[Euro] Total
Total prinicpal	21,354	121,890	407,158	782,497	1,298,251	**2,631,150**
Financing costs	9,331	53,259	177,903	341,902	567,255	**1,149,649**
						3,780,798

Summary project credit requirement						[Euro]
Year		**Sancioned**		**Repayment**		**Flow**
1	-	21,354		1,281	-	20,073
2	-	121,890		12,110	-	109,780
3	-	407,158		58,839	-	348,319
4	-	782,497		185,566	-	596,931
5	-	1,298,251		434,869	-	863,382
6				726,930		726,930
7				839,169		839,169
8				752,079		752,079
9				556,241		556,241
10				213,714		213,714
Totals	-	**2,631,150**		**3,780,798**		**1,149,649**



5 Regional support budget.

Provincial support budget

1	Promotion & marketing	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
1.1	Region / Woreda - level prom cpgn	# of cpgn	1	3	5	5	5	19	1,000	1,000	3,000	5,000	5,000	5,000	19,000
1.2	Biogas awareness wsp (25 pers)	# of wsps	4	16	40	60	80	200	100	400	1,600	4,000	6,000	8,000	20,000
1.3	Hh assessment & registration	# of hh	50	200	500	750	1000	2500	1	50	200	500	750	1,000	2,500
	Total promotion									1,450	4,800	9,500	11,750	14,000	41,500

2	Quality management	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
		[control %]													
2.1	Annual operation check	100%	50	250	750	1500	2500	5050	1.00	50	250	750	1,500	2,500	5,050
2.2	Plant control & acceptance	100%	50	200	500	750	1000	2500	5.00	250	1,000	2,500	3,750	5,000	12,500
2.3	QC completed	10%	5	20	50	75	100	250	6.00	30	120	300	450	600	1,500
2.4	QC under construction	5%	3	10	25	38	50	125	10.00	25	100	250	375	500	1,250
2.4	Q administration	# of reports	108	480	1325	2363	3650	7925	0.50	54	240	663	1,181	1,825	3,963
	Total quality management									409	1,710	4,463	7,256	10,425	24,263

3	Training	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
3.10	Biogas Extension workers	# of persons	1	5	15	30	50	101							
3.11	Kebele Extension worker (10 pers)	# of trg crs	1		2	3	5	11	200	200	-	400	600	1,000	2,200
3.12	KEW biogas refresher trg (10 pers)	# of trg crs		1		2	3	6	200	-	200	-	400	600	1,200
3.21	Biogas mason refresher wsp (20 pers)	# of trg crs		2	6	14	16	38	400	-	800	2,400	5,600	6,400	15,200
3.4	User trg pre-cons (25 pers)	# of trg crs	2	8	20	30	40	100	100	200	800	2,000	3,000	4,000	10,000
3.4	User trg op & maint (25 pers)	# of trg crs	2	8	20	30	40	100	100	200	800	2,000	3,000	4,000	10,000
	Total training									600	2,600	6,800	12,600	16,000	38,600

4	Extension	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
4.1	Demo slurry plots	# of plots	10	10	10	10	10	50	30	300	300	300	300	300	1,500
4.2	Slurry applicaltion wsps (10 hh)	# of wsps		10	25	40	50	125	100	-	1,000	2,500	4,000	5,000	12,500
4.3	Demo 3 in 1 & 4 in 1 plants	# of plants			10			10	500	-	-	5,000	-	-	5,000
4.4	3 in 1 & 4 in 1 plant wsp (15 pers)	# of wsps				5	5	10	200	-	-	-	1,000	1,000	2,000
4.5	3 in 1 & 4 in 1 plant follow up	visit/plant				10	10	20	10	-	-	-	100	100	200
	Total extension									300	1,300	7,800	5,400	6,400	21,200

5	Operational expenses	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
5.1	IT equipment	set	1					1	2,000	2,000	-	-	-	-	2,000
5.2	PILS equipment	set	2	2	2			6	300	600	600	600	-	-	1,800
6.2	Transport	m/cycle	2	2	2			6	2,000	4,000	4,000	4,000	-	-	12,000
6.3	Salary support	ls/month	12	12	12	12	12	60	200	2,400	2,400	2,400	2,400	2,400	12,000
6.4	Support operational costs	ls/month	12	12	12	12	12	60	200	2,400	2,400	2,400	2,400	2,400	12,000
	Total operational expenses									11,400	9,400	9,400	4,800	4,800	39,800

Summary Regional Support Budget *(total programme, not corrected for inflation)* *[Euro]*

# of regions: 4	Budget 1	2	3	4	5	total
1 Promotion & marketing	5,800	19,200	38,000	47,000	56,000	**166,000**
2 Quality management	1,635	6,840	17,850	29,025	41,700	**97,050**
3 Training	2,400	10,400	27,200	50,400	64,000	**154,400**
4 Extension	1,200	5,200	31,200	21,600	25,600	**84,800**
5 Operational expenses	45,600	37,600	37,600	19,200	19,200	**159,200**

6 National support budget

1	Promotion & marketing	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
1.01															
1.02	Dev & repr prom material	ls/year	1	1	1	1	1	5	4,500.00	4,500	4,500	4,500	4,500	4,500	22,500
1.03	EBP PR material	ls/year	1	1	1	1	1	5	2,500.00	2,500	2,500	2,500	2,500	2,500	12,500
1.04	Promotion activities	ls/year	1	1	1	1	1	5	7,500.00	7,500	7,500	7,500	7,500	7,500	37,500
										-	-	-	-	-	-
1.11	Assessment survey existing plants	survey	4		4			8	500.00	2,000	-	2,000	-	-	4,000
1.12	Refurbishment support exisitng plants	ls/plant	10	40	100	150	200	500	300.00	3,000	12,000	30,000	45,000	60,000	150,000
	Total promotion									**19,500**	**26,500**	**46,500**	**59,500**	**74,500**	**226,500**

2	Finance	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
2.01	Subsidy transfer & administration	# of transfers	200	800	2000	3000	4000	10000	2.00	400	1,600	4,000	6,000	8,000	20,000
2.11	Auditing	# of audits	1	1	1	1	1	5	3,000.00	3,000	3,000	3,000	3,000	3,000	15,000
2.12	Financial monitoring	# of regions	8	8	8	8	8	40	500.00	4,000	4,000	4,000	4,000	4,000	20,000
	Total finance									**7,400**	**8,600**	**11,000**	**13,000**	**15,000**	**55,000**

3	Construction & aftersales service	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
3.01	Biogas business development strategy	survey		1			1	2	3,000.00	-	3,000	-	-	3,000	6,000
3.02	Biogas business dev seminar (50pers)	# of seminar		6	6	6		18	1,500.00	-	9,000	9,000	9,000	-	27,000
3.03	BCT assessment & coaching	# of BCT		20	20	20		60	500.00	-	10,000	10,000	10,000	-	30,000
3.11	BCT Association support	# of assoc			4	4	4	12	250.00	-	-	1,000	1,000	1,000	3,000
	Total construction & a.s.s.									**-**	**22,000**	**20,000**	**20,000**	**4,000**	**66,000**

4	Quality assurance	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
		[control %]													
4.01	QCE completed	2%	20	30	40	60	80	230	50.00	1,000	1,500	2,000	3,000	4,000	11,500
4.02	QCE under construction	1%	10	15	20	30	40	115	75.00	750	1,125	1,500	2,250	3,000	8,625
4.03	Q administration	# of reports	460	1965	5360	9540	14720	32045	0.20	92	393	1,072	1,908	2,944	6,409
4.11	QM IT-equipment	ls/year	4			2		6	1,500.00	6,000	-	-	3,000	-	9,000
4.12	QM IT-software & maint	ls/year	1	1	1	1	1	5	500.00	3,500	500	500	500	500	5,500
4.13	PILS & GIS equipment	ls/year	4	1	1	2	1	9	500.00	2,000	2,500	500	1,000	500	6,500
	Total quality management									**13,342**	**6,018**	**5,572**	**11,658**	**10,944**	**47,534**

5	Training	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
5.11	Regional project admin trg	# of wsp	1						1,000.00	1,000	-	-	-	-	1,000
5.12	Regional project admin refresher trg	# of wsp		1	1	1	1	4	500.00	-	500	500	500	500	2,000
5.13	Regional Dbase trg (5 pers)	# of wsp		1				1	1,500.00	-	1,500	-	-	-	1,500
5.14	Regional Dbase refresher trg (5 pers)	# of wsp			1	1	1	3	500.00	-	-	500	500	500	1,500
5.20	Mason	# of persons	8	24	56	64	96	248							
5.21	Biogas mason trg courses (20 pers)	# of trg crs	1	2	3	4	5	15	3,000.00	3,000	6,000	9,000	12,000	15,000	45,000
5.22	Biogas comp business dev trg (10 pers)	# of trg crs		1	2	3	4	10	2,000.00	-	2,000	4,000	6,000	8,000	20,000
5.30	Technician	# of persons	12	12	8										
5.31	Biogas Technician trg (12 pers)	# of wsp	1	1	1	1		4	3,500.00	3,500	3,500	3,500	3,500	-	14,000
5.32	Biogas Technician refr trg (10 pers)	# of wsp		1	1	1	1	4	1,000.00	-	1,000	1,000	1,000	1,000	4,000
5.33	Plant loc & id sys trg (10pers)	# of wsp	1	1	1	1		4	2,100.00	2,100	2,100	2,100	2,100	-	8,400
5.34	Plant loc & id sys refr trg (10 pers)	# of wsp		1	1	1	1	4	1,400.00	-	1,400	1,400	1,400	1,400	5,600
5.35	ToT supp Technician trg	# of trg		1	1	1	1	4	750.00	-	750	750	750	750	3,000
5.36	Technician exchange wsp	# of wsp	1	2	2	2	2	9	500.00	500	1,000	1,000	1,000	1,000	4,500
5.31	GGC 2047 piloting	ls	1	1						8,000	8,000				16,000
5.32	Consultancy trg development	# of adv days	40					40	300.00	12,000	-	-	-	-	12,000
5.33	Curricula dev technical trg	ls/curr	2		2		2	6	1,000.00	2,000	-	2,000	-	2,000	6,000
5.34	Dev & distrib technical manuals	ls/year	3		2		1	6	1,000.00	3,000	-	2,000	-	1,000	6,000
	Total training									**35,100**	**27,750**	**27,750**	**28,750**	**31,150**	**150,500**

6	Extension	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
6.01	Bio-slurry application study	study	1		1		1	3	4,000.00	4,000	-	4,000	-	4,000	12,000
6.02	Dev bio-slurry manual	ls/year		1		1		2	500.00	-	500	-	500	-	1,000
6.03	3 in 1 and 4 in 1 prom mat dev	ls/year	1		1			2	750.00	750	-	750	-	-	1,500
6.04	Print & distrib ext material	ls/plant	200	800	2000	3000	4000	10000	1.25	250	1,000	2,500	3,750	5,000	12,500
	Total extension									**5,000**	**1,500**	**7,250**	**4,250**	**9,000**	**27,000**

7	Institutional support	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
7.01	Biogas Advisory Board establishment	study	1				1	**2**	1,500.00	1,500	-	-	-	1,500	**3,000**
7.02	BAB support	ls/yr	1	1	1	1	1	**5**	1,250.00	1,250	1,250	1,250	1,250	1,250	**6,250**
7.03	Training & staff development facility	ls/region/yr	4	4	4	4	4	**20**	4,000.00	16,000	16,000	16,000	16,000	16,000	**80,000**
7.04	Infrastructure improvement facility	ls/region/yr	4	4	4	4	4	**20**	3,000.00	12,000	12,000	12,000	12,000	12,000	**60,000**
7.11	Biogas sector development	study	1				1	**2**	1,500.00	1,500	-	-	-	1,500	**3,000**
	Total research & development									**32,250**	**29,250**	**29,250**	**29,250**	**32,250**	**152,250**

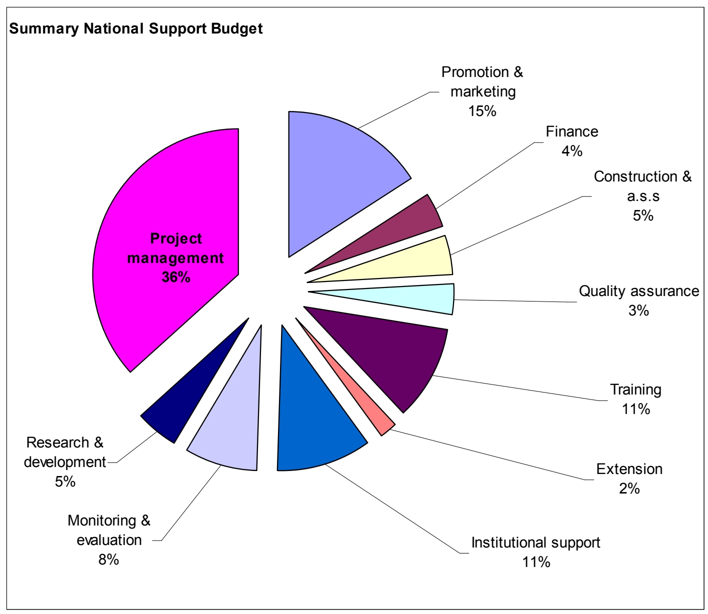
8	Monitoring & evaluation	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
8.01	Domestic energy baseline	survey	4	8	8				1,000.00						
8.02	Biogas user survey	survey		1	1	1	1	**4**	8,000.00	-	8,000	8,000	8,000	8,000	**32,000**
8.11	Biogas & environmental impact	study			1		1	**2**	4,000.00	-	-	4,000	-	4,000	**8,000**
8.12	Biogas & gender	study	1		1		1	**3**	6,000.00	6,000	-	6,000	-	6,000	**18,000**
8.21	External project progress evaluation	evaluation		1		1		**2**	8,000.00	-	8,000	-	8,000	-	**16,000**
8.22	External final project evaluation	evaluation					1	**1**	20,000.00						
8.21	MSc / BSc study support	ls/study	8	8	8	8	8	**40**	1,000.00	8,000	8,000	8,000	8,000	8,000	**40,000**
	Total extension									**14,000**	**24,000**	**26,000**	**24,000**	**26,000**	**114,000**

9	R & D / Standardization	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
9.01	Constr std development & formulation	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.02	A.S.S std development & fomulation	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.03	Appliances std dev & formulation	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.04	Standards printing & distribution	booklet	50		50			**100**	10.00	500	-	500	-	-	**1,000**
9.05	3 in 1 and 4 in 1 development	study	1					**1**	3,000.00	3,000	-	-	-	-	**3,000**
9.06	R&D support	ls/study	1	2	1	1	1	**6**	1,000.00	1,000	2,000	1,000	1,000	1,000	**6,000**
9.07	Dev & distrib techn instruct. material	ls	1	1	1	1		**4**	3,000.00	3,000	3,000	3,000	3,000	-	**12,000**
9.11	Technician manual development	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.12	Technician manual distribution	booklet	50		50			**100**	12.50	625	-	625	-	-	**1,250**
9.21	Mason manual development	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.22	Mason manual distribution	booklet	100		100		100	**300**	10.00	1,000	-	1,000	-	1,000	**3,000**
9.31	KEW manual development	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.32	KEW manual distribution	booklet	200		200		200	**600**	5.00	1,000	-	1,000	-	1,000	**3,000**
9.41	User manual development	ls	1					**1**	1,500.00	1,500	-	-	-	-	**1,500**
9.42	User pre-construction flyer distribution	booklet	200	800	2000	3000	4000	**10000**	0.20	40	160	400	600	800	**2,000**
9.43	User pre-construction flyer distribution	booklet	200	800	2000	3000	4000	**10000**	1.50	300	1,200	3,000	4,500	6,000	**15,000**
9.51	R&D biogas stove	ls	1					**1**	3,000.00	3,000	-	-	-	-	**3,000**
9.52	R&D biogas taps / watertrap	ls			1			**1**	500.00	-	-	500	-	-	**500**
9.53	R&D biogas lamp	ls		1				**1**	3,000.00	-	3,000	-	-	-	**3,000**
9.54	R&D biogas metad	ls				1		**1**	3,000.00	-	-	-	3,000	-	**3,000**
	Total research & development									**23,965**	**9,360**	**11,025**	**12,100**	**9,800**	**66,250**

10	Project management	unit	Planned activities						rate	Budget					
			1	2	3	4	5	total		1	2	3	4	5	total
10.11	Coordinator	pers month	12	12	12	12	12	**60**	750.00	9,000	9,000	9,000	9,000	9,000	**45,000**
10.12	Administrator	pers month	12	12	12	12	12	**60**	600.00	7,200	7,200	7,200	7,200	7,200	**36,000**
10.13	IT / GIS systems officer	pers month	12	12	12	12	12	**60**	450.00	5,400	5,400	5,400	5,400	5,400	**27,000**
10.14	Promotion & marketing officer	pers month	6	12	12	12	12	**54**	300.00	1,800	3,600	3,600	3,600	3,600	**16,200**
10.15	Chief Biogas Engineer	pers month	12	12	12	12	12	**60**	600.00	7,200	7,200	7,200	7,200	7,200	**36,000**
10.16	Biogas Engineer	pers month	12	24	24	36	36	**132**	350.00	4,200	8,400	8,400	12,600	12,600	**46,200**
10.30	Avg # of national office support staff	# of pers	**6**	**7**	**7**	**8**	**8**								
10.31	TA/DA NBPO support staff	days out	420	600	600	720	720	**3060**	10.00	4,200	6,000	6,000	7,200	7,200	**30,600**
10.32	Transportation	trip km	27500	35000	35000	40000	40000	**177500**	0.30	8,250	10,500	10,500	12,000	12,000	**53,250**
10.33	Additional support staff costs	pers month	6	7	7	8	8	**36**	969.01	5,330	6,783	6,783	7,752	7,752	**34,400**
10.34	Indirect support staff costs	ls/pers month	6	7	7	8	8	**36**	484.51	2,665	3,392	3,392	3,876	3,876	**17,200**
10.35	Staff development	ls/pers	6	7	7	8	8	**36**	484.51	2,665	3,392	3,392	3,876	3,876	**17,200**
10.41	Other programme expenses	ls/month	12	12	12	12	12	**60**	1,000.00	12,000	12,000	12,000	12,000	12,000	**60,000**
10.42	Utilities	ls/month	12	12	12	12	12	**60**	500.00	6,000	6,000	6,000	6,000	6,000	**30,000**
10.43	Office expenses	ls/month	12	12	12	12	12	**60**	500.00	6,000	6,000	6,000	6,000	6,000	**30,000**
10.44	Office furniture	ls						**0**		8,000	750	2,000	1,000	1,000	**12,750**
10.45	Office equipment	ls						**0**		20,000	1,000	10,000	1,000	1,000	**33,000**
	Total operational expenses									**109,909**	**96,616**	**106,866**	**105,704**	**105,704**	**524,800**

Summary National Support Budget		*(not corrected for inflation)*					*[Euro]*
		Budget					
		1	**2**	**3**	**4**	**5**	**total**
1	Promotion & marketing	19,500	26,500	46,500	59,500	74,500	**226,500**
2	Finance	7,400	8,600	11,000	13,000	15,000	**55,000**
3	Construction & a.s.s	-	22,000	20,000	20,000	4,000	**66,000**
4	Quality assurance	13,342	6,018	5,572	11,658	10,944	**47,534**
5	Training	35,100	27,750	27,750	28,750	31,150	**150,500**
6	Extension	5,000	1,500	7,250	4,250	9,000	**27,000**
7	Institutional support	32,250	29,250	29,250	29,250	32,250	**152,250**
8	Monitoring & evaluation	14,000	24,000	26,000	24,000	26,000	**114,000**
9	Research & development	23,965	9,360	11,025	12,100	9,800	**66,250**
10	Project management	109,909	96,616	106,866	105,704	105,704	**524,800**
National Support Budget		**260,466**	**251,594**	**291,213**	**308,212**	**318,348**	**1,429,834**
Contingencies	**5%**	13,023	12,580	14,561	15,411	15,917	**71,492**
Total National Support Budget		**273,489**	**264,174**	**305,774**	**323,623**	**334,266**	**1,501,326**

National support bgt / plant *150.13*



7 Technical assistance.

1	Technical assistance	unit	Planned activities 1	2	3	4	5	total	rate	Budget 1	2	3	4	5	total
1.01	Senior Technical Advisor (EUN)	pers month	12	10	8	6	4	**40**	9,600.00	115,200	96,000	76,800	57,600	38,400	**384,000**
1.02	Junior Technical Advisor (EUN)	pers month		12	10	8	4	**34**	7,000.00	-	84,000	70,000	56,000	28,000	**238,000**
1.11	Senior Technical Advisor (HCN)	pers month	12	12	12	12	12	**60**	1,400.00	16,800	16,800	16,800	16,800	16,800	**84,000**
1.12	Junior Technical Advisor (HCN)	pers month	12	12	12	12	12	**60**	1,000.00	12,000	12,000	12,000	12,000	12,000	**60,000**
1.21	Additonal advisory services	pers month	3	3	3	3	3	**15**	2,000.00	6,000	6,000	6,000	6,000	6,000	**30,000**
1.22	Other support expenses	ls/yr	1	1	1	1	1	**5**	5,000.00	5,000	5,000	5,000	5,000	5,000	**25,000**
	Total TA									**155,000**	**219,800**	**186,600**	**153,400**	**106,200**	**821,000**

8 Summary

Summary project budget	(corrected for inflation)					[Euro]		[Euro]
	BP II summary project budget							
	2006	2007	2008	2009	2010	total	/ plant	share
1a Farmer investment	71,182	304,726	814,316	1,304,161	1,854,644	**4,349,028**	434.90	44%
1b Credit financing costs	9,331	53,259	177,903	341,902	567,255	**1,149,649**	114.96	12%
1c Investment subsidy	28,818	115,274	288,184	432,277	576,369	**1,440,922**	144.09	14%
2a Regional support *(RBPO)*	59,467	83,202	159,443	175,586	216,825	**694,523**	69.45	7%
2b National support *(NBPO)*	273,489	264,174	305,774	323,623	334,266	**1,501,326**	150.13	15%
2c Technical assistance	155,000	219,800	186,600	153,400	106,200	**821,000**	82.10	8%
Total project	**597,287**	**1,040,434**	**1,932,219**	**2,730,949**	**3,655,558**	**9,956,447**	**995.64**	**100%**

Application of funds	[Euro]	[%]	per plant [Euro]
1 Investment			
1a Farmer investment	4,349,028	63%	434.90
1b Credit fiancing costs	1,149,649	17%	114.96
1c Investment subsidy	1,440,922	21%	144.09
Total investment	**6,939,599**	*70%*	**693.96**
2 Programme support			
2a Regional support RBPO	694,523	23%	69.45
2b National support NBPO	1,501,326	50%	150.13
2c Technical assistance	821,000	27%	82.10
Total project support	**3,016,848**	*30%*	**301.68**
Total application	**9,956,447**		**996**

Source of funds	[Euro]	[%]	per plant [Euro]
a Farmers			
a1 Farmer investment	4,349,028	79%	434.90
a2 Credit financing costs	1,149,649	21%	114.96
Total participating farmers	**5,498,676**	*55%*	**549.87**
b Donor / host government			
b1 Investment subsidy	1,440,922	40%	144.09
b2 Regional support	694,523	19%	69.45
c1 National support	1,501,326	41%	150.13
Total donor / host gvt	**3,636,770**	*37%*	**363.68**
c SNV			
d1 Technical assistance	821,000		82.10
Total SNV	**821,000**	*8%*	**82.10**
Total source	**9,956,447**		**996**

The study team, through SNV Ethiopia, requested Ethiopia Rural Energy Development and Promotion Centre (EREDPC), a key actor in the development and promotion of rural domestic energy technology, for comments on the draft report.

These comments, from Mr. Kitane Workneh, Biomass Technology Study & Development Team Leader, dated 26 June 2006, unfortunately only reached the study team after the completion and submission of the final report.

Although part of the comments have been taken care of in the final report, in this addendum a brief reaction on the comments.

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1 In the second section of the report 1.2 Limitations - exclusion of Southwest and western part of the country is quite not recommended if biogas can be used for intervention as a potential technology for reducing deforestation.

Within the available time it was not possible to thoroughly visit entire Ethiopia. The South-western / western areas of the country were excluded as the forest coverage in these areas –in general- was believed to be such that the population would have relatively easy access to (non-commercial) fuelwood. The team's assessment, hence, was that promotion of domestic biogas would have less potential in these areas. Nevertheless, here too deforestation looms as an environmental threat which could indeed be mitigated by a domestic biogas programme.

2 In the study findings section of 2.2 in the last two paragraphs it was stated that all biogas plant was not functioning in Amhara and SNNPRS. The reason give for their not being functional, however is not clearly stated.

Only EREDPC's own study clearly identifies causes of non-functioning biogas installations. The reports obtained from Amhara and SNNPRS, unfortunately, did not provide this detail. However, many of these installations were visited by the team. The study report does give an indication of failure causes of the visited plants.

3 In the above mentioned section of 2.3.2 plant size are too large in relation to dung availabilities, this has been the result of various factors including variation in animal size or that the digesters were constructed with the intention to serve both lighting and cooking.

It is very well possible that at the time of construction installations were actually sized correctly. The observations of the team, however, indicate that in relation with the current daily available cattle manure, most of the installations are too large.

4 Biogas Appliances: All RTPC (Rural Technology Promotion Centers) are producing their own Cooking stove and Biogas Lamps, which is over looked by the team.

Noted.

5 Additionally, there are miss understanding of the difference between Mirt and Lakech. Mirt is used for Injera baking while Lakech is used for cooking only.

Correct; in the draft report "Mirte" and "Lakech" were confused. In the final report this has been corrected.

6 In the section of potential demand 1.4 institutional aspects: More emphasis are given to Selam Vocational while regional RTPC who are actively involved in appliances manufacturing as well as construction of biogas plant are not considered.

Perhaps not everywhere sufficiently explicit, many suggestion and recommendations have the underlying assumption that: 1) quality assurance of construction and maintenance services of the installation and appliances is a key success factor for large scale dissemination programme, and; 2) longer-term sustainability is better served when the (local) private sector is the main implementing party.

Selam Technical and Vocational Centre (STVC) is suggested as a well placed central institution for initial R&D and training, particularly when a programme –as recommended- would introduce uniform construction, design and quality standards. Obviously, the outreach of STVC will be limited; with their experience, RTPCs can –and should- play an important role in training, supervision and quality control at regional / local level.

Guided by centrally developed training and guidelines and regionally supported by RTPC supervision, (eventually) locally established private biogas construction companies and workshops should become responsible for construction, maintenance and, respectively, manufacturing of appliances.

7 In the technical part, the distance from biogas plants to water source was mentioned as being very far. We still believe that a distance of 20-30 minutes away is too far for women to carry 36 liter of water every day to mix the input as recommended in the report.

Noted and agreed. The biogas programme in Nepal actually proposes a distance limit of 20 minutes for water collection. In view of the generally large distances that Ethiopian households have to travel for water and fuel, I thought it might be acceptable to suggest slightly larger distances. Clearly, shorter distances are preferable.

8 Additionally, equal distributions of biogas plant regionally are not fair in many ways. We believe that the basic criteria and reason for equal division of digester numbers should be clearly stated. We also suggest that regions with better potential should have relatively larger number of plants.

Agreed, the suggested equal distribution was solely intended as a first approach. Factual potential and demand should be the actual key for distribution. The report proposes regional-level studies to improve the insights in this matter.

9 In the design consideration section: 4m^3 digester volume with minimum of four cattle is recommended. It is quite good to include all households as much as possible. But in practical sense to get the households with four heads of cattle is very difficult in certain region. Additionally, the amount of biogas produced from the digester of this size is very low (.084 – 1.26 m^3) and serves only cooking for the family and not sufficient for lighting. Cost/volume ratio is very high – very costly for small portion of energy substitution.

Based on our field observations and backed up by population and livestock data, for most of the households the amount of daily available dung would justify installations with a digester volume of 4 to 6 m^3. As also argued in the report, this amount of manure will not fully satisfy the domestic energy requirement. The construction cost / volume ratio is indeed higher for smaller installations, but the construction cost / gas production ratio for a certain amount of feeding is optimal for the smallest feasible (correct hydraulic retention time) size. Clearly, proper sizing shall be based on the actual available feeding, and should be established in-situ.

10 With the recommended flat rate subsidy there is a possibility of having large gas capacity with Polyethylene biogas plant (7 m^3 digester volume that can produce 1.5 – 2 m^3 gas). We suggest this option is seriously considered.

Firstly, to stimulate the ownership awereness, the suggested subsidy levels are based on the assumption that farmers make a significant own investment in the installation. In case the programme would support polyethene installations, subsidy levels consequently should be lowered. More importantly however, the track record –at least in Asia- of polyethylene plants, in terms of durability and "operationability", is not encouraging. Despite the lower investment, in the service-context of rural Ethiopia, this technology would not be the preferred option.

11 In program outline section of main features: Investment in training is emphasized without specifying target groups. Which parts of the societies are targeted, this need to be identified *and clearly stated as this is a core process for the success of the biogas program.*

In the final report, to which the outline budget is annexed, more detail is provided. In brief technical training is proposed for masons –private biogas constructors- and technicians –regional government staff. Training on operation and maintenance is proposed for –in particular female- biogas owners. Further training is proposed in the field of business management for small construction and manufacturing enterprises and ToT (Training of trainers) for regional staff. A programme implantation document coud provide further detail.

12 In section of actors and activities: We understand that MoFED is the official organ through which such programs will be approved.

Correct, and included in the final report.

13 On the chart of actor-activity: Training, quality management and R&D responsibilities are given to Selam Vocational training center. We strongly suggest that in this activities regional rural technology promotion centers should also be included. Part of the responsibility given to Selam should be shared by regional RTPC.

Noted, see also reply on comment 6. I suggest working out implementation details in the programme implementation document.

14 Finally, suppose the plant fail to work properly due to technical failurity ***WHO is the risk taker for the farmer****? These issues must be addressed in detail within the document.*

Correct, and the omission is regretted. The report should have proposed a guarantee arrangement similar to the ones used in the Asian biogas programmes (Nepal, Vietnam, Cambodia, Bangladesh). In outline, these programmes charge a guarantee fee –directly or indirectly- from the farmer. The programme manages this fund, and finances service visits and guarantee cases from this fund.

15 Additionally, some organization such as WCDO and others who are involved in construction of latrine-biogas-kitchen and vegetable garden set up for poor urban communities roles are not considered or stated in connection with biogas dissemination strategy. We suggest this should also be incorporated in the program.

The mandate of the study pertained specifically to domestic biogas. Although the team visited WCDO head office in Addis Abeba and one project site in Awassa (and appreciated their activities), it was not felt prudent to elaborate on this beyond mentioning them in chapter 2.7.6 of section 2. However, during the formulation of the programme implementation document –and later on during the actual implementation for that matter- cooperation with WCDO can be considered.