A technical feasibility study

on the implementation of a biogas promotion programme in the Sikasso region in Mali- FINAL VERSION

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EXECUTIVE SUMMARY

This pre-feasibility study researched the technical potential to introduce biogas in the southern Mali region of Sikasso. This executive summary presents the results of this study.

Technical feasibility:
Climatically, Sikasso is a suitable region to introduce biogas: the average temperature allows for a biogas system to function, and the available water resources should be sufficient to feed a biogas system. However, the cattle rearing tradition and practices do pose a problem for a biogas introduction. The largest obstacle is the difficulty to collect manure, which is not guaranteed year round due to the temporary migration in the dry season. Cattle is absent from the household for several months a year, migrating to the south to search greener pastures. The number of families that do have cattle around the household year-round is small, and the amount of manure they would produce questionable in terms of quantity. A biogas system which needs daily input is therefore not an option in the Sikasso context. A technical option which does fit the cattle management situation could be a one batch-fed biogas system, which needs feeding once every six months.

Energy consumption:
Fuelwood is by far the largest energy source for households in rural areas in Sikasso. As women collect the wood themselves, the fuelwood has no monetary costs in rural areas, and is perceived as ‘free’ by the families using it. Even though women do have to walk large distances, it is not perceived as a very pressing problem by the people we spoke to during research. Kerosene, the most regularly used source of lighting in rural families, is becoming more and more expensive. Families do perceive this as a problem, and would like to address these rising costs and find an alternative to the current lighting situation. The large size of Malian rural households and their division in sub units per wife would make it difficult to connect enough burners to a biogas system to satisfy all the cooking needs of the women in the family. If biogas were to be introduced, both men and women in rural families prefer to use the gas for lighting over cooking.

Previous biogas experiences:
All previous biogas introductions in Mali have failed to set up a structure which could continue after the donor funding stopped. As far as known, from the 70 known systems introduced by projects in the 1980s-1990s, only one system is still in use. The one ongoing initiative in Kayes is experiencing large problems to even get the biodigesters constructed. None of the projects have focussed on creating a market based system with an independent supply side and a well informed demand side: all were centralised,

subsidised efforts to install biogas systems with as much project control as possible, not focussing enough on training, commercialisation, follow-up and continuation of the business as an independent unity. The exorbitantly high costs of the biogas digesters inhibit other interested families to adopt the technology, therefore limiting impact to the families chosen by the projects.

The previous experiences in Mali have indicated difficulties to feed the system on a daily basis; gas use which was not in line with the user's perceived needs (stoves instead of lamps); difficulties to find spare parts once broken; and not knowing how to repair the system or find a technician with the appropriate know how are reasons for discontinuation of the biogas system. Also, the extremely high costs of the biodigesters have inhibited a market based development of the technology once the projects were finished. The projects have not been able to counter these problems and provide low maintenance, low upkeep management combined with a sound follow-up.

Financial feasibility:
The financial potential is based on the one batch-fed system of 10m3, which estimated costs are € 880. Even with a very large investment subsidy of € 220 or 25% of the value of the biodigester is considered to be insufficient on financial terms.

When looking at the financial sector's indicators for the rural population in Sikasso, we can see that the annual revenues of 55% of their clients are estimated between € 278 and € 556, which indicates that –if these people would have enough manure and the willingness to invest in biogas- the annual repayment loan of €250 would be a heavy burden, although the replacement value of kerosene would ease it a bit (see table 12). It is estimated that for a farmer a positive FIRR of about 30% over the first three years is important to influence investment decisions. The period of 7 years before reaching a positive FIRR is therefore too long.

The standard arguments which influence the demand for biogas, for example in Asia, do not seem to be relevant in Mali. Financial terms do not encourage people to invest in a biodigester, as it is too expensive. Other arguments which might persuade potential clients to still buy the expensive system are not favourable either. Manure is not readily available throughout the year. Even with a one batch-fed system, people still have to get the manure from cattle pens outside the household –contrary to most Asian situations where pigs are besides the household. In terms of hygiene, this will not change the current situation. In terms of use of biogas, the preference for lighting has been expressed over the preference for burners for cooking, therewith taking away the advantage of reducing women's workload and improving the health situation of mainly women and children.

Based on the above, the biogas pre-feasibility team concludes that the introduction of biogas is most likely not to succeed. The main reasons to come to this conclusion are threefold. First, in terms of technical feasibility, there is an absence of a regular supply of dung at most agro-pastoral farms in Sikasso.

Secondly, in terms of choice of technology and financial feasibility, the costs for the biogas plant construction are high because of the need for large batch-fed plants. Thirdly, socially, gas would only be used for lighting given the general idea that fuelwood is free of charge and the difficulty of dividing the burners in the large complex family structures. If so, other renewable energy sources might be a more suitable solution.

RAPPORT PRÉLIMINAIRE

La présente étude de préfaisabilité poursuivait la connaissance du potentiel technique d'introduction du biogaz dans la région sud du Mali de Sikasso.
Ce rapport préliminaire d'exécution présente les résultats de l'étude.

Faisabilité technique:
Au plan climatique, Sikasso est une région propice à l'introduction du biogaz: La plage de température permet le fonctionnement d'un système de biogaz, de même que les ressources en eau sont suffisantes à son alimentation. Cependant, la tradition de vacation du cheptel pose un problème à l'introduction du biogaz. L'obstacle majeur est la collecte de la bouse, dont la disponibilité n'est pas garantie toute l'année, du fait de la migration temporaire en saison sèche. Le bétail est absent des enclos pendant plusieurs mois de l'année, quand il migre plus au sud à la recherche de pâturages plus fournis. Les familles qui tiennent les troupeaux à proximité toute l'année sont peu nombreuses, et la quantité de leurs excrétions est problématique. Dans ce contexte, un système de biogaz requérant une alimentation quotidienne n'est donc pas une option technique pour Sikasso. L'option convenable, qui tient compte de la pâture du cheptel, serait un tel système de biogaz, dont l'approvisionnement serait intermittent, par exemple une fois les six moi.

Consommation d'énergie :
Le bois de chauffe est de loin la principale source d'énergie dans les milieux ruraux de Sikasso. Comme ce sont les femmes elles mêmes qui en font la collecte, ce bois n'y a pas de coûts monétaires, et est aperçu comme « gratuit» par les familles qui l'utilisent. Malgré que les femmes parcourent de longues distances à la quête du bois de chauffe, la question n'est pas perçue comme étant un problème d'une quelconque acuité par les personnes avec lesquels nous en avons discutée. Le pétrole lampant, la principale source d'éclairage dans les familles rurales, dévient de plus en plus cher. Les familles perçoivent cela comme un problème, et elles souhaiteraient changer ces coûts grimpants, éventuellement en trouvant des solutions alternatives à la situation présente en matière d'éclairage. Les dimensions larges des concessions villageoises du Mali et leur division en sous unité par épouse rendraient plus difficile la connexion de suffisamment de foyers à un seul système de biogaz, qui puisse satisfaire les besoins de cuisson des femmes dans la famille. Si le biogaz était tout de même introduit, et les hommes, et les femmes, tous souhaiteraient l'utiliser plutôt pour les besoins d'éclairage que pour la cuisson.

Expériences antérieures de biogaz:
Toutes les introductions antérieures de biogaz au Mali ont défailli à mettre en place une structure qui a pu continuer après le financement de bailleurs de fonds a cessé. Autant

que nous le sachions, de tous les 70 systèmes mis en place dans les années 1980-1990, un seul continue de fonctionner. Une initiative en marche à Kayes fait face à de multiples problèmes, même pour faire construire le bio-digesteur. Aucun des projets n'a concentré ses efforts sur la création d'un système basé sur les règles de marché, avec un coté indépendant d'approvisionnement et un coté bien informé de demande: tous se concentraient sur l'installation des systèmes de biogaz subventionnés, avec en plus un maximum de contrôle possible de la part du projet, et ce, au détriment de la formation, de la commercialisation, du suivi et de la continuation de l'activité comme une unité indépendante d'affaire. Les coûts exorbitants des digesteurs de biogaz découragent les autres familles intéressées d'adopter la technologie, ce qui limite l'impact des projets aux seules familles immédiatement proches des sites.

Les expériences antérieures au Mali ont montré des difficultés en terme d'alimentation des systèmes sur une base journalière quotidienne ; l'usage du gaz qui n'était pas envisagé parmi les besoins perçus (feu au lieu de lampes), les difficultés d'approvisionnement en pièces de rechange en remplacement de celles devenues défectueuses, la méconnaissance de comment réparer le système ou de trouver un spécialiste compétent à même de le faire en cas de panne, constituent des raisons de d'arrêt des systèmes de biogaz. Les coûts élevés des digesteurs de biogaz ont empêché une expansion marchande du système, une fois que les projets arrivaient à terme. Les projets ont été inaptes à prendre en compte ces problèmes et à fournir une maintenance à moindres coûts, une gestion pérenne abordable combinée à un suivi de base.

Faisabilité financière:

Le potentiel financier s'appuie sur le système à alimentation intermittente de 10 m3, dont le coût estimatif est de 880 euro. Même (avec) une subvention importante d'investissement de 220 euro, soit 25% du montant du biodigester est supposée être insuffisante en terme financier.

En analysant les indicateurs du secteur financier pour les populations rurales de Sikasso, nous constatons que le revenu annuel de 55% de leurs clients est estimé compris entre 278 et 556 euro, ce qui montre, que si ces populations avaient suffisamment de bouse et de bonne volonté pour investir dans l'acquisition d'un système de biogaz, le remboursement annuel du prêt de 250 euro serait pour eux un lourd fardeau à supporter, même si les coûts de kérosène sont remplacés par le biogaz (voir tableau 12). Il est admis que pour un paysan**,** un FIRR ('retour financier sur investissement') positif d'environ 30% pendant les 3 premières années est suffisamment important pour influencer ses décisions d'investissement. Une période de 7 ans, avant d'en arriver à un FIRR positif est donc trop longue.

Les arguments standards, qui motivent la demande de biogaz, comme en Asie, semblent inopérants au Mali. Les conditions financières n'incitent pas les gens à investir dans le biogaz, tant il est coûteux. D'autres arguments, qui soient à même de persuader des clients potentiels à acheter quand même ces systèmes coûteux, s'avèrent être pas plus convaincants. La fumure tout prête n'est pas non plus disponible toute l'année.

Même avec les systèmes à alimentation temporaire, les gens doivent toujours chercher de la fumure d'ailleurs en dehors de leurs enclos. Cela ne changera pas la situation quotidienne en termes d'hygiène. En matière d'utilisation du biogaz, la préférence exprimée va à l'éclairage au détriment de l'alimentation énergétique des foyers de cuisson, ce qui, du coup, fait perdre les avantages du biogaz en termes d'allègement de la corvée des femmes et de l'amélioration de la santé, surtout des femmes et des enfants.

Se basant sur ce qui précède, l'équipe d'étude de préfaisabilité du biogaz a conclu que l'introduction du biogaz a peu de chance de réussir. Les raisons principales qui conduisent à cette conclusion sont de 3 ordres. Premièrement, au plan de la faisabilité technique la majorité des exploitations paysannes ne peut assurer la fourniture régulière de la fumure. Deuxièmement, en termes de choix de la technologie et de la faisabilité financière, le coût de construction des unités de biogaz est élevé à cause de la nécessité de grands réservoirs d'alimentation. Troisièmement, d'un point de vue social le biogaz sera utilisé seulement pour l'éclairage, ce qui alimentera l'idée générale que le bois de chauffe est gratuit, sans compter les difficultés de répartition des foyers dans les structures familiales complexes. Ainsi vu, une autre source d'énergie renouvelable serait une solution mieux appropriée.

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ABBREVIATIONS

AMADER	Agence Malienne pour le développement de l'énergie domestique et de l'électrification rurale
AMCFE	Association Malienne pour la Conservation de la Faune et de l'Environnement
BORDA	Bremen Overseas Research and Development Agency
CMDT	Compagnie Malien de Développement des Textiles
CNESOLER	Centre National d'Energie Solaire et des Energies Renouvelables
CREPA	Regional Center for Low Cost Water Supply and Sanitation
DMA	Direction de Machinisme Agricole
DNE	Direction Nationale de l'Energie
DNSI	Direction Nationale de la Statistique et de l'Informatique
FAMALI	Foyers Améliorés de Mali
FCFA	Franc CFA – Western African Franc
FEM	Fonds pour l'Environnement Mondiale
FIRR	Financial Internal Rate of Return
GJ	GigaJoule
hh	Household
IPR/IFRA	Institut Polytechnique Rurale – Institut de Formation et de Recherche Appliqué
Kafo Jiginew	Mali's largest rural bank
MFC	Mali FolkeCenter
NEP	National Energy Policy
NGO	Non Governmental Organisation
TPE	Tons of Petroleum Equivalent

Exchange rate: 1€ = 655 FCFA.
1US$ = 480 FCFA.

1. INTRODUCTION AND BACKGROUND

This pre-feasibility study which assesses the technical potential of a biogas introduction in the Sikasso region in southern Mali is part of the larger initiative '**Biogas for Better Life, An African Initiative'**[1]**.** This initiative aims to improve the health and living conditions of men, women and children; to reduce the use of fuelwood and charcoal for cooking; to improve soil fertility and agricultural production; to reduce greenhouse gas emissions; and to create new jobs, through the development of a robust biogas-related business sector in Africa.

The Initiative aims to install 2 million household-level biogas plants in 10 years. The ultimate objective is to develop a sustainable, commercial biogas sector, which will in turn improve the lives and livelihoods of families in Africa.

One of the first steps of this initiative is to identify "pockets of opportunity", to be able to focus on programs in African countries with the strongest market potential. Feasibility studies are carried out in a number of African countries. In a first Africa-wide assessment regarding the potential for biogas in Africa, Mali was pointed out as a country which might qualify for large scale biogas dissemination programmes[2]. This study is a pre-feasibility study to assess whether it is technically feasible to install biogas systems in Mali.

The research team in Mali has chosen to take the southern province of Sikasso as a starting point. Sikasso is a region which –according to an earlier desk study- could present opportunities for biogas due to the partly sedentary cattle raising tradition, to the availability of water, the climatic conditions and expected economic situation of its population. This study looks at these and other aspects in detail before it comes to conclude on the technical feasibility of introducing biogas in Sikasso.

The report is structured as follows. After this introduction this report starts to explain the methodology and specific objectives of the research in chapter two. A general introduction on Mali follows in chapter three, with information on social structures, agricultural and livestock practices in general, gender roles and the specific energy situation in the country. After these chapters, the study will mainly focus on Sikasso. Chapter four introduces farming and cattle management practices in the region, while chapter five describes the current energy consumption patterns, with the aim to provide a basis for analysis in later chapters. The sixth chapter describes earlier experiences with biogas introduction in Mali, and analyses the lessons learned. Chapter seven – based on the information provided in the earlier chapters- introduces our view on the technical feasibility of introducing biogas in the Sikasso region. Chapter eight concludes, and provides some recommendations. Annexes provide the ToR, an overview and

1 See www.biogasafrica.org for more detailed information.
2 Ter Heegde, Felix and Kai Sonder (2007).

pictures of people met and interviewed, and a schematic summary of the research findings

2. OBJECTIVE, METHODOLOGY AND LIMITATIONS

This pre-feasibility study started from the conclusions of a desk study[3] about the theoretical potential of biogas in Mali. The desk study pointed at Sikasso as a potentially interesting region to study biogas feasibility in depth, due to the statistics about quantity of cattle, water availability and population density. The hereby presented pre-feasibility study therefore took Sikasso as a research region.

The pre-feasibility study, which aimed to assess the technical feasibility of and demand for implementing a biogas promotion program in the Sikasso region in Mali, consisted of two components:

- A technical analysis of the potential of biogas systems in the cattle breeding context in the Sikasso region.
- A socio-economic analysis of cattle breeding families to analyze (demand and possibilities of) potential market segments in a biogas implementation market in the Sikasso region.

The results have been combined in underlying report.

The pre-feasibility study team consisted of a biogas, socio-economic and local situation expert.

The mission was carried out during the first days of June 2007. Ten days were spent in the capital Bamako and the rural area of Sikasso. In Bamako the team visited government institutions and NGOs to gather both theoretical and statistical information. After obtaining a reasonable statistical database, the team traveled to the Sikasso region to collect practical information in the field. Renewable energy companies and organizations, NGOs, local government departments, credit associations and cattle farming families were consulted (see list and photos of people met and interviewed during mission, Annex 2). One functional and two dysfunctional biogas installations at household level were assessed. To complete the practical information, two more days were spent in Bamako for the required additional data.

It proved difficult to obtain statistical data. Few region specific censuses are carried out and national data are either outdated or not very detailed. At the regional and local level very few institutions have statistical data about their target groups. A few reasoned assumptions therefore had to be made in this report.

[3] This desk study has not been published. It was carried out during the first months of 2007.

3. MALI BACKGROUND

On the Human Development Index of 2006, Mali ranks 175th out of 177 countries. Mali has a population of 12 million people (DNSI 2005, p 9), which is growing rapidly as the fertility rate is more than seven children born per woman (CIA 2007). However, the infant mortality rate is extremely high at 83 deaths per 1,000 live births (DNSI, 2006) and life expectancy at birth is just 48 years. 81% of the population older than 15 is illiterate.

The Malian population is mainly rural (70-80%). Cities are growing rapidly due to a rural exodus, which is incited by difficult living conditions in rural areas which are more and more impoverished. Interior migration in Mali is mainly characterized by its seasonality. The rainy season, upon which rural agriculture depends, lasts for about four months. Consequently, each year once that season is over, many (young) people migrate to cities to find work. In addition to the limited rainy season, the decline in agricultural yields, directly related to techniques that exhaust the soil, and indirectly related to overuse caused by the need to feed a large population cause people to migrate. Another reason is the over-concentration of economic, educational, health, and other infrastructures in the large cities. A result of this concentration is scarcity of employment opportunities in rural areas (N'Djim, 1998).

Mali is landlocked and has the following neighbouring countries: Algeria in the northeast, Burkina Faso in the east, Guinea Conakry in the southwest, Cote d'Ivoire in the south, Mauritania in the northwest, Niger in the east and Senegal in the west. None of the neighbouring countries has a large domestic biodigester dissemination programme.

The climate in the Southern part of Mali, where the bulk of the population lives, is subtropical to arid; hot and dry (February to June); rainy, humid, and mild (June to November); cool and dry (November to February)

Figure 1: Map of Mali

3.1 Structure and social hierarchy

The large patri-linear family ties and –history are the basis of the social structure of Malian society. Every family is headed by a chief of family, who manages the family's goods, including the lands, natural resources and organizes the production activities.

Families are the usual nucleus of a production unit. Most rural families are polygamist. Often brothers and their wives occupy one court: if men have more than one wife, family size can easily reach 50 members. Society knows a hierarchy based on social and economic status, order of arrival in a village and the occupation of lands.

3.2 Economy

Some 80% of the labour force is engaged in farming and fishing. Industrial activity is concentrated on processing farm commodities. Mali is heavily dependent on foreign aid, remittance from workers in France and neighbouring countries. Especially the rural economy has proven to be very vulnerable to fluctuations in world prices for cotton, its main export. Another important foreign currency earner is gold; tourism is still in its infancy but on the rise.

Worker remittances and external trade routes for the landlocked country have been jeopardized by continued unrest in neighbouring Cote d'Ivoire.

Mali's GDP (PPP) is US$ 998 (UNDP, 2006).

3.3 Agricultural & livestock sector

As stated above, the main economic activity in Mali agriculture: 80% of the population is rural, deriving its income from agriculture and livestock. In those rural areas 90% of the population are engaged in farming, which takes up nearly all of people's time for five to six months of the year. The main crops cultivated are peanuts and cotton for export; and millet, sorghum and maize for local consumption.

Besides agriculture, cattle holding plays an important role in the Malian rural economy. The northern part of Mali is characterised by nomadic livestock holding, the southern part is characterised by semi-nomadic and sedentary livestock holding. Zero-grazing is non-existent in Mali.

According to data of CMDT, representing 98% of the farmers in the southern part of Mali, almost all farmers own at least some cattle. Bovine breeds are represented by zebus, taurins and their crosses. In general Azaouak and Touareg zebus are kept in the north, Moors in the west. As for the taurins they are raised in the south, especially the N'dama breed.

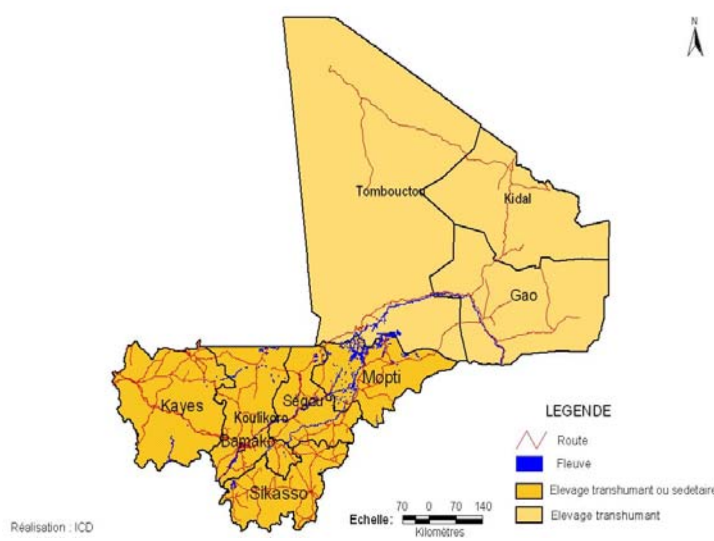


Figure 2: Map of Mali with nomadic (north) and semi- nomadic (south) livestock rearing.

Source: ICD, Mali, 2007.

Compared to the proportion of the population it involves, this primary sector is not very productive; its share of the GDP was only 45.8 percent in 1990.

3.4 Energy demand and supply, policy and plans

The national energy consumption in Mali is excessively characterised by wood and charcoal consumption (81%), followed by petroleum products (16%) and electricity (3%). Renewable energy represents an insignificant amount of the consumption, although Mali has a very large hydro-electric plant in the Senegal river. Most of the electricity produced is exported to Senegal and some to Mauritania. A large share of the electricity for national consumption comes from a hydro plant in Selengue. Households account for the largest share of energy consumption, being 86% (MMEE, 2006).

Consumer prices for electricity in Mali are the highest in the West-African region, despite that most electricity is generated from hydro-electric plants. This means that cooking on electricity is no option for the vast majority of the population: less than 12% of the population has access to formal electricity services, and the majority of these are in the capital Bamako and the principal towns. In rural areas, less than 1% has access to electricity.

The energy indicators of Mali are low: average energy consumption per person per year is 0.3 TPE (or 13.6 GJ), compared to a sub-Saharan average of 0.7, and a global average of 1.8.

Mali's National Energy Policy (NEP) adopted in March 2006 aims to contribute to sustainable development of the country through the supply of low-cost energy services accessible by the largest possible part of the population, and encouraging the promotion of socio-economic activities. The sub sector Renewable Energy has defined thirteen measures to contribute to the overall goal of the NEP, two of which might be useful for a (commercial) biogas introduction:

- Measure 3: Promotion of energetic valorization of biomass (biogas, vegetable oil, alcohol, etc) in agricultural and agro-industrial zones.
- Measure 6: Promotion of systematic inclusion of income generating activities in renewable energy projects and programs.

The Poverty Reduction Strategy Paper in Mali has not included any energy component.

Important governmental institutions regarding renewable energy introductions for households in Mali are:

- The Ministry of Mines, Energy and Water (MMEE), which supervises:
  - The National Direction of Energy (DNE) – a central service
  - The National Center for Solar Energy and renewable Energies (CNESOLER)
- The Malian Agency for the Development of Domestic Energy and Rural Electrification (AMADER).

4. HISTORY AND ANALYSIS OF DOMESTIC BIOGAS

There have been few initiatives introducing biogas in Mali over the last 25 years. All were heavily or completely subsidized, and none was set up at a large scale. All have failed (and most never had the intention) to create sustainable market structures. The only ongoing biogas initiative takes place in Kayes, on a very small scale.

4.1 Compagnie Malien de Développement des Textiles –CMDT : 1984 - 1994

Programme composition:
A biogas introduction program began as a cooperation between the Direction de Machinisme Agricole DMA; Eaux et Forets; the Centre National d' Energie Solair et des Energies Renouvelables CNESOLER and CMDT.

The programme was set up to generate an alternative to use of fuelwood. The training department of CMDT did some production trials with the support of a French technician between 1980 and 1982 in Nankorola. The trial was not successful due to lack of construction experience.

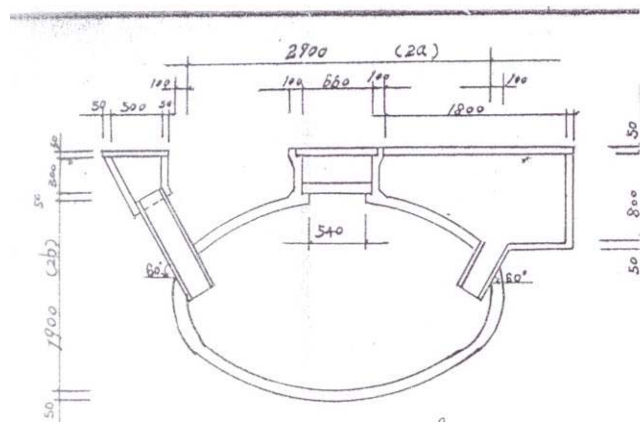


Figure 3: The CMDT biodigester model (based on Chinese model).

In 1984 an experienced Chinese expert was hired to improve the plant construction. The Chinese batch-fed biogas model Casimir –used in the hotter areas in China- was successfully adapted with only minor adjustments to the Malian situation. Other Chinese systems were analysed, but the adapted Casimir model seemed the most suitable. Between 1984 and 1994 64 biogas systems were built by CMDT - the Compagnie Malien de Développement des Textiles. CMDT worked with 6m3, 8m3 and 10m3 systems. Out of the 60 systems, only five were built for households. The large majority of the systems were built for communal use in maternities, schools and mosques. A long term objective was to build private –household- biogas systems as well.

Where: CMDT's intervention area (Ségou, Sikasso).

Roles: CMDT informed villages and was responsible for awareness raising. The Chinese expert and later the CMDT expert trained a total of 10 literate masons, who constructed at least two systems (under supervision of the CMDT expert) before they constructed systems independently.

Costs: Costs for the communal biogas systems varied between 132.000 FCFA and 226.000 FCFA. Costs for the private biogas systems varied between 160.000 and 227.000 FCFA depending on the size of the systems and excluding labour[4], or € 244 and 347. Costs for cement, iron and accessories were pre-financed by CMDT, except for local materials and labour during construction. There is very little data available for the collection rate of these credits: the data available suggests that 62.5% have been repaid, 37.5% have not been repaid[5].

Current status of biogas systems built: Only one private system is still in use, this system is owned by the man who built it and who is very conscious about the technical operation and maintenance requirements. His (photo) story is attached as Annex 5. All communal systems do not function anymore. CMDT has not structurally researched the reasons for this almost complete abandonment of the technology. The coup d'état in 1991 is held responsible for social disruption and has largely affected communal organisation structures: the biogas system management was most likely abandoned because of lack of organisation of the Village Associations in charge of the system. This does not explain the abandonment of the systems at household level however. Most likely reasons –according to the CMDT biogas programme manager- for the dysfunction of the private systems are lack of maintenance, and families which move and who do not leave instructions for the next owners.

Spin off of the program: One of the masons who was trained to construct the biogas system still successfully manages his household system: he owns the only known system still functioning. After the closure of the program, he has individually built 4 more systems, in cooperation with the CMDT program manager. The mason did the actual construction; the CMDT program manager would import the lamps and other accessories. Not more were built because there was no demand.

Lessons learned: Lessons learned which are interesting for household biogas system introduction are that all biogas users in 1993 expressed lighting to be the most important service of a biogas system. Heating water and cooking a meal on biogas were only mentioned after lighting. During this current mission in 2007 this was reconfirmed. The only biogas system still functioning had 7 gas lamps and 1 cooker which obviously was hardly used. Families without biogas were clear in their desire to first improve their household lighting before improving the cooking situation as well.

[4] Based on CMDT report (1993). According to the CMDT program responsible, the given costs for a 6 m3 biogas system included: 16 sacs of cement; 3 m3 of sand: 3 m3 gravel: 3 lamps; 1 stove; 100 m of 8 mm gas tube and connections; 1 switch. The given costs for a 10 m3 biogas system included: 20 sacs of cement; 5 m3 of sand: 5 m3 gravel: 4 to 5 lamps; 1 stove; 100 m of 8 mm gas tube and connections; 1 switch.

[5] This is based on data of 8 biodigester systems, provided in the 1993 CMDT report, and therefore not very reliable or representative for the biogas program as a whole.

4.2 Mali Folkecentre: 2000-2001

Project composition:
In 2000, Mali FolkeCenter cooperated with IPR-IFRA (Institute Polytechnique Rurale de Formation et de Recherche Appliqué) to build six BORDA biodigesters of 6m3 [6].

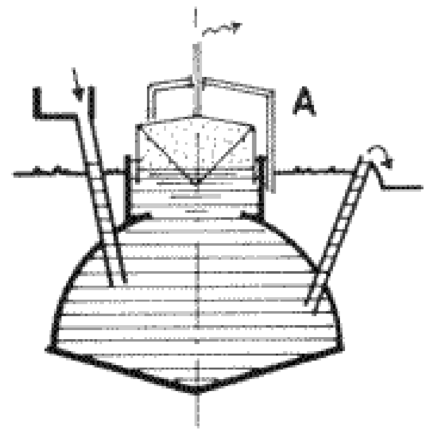


Figure 4: BORDA biodigester

Aim of the introduction of these German type floating drum/ dome type hybrid biogas digesters (see drawing) was twofold. The first objective was to research the technology and see if a larger biogas program could be introduced. The second was to reduce fire wood consumption and reduce the burden of women to spend many hours searching for wood. For this reason, no lamps were introduced in this program, only cookers. The assumption was that heads of families would not allow cookers if lamps were another option.

Where: Around Bamako: Sanankoroba (Koniobla – Sinsino); Dialokoroba (Dialakoroba); Bougoula (Falan); Yelekebougou (Guili Sokoro); Koulikoro (Katobougou); Koumantou (Tabacoro).

Roles: A mason and a technician from IPR-IFRA built all six digesters, formation and training was given by MFC staff.

Costs: No reliable information regarding the plant cost could be given. The plants are fully subsidized with the exception of local materials (sand and gravel) and labour, which the beneficiaries supplied. Probably similar to the costs of the AMCFE systems (see 4.3).

Current status of the systems: Most –probably all- of the biodigesters are not in use anymore: exact figures are not available which also indicates that there has been no proper follow up of the plants and support to the users. The only one system which was likely to still be in use was visited and not in use anymore. Main reason is that the plant design choice was for continuous feeding. Obviously it is difficult for cattle farmers to adopt a totally new animal waste management practise by collecting waste on a daily basis. Several people have explained this as a lack of 'maintenance culture'. It proved difficult for households to upkeep the daily tasks, resulting in feeding the systems only once every two or three days. Another important reason is the difficulty of finding spare parts once accessories, such as tubes and tabs, break. It proved too difficult for biogas users to find those parts on the local or regional markets. Also, the ex biogas using

[6] The MFC biodigesters were built in Sanankoroba (Koniobla – Sinsino), Dialakoroba (Dialakorosa), Bougoula (Falan), Yelekoubougou (Guili Sokoro), Koulikoro (Kaibougou) and Koumantou (Tabacoro).

family we spoke and the MFC biogas responsible both mentioned that if it were to be done again, that there should be connections for lamps, which was not the case with the MFC biogas systems.

Spin off of the program: A follow up program was never realised as donor support ended after this first phase. Furthermore, the project was not set up to give masons enough incentives to continue independently.

Lessons learned: If MFC were to do it again, they would either adapt the system to provide for lighting and cooking, or focus solely on lighting. The follow up should have been more intense, with someone to refer to in case of technical problems, so systems do not fall into disrepair once a single element has broken. MFC does not believe in a commercial biogas market without long and costly programme intervention.

4.3 AMCFE – January 2005 – present

Project composition: The ‘Association Malienne pour la Conservation de la Faune et de l'Environnement’ (AMCFE), a local NGO, started a biogas pilot project in the northwestern region Kayes in 2003. The design of choice is similar to the MFC used design, continuous fed 6m3 Borda model. The project aimed for the construction of 20 plants in 14 villages for demonstration purposes.

The families that have been selected for plant construction are in the close vicinity of a permanent lake in the otherwise very dry region. The year round presence of water allows the families to keep some cattle on a permanent basis near their house. The users are advised to feed the plants daily with 30kg of dung and an equal amount of water.

The project started without a clear idea on what systems would be used. Several models have been tried and were not functioning properly. This has damaged the reputation of the biogas technology in the region.

Project period:
Planned for January 2003 – June 2006, but still running as per June 2007.

Where: Kayes cercle, in the communities Ségala, MarénaDiombougou, Koniakary and Séro-Diamanou.

Roles:
An AMCFE technician supervises the installation of the systems, together with the family who is responsible for the bricks and other local materials like sand and gravel as well as for the unskilled labour. A professor of IPR-IFRA has been involved in the introduction of the Borda digester. The methodology whereby family members were trained to construct the biodigester did not succeed, as the quality of their work was inferior and they could not acquire the necessary skills.

Costs:
According to AMCFE the cost per 6m3 plant amounts to FCFA 750,000, or € 1145,-. An important component of the total cost is the steel drum at a cost of FCFA 200,000. A summary of the plant cost is given below. As MFC used an identical design the cost of their plants will be close to what has been quoted by AMFCE.

Table 1: Costs of AMFCE biodigester construction

Quantity	Item	Unit cost	Total
01	Steel drum	200.000	200.000
02 trips	Sand	35.000	70.000
02	Inlet/outlet pipes	15.000	30.000
26 bags	Cement	6.000	156.000
02	Biogas stoves	20.000	40.000
01	Unskilled labour	50.000	50.000
01	Cement bricks	15.000	15.000
25 m	PVC piping	-	20.000
01	Skilled labour	65.000	65.000
01	Supervision	100.000	100.000
04 wheelbarrows	Gravel	1.000	4.000
		Total	**750.000 FCFA**

Current status of the systems:
At present 8 out of the planned 20 plants have been completed of which, according to the AMCFE, 5 are in operation. It is not likely that more plants will be build because of budget constraints.
.
No reason has been given for the non-functioning of 3 plants. Kayes could not be visited during the mission as it is too far away from Bamako and Sikasso.

Spin off of the program:
As far as known, no spin off has yet been achieved: the program is largely delayed due to mostly technical problems with the biodigesters, and as such the technology does not seem to be proven yet in the communities.

Lessons learned:
Before starting, a sound technology should be chosen which is adapted to both the technical and social conditions in a household. Problems with biodigesters which do not function properly are very damaging to the reputation of the market.
Also, the very expensive set up of the biogas plant construction and the small scale of the project make the biogas introduction completely dependent on the project, with no perspective whatsoever on independent continuation of a biogas market. Commercial introduction of an already expensive technology should be planned from the first day of

the introductions, if the project wished the technology to become a market-introduced technology.

4.4 Conclusion on feasibility biogas based on previous biogas introductions in Mali

All previous biogas introductions in Mali have failed to set up a structure which could continue after the donor funding stopped. As far as known, from the systems introduced by projects in the 1980s-1990s, only one system is still in use. The one ongoing initiative in Kayes is experiencing serious problems to even get the biodigesters constructed.

None of the projects have focussed on creating a market based system with an independent supply side and a well informed demand side: all were centralised efforts to install biogas systems with as much project control as possible, not focussing enough on training, commercialisation, follow-up and continuation of the business as an independent unity. The exorbitantly high costs of the biogas digesters inhibit other interested families to adopt the technology, therefore limiting impact to the families chosen by the projects.

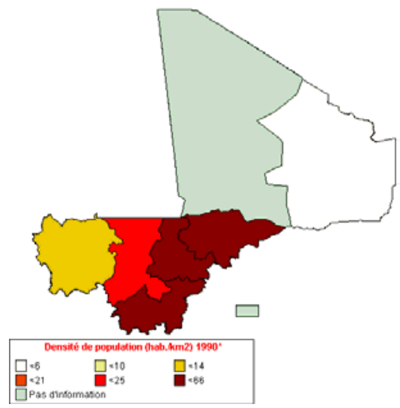
The previous experiences in Mali indicate that difficulties to feed the system on a daily basis; the gas use which was not in line with the user's perceived needs (stoves instead of lamps); difficulties to find spare parts once broken; and not knowing how to repair the system or find a technician with the appropriate know how are reasons for discontinuation of the biogas system. Also, the extremely high costs of the biodigesters have inhibited a market based development of the technology once the projects were finished. The projects have not been able to counter these problems and provide low maintenance, low upkeep management combined with a sound follow-up.

5. SIKASSO: FARMING AND CATTLE MANAGEMENT

The Sikasso region which is the focus of this pre-feasibility study has a total population of 2.1 million, of which 590,235 (28%) urban and 1,540,965 (72%) rural. Sikasso is one of the regions with the highest population density in the country (more than 66 people per km2).

Climatically, Sikasso is characterised by a hot and rainy season from June to November, cold and dry from November to February, and hot and dry from February to June. The average temperature lies well above the for biogas preferable 20C. Permanent shallow and deep wells should enable households to collect enough water for a biogas system to be fed. Both rainfall and temperatures are shown in table 2.

Figure 5: Population density per region in Mali



Source: ENDA TM report.

Table 2 : Statistics on temperature and rain in Sikasso

Sikasso	**2001**	**2002**	**2003**	**2004**	**2005**
Average yearly temperature (°C)	27,3	27,5	28	28,2	28,1
The hottest month	April	April	May	April	May
Average temperature of hottest month (°C)	31,7	31,4	32,7	31,9	32
Coldest month	Dec	Dec	Jan	Jan	Jan
Average temperature of coldest month (°C)	24,7	24,7	25,2	25,4	24,6
Amount of rain (mm)	1082	722,7	840,9	1224	1078

Source: (Le Mali en chiffres, p2)

Sikasso belongs to the semi-arid to sub-humid Sudan zone. Because of the more abundant rainfall, the agricultural activities are more intensive with a certain guarantee of success. Stock-rearing is sedentary with a seasonal migration; it is more and more integrated with crop production (Coulibaly, 2003).

5.1 Farming practices in Sikasso

Sikasso has both nomadic and sedentary livestock systems, often combined in one cattle holding family according to the season. During the wet, crop growing season cattle are mostly taken out during the day and come back to the cattle pen next to the village at night. During agricultural slack time –about seven to eight months from October to May in the dry season- the majority of cattle often migrate in search of greener pastures in the south.

5.2 Quantity and economic importance of cattle

The National Statistics Direction has researched the number of cattle owning families in Sikasso and concludes that almost 70% of these families owns between 5 and 50 animals.

Table 3: Amount of animals per family and amount of cattle raising families in Sikasso

	Number of animals and cattle raising families in Sikasso										Total
# Animals	0	1 -2	3-4	**5 - 9**	**10 – 19**	**20-49**	50 - 99	100-199	200-499	500+	
# Families	6815	5819	7219	**19261**	**21623**	**26794**	8316	1693	183	0	97725

Source: DNSI, 2007.

The distribution according to type of animals (narrowed down to the ones which might contribute to feeding a biogas system) is specified by these 2004 data from the Department of Agriculture. On average, a rural household in Sikasso owns around 10 cattle, 3 traction cows and about half of the households own a donkey used for traction.

Table 4: Distribution of animals per family in Sikasso

Region	**Cattle (total)**	**Draught cattle**	**Draught donkeys**
Sikasso	942000	278400	41300
Average per family[7]	10	3	0.4

Source: Recensement de l'Agriculture 2004.

The subgroup of cattle holding families which is relevant for this study is the group which has both cattle and agricultural fields, as they are the ones who might have the necessary input (manure) and would benefit from the slurry to fertilise their fields. Sikasso is part of the CMDT zone, with many cotton producing farmers, representing 98 % of all farmers in the region.

The data CMDT has collected systematically over the last years have therefore been taken as representative for the farmers in Sikasso. The data on the quantity of cattle in the CMDT production units (farming families) coincide largely with the data of the Department of Agriculture: CMDT data suggest that the average number of cattle per household is 13 (CMDT, 2007). CMDT has no segregated data on the percentage of draught animals.

The animals which are most relevant for this study are the draught animals and the dairy cattle. These are the animals which are sedentary. The other cattle are used as a means to 'store' money and as a status symbol. These animals migrate part of the year, and can therefore not be counted on for a steady supply of manure (see 5.3).

Data from the Koutiala dairy cooperative Danaya Nono showed that most families delivering milk to the cooperative have three, four or five dairy cattle, which each produce two litres of milk a day. The cooperative gives an estimation of the other cattle

[7] The average is calculated on a total of 97725 families in Sikasso, as there are no data on the number of families in 2004.

of their 107 members[8], which varies between 14 and 1100 heads. 1100 heads is an exception however: the large majority of their members own between 14 and 20 cattle. There are some families who milk their cows, especially during the rainy (calving) season. They use this milk mainly for their own consumption, and might sell very small quantities at the local markets during this period of the year. They do not invest much in the dairy cattle; it is an additional product without much extra input such as additional feeding and vaccinations. There are no exact numbers on dairy cattle whose owners do not sell to dairy cooperatives, but one can assume that they are counted under the general category 'cattle' in the statistics.

Economic importance of cotton and cattle:
Cattle are often seen as a means of investment: after the harvests, no money is set aside at the bank, but cattle will be acquired. In a communal society, this is a strategy to keep profit and investments within the family: it is very hard and almost impossible to deny a request for help when one has cash in the house. Selling cattle is an extra obstacle before people can access your wealth, and therefore better safeguards the savings of the families.
A related phenomenon is that cattle are seen as steady savings, a storage of capital. In other words, people see cattle as a sign of wealth, and therefore status, not necessarily as a productive asset. People speak about 'prestige cattle', with the number of heads directly related to the wealth of a family. This is the reason cattle holders are resistant to speak about the number of cattle they own; afraid of taxes, and not willing to let others know the resources of the family.
Animals are used for traction, meat or simply as an investment. Active investments are not necessarily made in the animals themselves: only 15% of all loans for productive activities of the largest rural credit bank in Sikasso are used for cattle related activities. Cattle are taken to areas where they can find food and water, but not always are extra investments made in the health of the animals. The aim of most families is to have as many heads as possible. Together with the relatively dry climate, this means that most animals are rather thin and not very well looked after. Manure production per animal is consequently low.

Below a comparison has been made between cotton production revenues and the added values of both cotton and cattle. Cotton is the largest cash crop in the Sikasso region, and almost 98% of all farmers produce cotton. First, the lowest, median and highest cotton revenue zones in Sikasso were selected from a CMDT database (CMDT, 2007) with data on 2006. These were Yanfolila (lowest cotton revenue), Yorosso (median) and Kléla (highest). Then the average number of bovines, sheep/goats and donkeys per production unit in these same zones were added to the table, again based on the same database, and the value of these animals calculated, based on the following prices:

[8] The Dairy cooperative had 137 members in 2006. In 2007 they work with 107 members. Compared to the total population of Sikasso, this means that families owning dairy cattle and selling through a cooperative are a minority in the region.

Table 5 : Prices of animals in Sikasso, 2007.

Animal	Price in FCFA (full grown adult)	Price in € (full grown adult)
Cow	100.000	153
Sheep/ goat	30.000	46
Donkey	50.000	76

Source: Interviews during fieldwork in Sikasso region, 2007.

Table 6: Cotton revenues and wealth of cattle.

€	Average Income	Stratification	Average # Animals			Average Value €	Accumulated value cotton& animal
Zone	**Cotton**		**Bovine**	**Sheep/ Goat**	**Donkey**	**Animals**	
Yanfolila	573	Low	13	11	1	2565	3138
Yorosso	807	Median	10	11	1	2107	2914
Kléla	1258	High	12	9	1	2321	3579

Source: CMDT data 2007

From these calculations, it is clear that cattle function as a financial buffer for unforeseen and foreseen circumstances: the value of cattle is on average 3.8 times the value of the yearly cotton revenues. Also, it shows that it is mostly cattle, instead of monetary income from a cash crop such as cotton, which reflects the wealth of a family.

5.3 Cattle management and migration

Cattle management is characterised by the seasonality of the climate. During the dry season, roughly from October to May, cattle can not damage many fields and are taken to areas where enough water and pasture is available. During the first dry months, cattle will be taken to eat the remaining crop residues on the field. Crop farmers with few cattle of their own will invite herdsmen to let the animals graze on their lands. In exchange, the herdsmen will get some sort of reward like millet. Afterwards, they will have to go further away. Often this means moving the entire herd, which can consist of the animals from several families, with a herdsman to an area far off from the household. These animals will not come back to the household or cattle enclosure next to the village at night, but can stay away for months on end. Even when the water holding area is not too far off, cattle do not come back to the household but spend the entire dry season near the water source.

Cattle taken out to graze with a herdsman.

During the rainy season, crop growing takes place and cattle should be more strictly supervised in order to limit damage to standing crops. Feeding is less of a problem than during the dry season. Herdsman might take the cattle out during the day only to communal grazing lands and come back to the cattle pen or animal enclosure next to the village. However, they can also find a steady place where they will stay during the nights in the rainy season. Calves are kept apart during the night, in a separate enclosure. In general, cattle are closer to home in the months June to December.

Traditional cattle pens, on the left for the calves, with hardly any fencing and no agricultural residue.

Certain animals, such as a limited number of dairy cattle and draught animals, are around the house all year long. Dairy cattle are often taken by children to the surrounding area to feed during the day and return at night. Draught animals work the fields during the day and return at night. Dairy cattle are often seen in the middle of the court, under a shelter and on top of stalks to keep their area tidy. Traction animals are either kept in the court or just outside the court in a similar set up.


Cattle under a shelter at the household court

5.4 Current practices of manure collection and application / compost techniques

All agricultural families use household waste, crop residues and manure for fertilising their fields. Promotion campaigns for agro-pastoralists –especially CMDT's *Lutte contre l'érosion programme*- have paid much attention to producing compost as agricultural fertiliser, and even though almost all families use their waste, most do not seem to have adopted the practice of collecting, composting and applying household waste, cattle manure, crop residues or a combination of those in an efficient manner.

The CMDT promotion campaign to introduce cattle pens next to the village where cattle could be kept at night and where manure would be concentrated for easier collection seems to have been adopted by just a small percentage of the households. This information might however be coloured by the difficulty in pin pointing the difference between improved and traditional cattle pens[9]. Waste pits seem to have been accepted much more according to CMDT data (see table below), although in our visits, we only saw the waste heaps next to households, and never have seen a pit.

Concerning the amount of manure collected, no hard figures can be given because they do not exist with the organisations involved with cattle rearing and/or agriculture. Because cattle is absent for a large part of the year and, when they are near the farm, they are not always kept in a confined area, the volume of collectable dung is very low. Our estimate would be that less than20% of the produced dung is eventually collected.

[9] The CMDT data might be distorted by a definition problem between 'improved' and traditional cattle pens. Improved cattle pens always have a fence, use crop residues as basis and have a limited m2 per animal. Traditional cattle pens might have (adopted) one or two of those criteria, but would then not be classified as 'improved'.

Table 7 : Adoption new techniques at production units in Sikasso region (2005/2006)

	% of production units having			
	IMPROVED CATTLE PENS		**WASTE PITS**	
	% of production units with improved cattle pens	Number of improved cattle pens	% of production unit with waste pits	Number of waste pits
Total Sikasso	**8%**	**9,300**	**45%**	**58,000**

Source: CMDT data 2007

The cattle pens are best described as enclosures, with a fence made out of wood or sometimes metal and without roofing. Improved cattle pens have soil covered with crop residues which –once mixed with the animal manure- can be used as compost. The amount of m2 per animal is limited to concentrate the manure and crop residues on a smaller surface. In the rainy season, extra crop residue is added so animals do have a rather dry soil to stand and lie on (*see picture of family showing their cattle pen just after adding extra padding*). This manure is collected once a year, normally in March and April, and then directly applied to the agricultural fields. Often the compost is left for about a month, and then, just before the first rains start, the compost and soil will be ploughed.

Improved cattle pens with agricultural residue and fencing

Household waste is collected and typically deposited on a spot next to the household compound. This is the traditional manner of composting: the improved composting heaps would become pits, where water might be added. Even though families know that when deposited in a pit the composting will take place more rapidly and more efficiently compared to leaving it on the heap, none of the randomly visited families, or their neighbours, practised this, even though they were familiar with the technique. After a few years, the soil underneath is taken to the fields as well, thereby creating a shallow pit after all. When asked why people do not dig a compost pit, they would reply that it was too much work: when the household waste was left on the normal waste heap, humidity would have done the composting as well. In general the household compost, together with the crop residues and manure which are collected in the cattle pens where livestock might spend the night, is applied to the farm fields at the same time, just before the rains.

Waste heaps next to households

Bodnár (2005, p65) in his research in southern Mali found that composting practices were strongly related to the possession of donkey carts and ox carts to transport the compost to fields. Most compost is applied to maize and cotton fields and increased from 14 to 25% between 1992 and 2002 (idem, p65), which is relative to the increase in cultivated area for cash crops. Kanté (2001) in Bodnar (2005, p75) writes: "Good soil fertility managers' as classified by farmers themselves, had larger farms with more cattle, were better equipped with oxen and donkey carts, collected more crop residues, especially for fodder and cattle pen bedding, and produced more compost."

The manure from cattle held year-round at the household, normally not more than 4 to 5 draught or dairy cattle, will be collected once a year when kept in a pen. When kept in the family compound, the manure will be thrown at the same household waste heap.

The above suggests that even though farmers do compost household waste and collect manure from the cattle pens for fertilising the fields, they have not easily adapted the new technologies introduced.

5.5 Availability of water at livestock farms

It proved very difficult to obtain statistical data on the availability of water on household level. According to the National Strategy of Provision of Drinking Water and Waste Treatment in Rural and Semi-urban Areas the objective is to have at least one modern water provision point for every 400 inhabitants. In practice one sees that most villages have either an open water source or a (deep or shallow) well, where several families will collect their water. It is exceptional for a family to own a private well at the household. Most villages are actually founded on the basis of having access to water. There are no large problems with the availability of water in Sikasso, even though the water quantity does decrease rapidly in the dry season.

Data for Sikasso are given below. If you divide the total number of water provision points with the number of families, this would mean that every water source would be used by 19 families.

Table 8: Inventory of modern water provision points in Sikasso (2003)

	Well	Modern well	Natural springs	Total
Sikasso	4 210	422	408	5 040

Source: ICD Mali.

5.6 Human waste collection and treatment

Randomly visited villages showed that every cluster of households had one or more latrines at the court. Most of them are pit latrines (see pictures) and were used by people living in the court.

Pit latrine in a family court.

Inside the pit latrine.

Numbers from CREPA, the Regional Center for Low Cost Water Supply and Sanitation, indicate that both traditional latrines, pit latrines and sceptic tanks are used in rural areas in Mali. They are less optimistic about their adequacy: less than 10% of the people have access to an adequate[10] sanitation system according to their data. The hygiene situation is not optimal, as people do not always (properly) use the latrines. Children often defecate outside the latrines.
The introduction of a biogas system which would build and/or connect latrines to the digester would however not change much to the current hygiene and sanitation of families already use pit latrines: the latrines are available, yet their proper use would have to be promoted more actively.

[10] Unfortunately, the information does not specify what they mean with ‘adequate’.

5.7 Conclusion on feasibility biogas based on farming and cattle management practices in Sikasso.

Climatically, Sikasso is a suitable region to introduce biogas: the average temperature allows for a biogas system to function, and the available water resources should be sufficient to feed a biogas system.
The cattle rearing tradition and practices do pose a problem for a biogas introduction. The largest obstacle is the difficulty to collect manure, which is not guaranteed year round due to the temporary migration in the dry season. Cattle is absent from the household for several months a year, migrating to the south to search greener pastures. The number of families that do have cattle around the household year-round is small, and the amount of manure they would produce questionable in terms of quantity. A biogas system which needs daily input is therefore not an option in the Sikasso context. Due to similar migration patterns for cattle in the rest of southern Mali we can assume that the above conclusion can be applied to the southern Mali context in general.
A technical option which does fit the cattle management situation could be a one batch-fed biogas system, which needs feeding once every six months. This option is more suitable to the cattle management practices in Sikasso, yet presents other difficulties, which will be presented later.

6. CURRENT CONSUMPTION OF ENERGY IN SIKASSO

6.1 Cooking

Traditionally in Mali access to wood is free, even though certain species are not to be cut for economic, ecological or socio-religious reasons. In rural areas women search for fuelwood, and aim to collect a large quantity of wood during the dry season, in order to stock for the rainy season. Having a large stock of fuelwood is prestigious, which sometimes results in up to 25% of the fuelwood rotting before use. The average distance women in Ségou –a region geographically and climatically comparable with Sikasso- cover to search fuelwood is 10 kilometres (DNSI 2004). Women complain of the large distances they have to walk in order to find suitable quantities of wood. However, in rural areas, people do not perceive the fuelwood, or the time women spent to collect it, as a cost. Therefore, all investments made in technology to either reduce or completely substitute the use of wood, have to take into account that they are 'competing' with a resource which is perceived as a utility without costs. Fuelwood collection and charcoal making for the urban market is a commercial activity: men are in charge of collection, transport and sale, normally along the larger routes. Urban prices of wood and charcoal can be found in Annex 5.

Almost 100% of rural households collect wood in nearby forests. The average consumption per rural inhabitant is 1,57m3 of wood per year (DNSI 2004). Our estimation is that for an extended family of 40 - 45 people, 30 kg of wood is required to cook three meals. The picture below on the left shows the daily amount for a 40 person family.

Picture of wood needed for 3 meals – women of Oumar Berthé- and traditional 3 stone open pit fire

Even though several promotion campaigns have stressed the importance of improved cookstoves their adaptation has not been widespread. The government institution AMADER now largely subsidizes the introduction of different models of improved cookstoves. Without a large shift in consumption behaviour in rural areas, one can say that the consumption of wood is still likely to increase with an increasing population density.

6.2 Lighting

Most rural families have access to different technologies for lighting at night. The older people still prefer the use of a shea butter lamp, which is simply a wick in shea butter (see photo below). One ball of butter costs 25 FCFA and lasts the entire evening: if one would want light during the night, 2 are needed, thus totalling 50 FCFA.


Shea butter lamp

Younger people and especially women who still have to work prefer a kerosene lamp, but the rapidly increased and increasing prices of kerosene make this a costly energy option. Normally one lamp costs 75 FCFA per evening.


Kerosene lamp


Lamp on dry cell batteries

Another option is to buy dry cell batteries. These lamps are considered modern and will not be used continuously. On average a family will change the dry cell batteries once a month and –needing 6- then spend 900 FCFA.

6.3 Current expenditures for lighting

Based on cross checked price information and consumption information of one of the rural families visited who had the following lighting technologies, we can calculate the average cost for lighting for this cattle rearing agricultural family with 70 members[11].

Table 9: Current expenditures for lighting: example of a 70 member family

Lighting	**# of lamps**	**Cost/ unit**	**Cost / month**	**TOTAL FCFA**	**TOTAL €**
Shea butter lamps	3	25	3*25*30	2250	0,38
Kerosene lamp	20	75[12]	75*20*30	45000	68,70
Battery lamp	1	900	900	900	1,37
TOTAL Costs				**48150**	**73,50**
Cost per person per month			93150 / 70	687,85	1,05

Thera (2005) has researched household's expenses for both cooking and lighting in the town of Ségou, in a neighbouring province. It is not directly comparable to above calculation, as 96% of the interviewed households in Ségou town did not search but buy wood, so the costs of wood are added. 64% of the Ségou households had less than 10 members[13], compared to the family of 70 in the earlier presented example. According to these data, about 70% of households spend between 2500 and 10000 FCFA per month on household energy.

Table 10: Expenditures for cooking and lighting – urban households in Ségou.

Expenditures in household energy in FCFA	**%**
Less than 2500	20,3
2500-5000	37,8
5000-10000	30,5
10000-15000	7,7
More than 15000	3,7
Total	100,0

6.4 Lighting versus cooking improvements, and the role of women in decision making.

All members (men and women) of rural cattle farming families spoken to during the research preferred improved lighting technologies, such as gas lamps or PV systems, over improved cooking technologies. Even the women, aware of the financial situation of the family and the fast increasing prices of kerosene over the last period, would prefer an alternative to the costly kerosene lamps over the improved woodstoves or gas burners for cooking.

[11] There are many data on household expenditures in urban areas for wood and charcoal expenses, but very little research has been published to household expenditures for lighting in rural areas, hence this example.
12 1 litre of kerosene costs FCFA 650,-
[13] The division was: 2-5 people/ household = 22%; 6-10 = 42%; 11-15 = 17%; 16-20 = 11%, 21-30 = 5%; 30+ = 2%

The family with a functioning biogas system had installed one burner for cooking and seven gas lamps for lighting. The burner still appeared new even though it had been installed more than two decades ago and was obviously hardly used. The seven gas lamps on the contrary were used intensively. This indicates that when families can choose, lighting alternatives seem to be a larger need than cooking.

Another factor is the shared use of the produced gas from a biodigester. The lamps can be used by all members of a family. However, each woman cooks for her own children, on a family compound one can see a great number of woodstoves. Practically it is impossible to share the gas among all women for cooking purposes.

We have to take into account that the decision on how to use the biogas will be made by the head of the family, a man who never has to cook or search for wood. In general however, the head of family would have to account for large investments to the entire family, and when women would strongly be in favour of applying the biogas for cooking, it probably would happen, at least partially.

Based on information from initiatives trying to introduce appropriate technologies to rural households in Mali[14], the role of women in the adoption and application of new technologies is multiple. First of all, Malian women in rural areas do not have any decision-making power in public. However, when women are convinced of a certain technology, they are often the ones who manage to convince others in their households to obtain this new technology. Men are often harder to convince, and programs find the women becoming rather important co-promoters. With many adjusted technologies which have been introduced in Mali, such as improved cookstoves and latrines, the women are responsible for the use and also take care of the maintenance of the equipments. Depending on the sensitivity of a new introduction within the rural household, some promoters encourage a separate training for men and a separate training for women.

6.5 Conclusion on feasibility biogas based on current energy consumption.

Fuel wood is by far the largest energy source for households in rural areas in Sikasso. As women collect the wood themselves, the fuel wood has no monetary costs in rural areas, and is perceived as ‘free’ by the families using it. Even though women do have to walk large distances, it is not perceived as a very pressing problem by the people we spoke to during research. Kerosene, the most regularly used source of lighting in rural families, is becoming more and more expensive. Families do perceive this as a problem, and would like to address these rising costs and find an alternative to the current lighting situation.

[14] Talks to CREPA, FAMALI, Yeleen Kura.

The large size of Malian rural households and their division in sub units per wife would make it difficult to connect enough burners to a biogas system to satisfy all the cooking needs of the women in the family. If biogas were to be introduced, both men and women in rural families prefer to use the gas for lighting over cooking.

7. POTENTIAL DEMAND FOR BIOGAS AND TECHNOLOGY CHOICE

This chapter aims to assess the potential demand for biogas and bases the analysis on the one batch-fed biodigester. The aim of this chapter, and this study, is not to introduce a final and complete financial analysis of introducing biogas. Rather, it analyses the demand after having studied the Malian context in terms of manure and cattle management and current energy use, and then introduces a first impression of the financial aspects[15].

7.1 Technical potential for domestic biogas

Table 11: Number of animals and cattle raising families in Sikasso

	Number of animals and cattle raising families in Sikasso										Total
# Animals	0	1 -2	3-4	**5 - 9**	**10 - 19**	**20-49**	50 - 99	100-199	200-499	500+	
# Families	6815	5819	7219	**19261**	**21623**	**26794**	8316	1693	183	0	97725

Source: DNSI 2007.

DNSI data suggest that most families have between 5 and 50 animals. These are the total number of animals per household. For biogas only the animal that are kept in a pen every night are of interest. As the animal do not produce a lot of dung, are kept only part of the day in a pen, and dung gets lost because it is only sporadically collected from the pen, at least 6 of such animals are needed to feed a small digester.

There are no data on the number of families who have at least six animals in or around the household all year long. These would be the most reliable data to assess the technical feasibility of biogas.

We do have data on the number of families with the number of animals they have in total. These animals are not around the household all year long, and will thus only be able to contribute to batch-fed biodigesters. The technical feasibility calculated below is therefore only the technical feasibility for a batch-fed system, and not for biodigesters which need to be fed daily.

If we take all families who own 5 or more animals (based on the table above) we see that there are 77.870 families in this category, who potentially might be interested in a batch-fed biodigester. Assuming that all of them could fulfil the other requirements to make a biodigester function, this would mean that he total technical potential for batch-fed biodigesters in Sikasso is estimated at 77.870 plants. Based on experiences of newly started biodigester programmes in other countries and given the conservative

[15] ETC Energy has simulation models which have been applied in a market and financial analysis of biogas in a feasibility study for implementation of biogas in Kenya. This knowledge has served as the basis for the analysis in this chapter.

nature of the rural households in Mali, it is unlikely that plant construction can be realised at a small fraction[16] of the households who have the technical potential within a first program phase of four years. The number of plants to be constructed at the first phase of an eventual batch-fed biodigester introduction programme is estimated to be less than 2500.

7.2 Financial analysis of a 10m3 batch-fed biogas plant

Given the distribution figures of cattle over the rural households, the semi-nomadic grazing practices for a large part of the animals together with the stabling practices and the sporadic dung collection practices, only batch-fed plants will be able to function for a large part of the year. These plants can be fed with 6 monthly intervals. In order to have reasonable daily gas production these plants have to be considerably larger than continuously fed plants; 10m3 plants would be the most appropriate size given use and construction limitations.

With a feeding of 4500 kg per 6 months, such a plant will produce enough gas to modestly operate 5 lamps for 3 hours per day each. Gas will not or only rarely be used for cooking as fuelwood is considered free of charge while kerosene needs to be bought. Also the family structure with several subunits of women with children does not fit the use of 2-3 biogas stoves: in most families one can find up to a dozen woodstoves of 3-stones or simple clay design woodstoves. Introducing just a small number of burners might present social problems in terms of ownership and use.

The replacement value of the biogas for kerosene lamps amounts to 0.11 litres/day/lamp[17] or 40 litres/year/lamp. For 5 lamps the savings will be therefore 200 litres/ year/ hh if the plant is in operation the whole year. As this is not the case, twice a year the plant needs to be emptied and refilled, and because biogas lamps are very maintenance sensitive, the actual savings are estimated at 150 litres/year/hh. This will save the family 97,500 FCFA or € 149 per year on kerosene expenses.

The plant model used for the analysis is a Chinese dome model that was introduced on a modest scale in the late eighties - early nineties by the CMDT with Chinese support (see paragraph 6.1). This model was selected as it is the only of several models introduced that seems to function to some extent.

Included in the plants costs calculation are the unskilled labour component (digging, etc.), fee for construction and guarantee service as well as pipes and appliances. As biogas appliances are not available prices for the appliances had to be assumed. This was done by comparing the appliances cost with the total plant cost for the biodigesters in Rwanda (GGC model) and Cambodia (Deenbandhu model). In Rwanda pipes and

16 Experiences with national biogas programmes in other countries show that it is only 3% of the potential what new programmes can realize in the first phase (4 years) of such a programme.

17 Based on the information given by rural families that one litre of kerosene is used for 9 days: 1 litre of kerosene / 9 days = 0.11 litre of kerosene per lamp per day.

appliances make up 9.3% of the total plant cost while in Cambodia appliances and pipe are 10.6% of the total cost. Based on these figures a cost of 10% of the total plant cost for appliances has been assumed in Mali. The plant cost calculation is given in annex 7. The material list needed for the construction has been provided by the CMDT while the material unit prices where checked at the market in Koutiala.

The basic data for the financial analysis are presented in table 12 (see below). The benefits associated with the use of biogas plants are derived uniquely from the savings in expenditures from kerosene used in lamps. The value of saved labour and the recovered nutrients from bio-slurry are assumed to be zero because they do not yield an immediate financial return.

Table 12: Basic data for financial analysis

Costs	**FCFA**	**€**	
Investment costs	576250	880	See annex 7 for calculation
Ann maintenance costs	23050	35	4 % of investment costs
Subsidy	144063	220	25% Idem
Net cost	432188	660	
Down payment	57625	88	10 % Idem
Loan amount	374563	572	15 % Ann. Int. 3 yrs term
Ann loan payment	-164050	-250	
Annual savings	**Unit (ltr)**	**FCFA/unit**	**Total FCFA**
Kerosene	150	655	97500

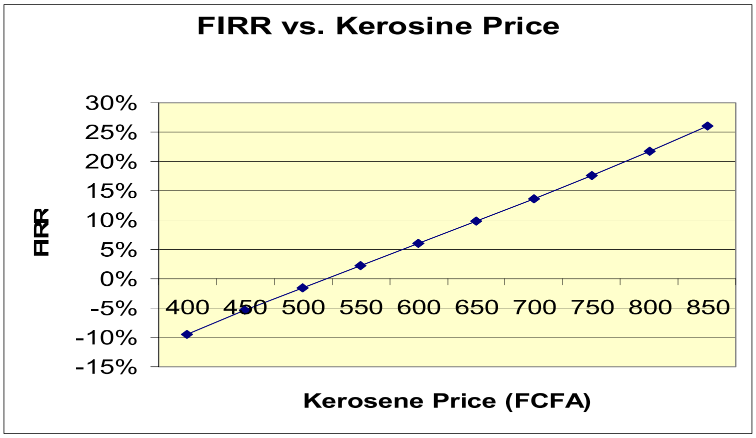
We believe that a market based introduction of a biogas system should not standard include a subsidy. The above example however has included a € 220 subsidy[18], which can be seen as a promotion of the first systems which would be introduced. In later stages, the biogas introductions should prove itself without subsidy.

The mentioned interest rate is based on figures obtained from Kafo Jiginew, the largest rural bank in Mali.

The base analysis indicates a financial internal rate of return (FIRR) of 10 % becomes positive over 7 years. Figure 1 below presents the results of a sensitivity analysis on the assumed price of kerosene. The FIRR becomes negative when the price of kerosene is below 525 FCFA/ litre and is 22 % at 800 FCFA/ litre.

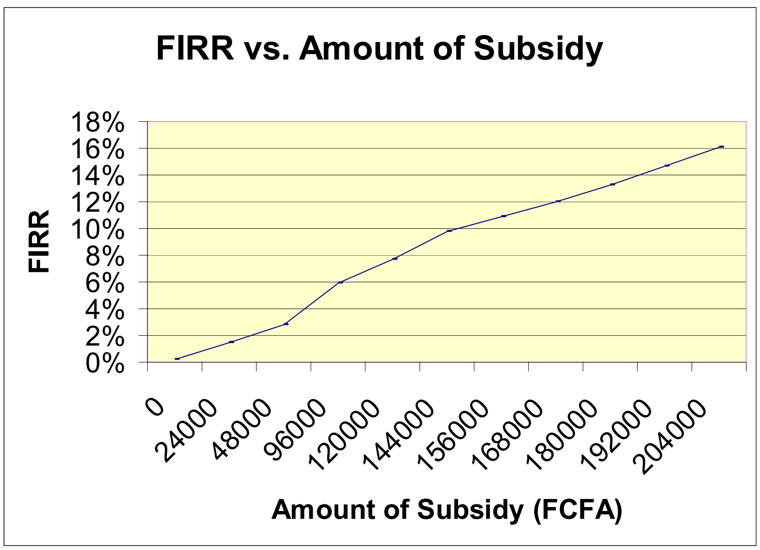
[18] The height of the subsidy amount included in this example is based on the maximum investment subsidy (€ 220) as indicated in the 'Conditions for Successful Introduction of Large-Scale Domestic biogas Programmes in Africa'. These conditions were drafted for the Africa Initiative Biogas Workshop 2006 in Amsterdam.

Figure 6: The Financial Internal Rate of Return (FIRR) depending on the price of kerosene



A sensitivity analysis on the amount of the subsidy provided is presented in figure 7. The FIRR becomes less than 5 % when the subsidy is below 80,000 FCFA (€ 122) per plant and becomes 0 % without subsidy

Figure 7: The Financial Internal Rate of Return depending on the subsidy level



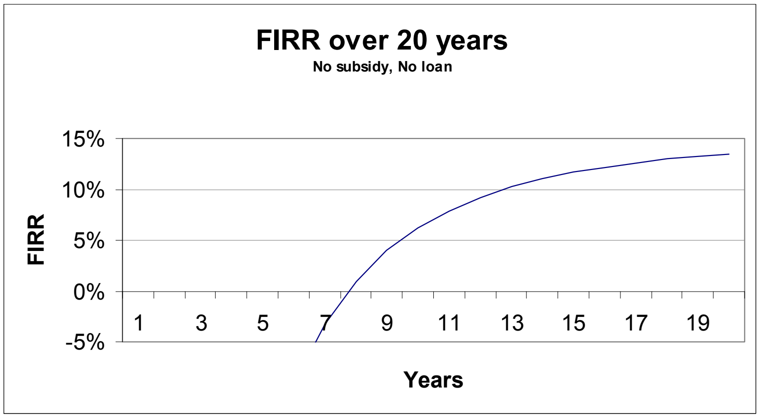
An investment subsidy of FCFA 144,000 (€ 220) or 25% of the value of the biodigester is considered to be insufficient to attract a significant number of potential farmers.

A 25% subsidy in combination with a three year loan against 15% annual interest would still take 7 years before the FIRR would become positive. Afterwards the FIRR would slowly grow to 10% in year 10 and to 17% in year 20.

It is estimated that for a farmer a positive FIRR of about 30% within the first three years is important to influence investment decisions. The period of 7 years before reaching a positive FIRR is therefore too long.

Moreover, without subsidy and without credit performance is less promising.

Figure 8: FIRR without subsidy and without loan



FIRR will only be positive in year 8 and FIRR in year 10 and 20 will be 6% and 13% respectively.

The alternative investment opportunity for lighting in a photovoltaic system against a price of €10 per Wp or €500 for a 50Wp system installed, would also be able to operate 5 energy efficient light bulbs for 3 hours a day. Total investment and maintenance costs would be lower, the idle time of the system would be less and the convenience higher. Moreover the system could be used to power other equipment, like radio and TV, and thus substitute other energy expenses and potentially generate more savings.

At present, a hard economic analysis is not yet possible due to the lack of data. Based on similar installations though, functioning in a similar economy (Nepal), we can say that the economical internal rate of return value rises in proportion with the amount of factors taken up in the analysis (indoor air pollution, toilet attachment, soil fertility, working hours saved, …).

7.3 Financial Sector indicators of the rural population in Sikasso

The largest credit provider in the Sikasso region, Kafo Jiginew, has since its creation in 1987 set out more than 9 billion FCFA in credit. The repayment rates vary per type of credit, but according to their own information ranges between 95 - 97%. The credit providers describe their clientele as poor to average: only 1% of their clients are considered 'rich and urban' (see table below). The economic situation of families in the region is "more and more precarious: more and more people become indebted or have to sell their goods (cattle mostly) to be able to pay of their debts"[19].

[19] According to the General Director of Kafo Jiginew in July 2007.

The type of loans given out shed a light on the amounts and frequency of the credits.

- 70% of the loans Kafo Jiginew supplies are short term loans and have to be paid back within a year with 15% interest. The minimum amount people can borrow is FCFA 10.000 (€ 15), the average is FCFA 120.000 (€ 183). The maximum amount to be borrowed is 33% of the annual income of the borrower.
- On the mid-long and long term with payback between 1 and 5 years and an interest rate of 20%, Kafo Jiginew gives out loans with an average of FCFA 150.000 (€ 229) in the rural areas. The maximum amount to be borrowed is 40% of income, based on the last three production years. The mid-long term loans only represent 20% of all loans.

When looking at the rural bank's clients, one sees that most of the people able to borrow money are very poor to poor, and that these data do coincide with the earlier presented CMDT data on income. Kafo Jiginew has divided the bank's clients in four distinct groups:

Table 13: Stratification of clients of rural credit provider Kafo Jiginew in Sikasso

Group	Daily revenue (FCFA)	Annual Revenue (€)	% of KG's client	Average number of animals in this group
Poorest	500 F/ person	278	15 %	No animals (no plough)
Poor	500-1000 F/ person	278 - 556	55 %	Between 2 and 7 small animals (goats, sheep, chicken) per household
Average	>1000 F/ person	> 556	30 % (of which only 3% live in rural areas)	These (urban based) people often have herds of about 50 to 200 animals in the villages.
Rich	<1% of their clients can be considered rich. All of these people live in urban areas.			

From the clients of Kafo Jiginew in Sikasso, only a very small percentage would be able to pay for a biogas system under the prices and conditions presented above.
Also, it shows that more than 70% of the loans are short term (one year) and the longest loans are up to five years: the FIRR which had been simulated for a biogas introduction would only become positive over 7 years, which indicates that potential end users would have to see many non-financial advantages to construct biogas system before adapting this technology.

7.4 Clean Development Mechanisms

When looking at the macro-economic perspective of introducing a biogas implementation program, the Clean Development Mechanism could serve as an additional source of financing to stimulate the introduction of biodigesters. The advantages of the biogas system would have to be gained in better manure management and by introducing a fuel switch from non-renewable to renewable energies.

In Sikasso, there are no credits to be gained by improved manure management. In the traditional handling of manure there is no methane as the digestion is aerobic. The fuel switch from kerosene would however present possibilities for gaining credits. Per installation, one would gain an average of 150 Liter/ kerosene/ year (as based on the earlier introduced example). This would account for 386 kg / CO_2/ year. With a price of US$10/ ton this would increase the FIRR to 12% in year 10. The FIRR would still only become positive in year 7.

The question still remains if –with the given potential in Mali- the CDM financing source is an interesting option, as it is most interesting to start a CDM program with large quantities.

7.5 Conclusion on feasibility biogas based on choice of technology and financial feasibility.

The technical potential in Sikasso is estimated at 2.336 10 m3 batch-fed biodigesters in the first four-year phase of a program.

The financial potential is based on the one batch-fed system of 10 m3, which estimated costs are € 880. Even with a very large investment subsidy of € 220 or 25% of the value of the biodigester is considered to be insufficient on financial terms.

When looking at the financial sector's indicators for the rural population in Sikasso, we can see that the annual revenues of 55% of their clients are estimated between € 278 and € 556, which indicates that –if these people would have enough manure and the willingness to invest in biogas- the annual repayment loan of €250 would be a heavy burden. It is estimated that for a farmer a positive FIRR of about 30% over the first three years is important to influence investment decisions. The period of 7 years before reaching a positive FIRR is therefore too long.

The standard arguments which influence the demand for biogas, for example in Asia, do not seem to be relevant in Mali. Financial terms do not encourage people to invest in a biodigester, as it is too expensive. Other arguments which might persuade potential clients to still buy the expensive system, are not favourable either. Manure is not readily available throughout the year. Even with a one batch-fed system, people still have to get the manure from cattle pens outside the household on a six-monthly basis. In terms of hygiene, this will not change the current situation. In terms of use of biogas, the preference for lighting has been expressed over the preference for burners for cooking, therewith taking away the advantage of reducing women's workload and improving the health situation of mainly women and children.

8. CONCLUSIONS AND RECOMMENDATIONS

The biogas pre-feasibility team concludes that the conditions for the introduction of biogas are not favourable. The main reasons to come to this conclusion are threefold. Firstly, in terms of technical feasibility, there is an absence of a regular supply of dung at most agro-pastoral farms in Sikasso, and southern Mali in general. Secondly, in terms of choice of technology and financial feasibility, the costs for the biogas plant construction are high because of the need for large batch-fed plants. Thirdly, socially, gas would only be used for lighting given the general idea that fuelwood is free of charge and the difficulty of dividing the burners in the large complex family structures. There is no widespread prevalence of LPG cooking in rural areas either. Other renewable energy sources for lighting might be a more suitable solution. Below, this conclusion is explained in more detail.

Technically, due to the semi nomadic cattle holding, with most of the cattle leaving the farm during at least a few months in the dry season, a biogas system which needs to be fed daily is not a suitable option in the Sikasso context.

The choice for a one batch feeding system technology might work in terms of available cow dung and timing coinciding with agricultural practices. This will present several difficulties however. First of all, a batch-fed system has to be larger and thus costlier than a continuous fed system with the same daily gas production. This will decrease the potential client base as costs rise. Second of all because technicians will be needed at the same time during the year (all cattle farmers have the same routine, with animals leaving during the dry season and returning when rains start). Also the technicians will need to do regular maintenance checks and assist in opening and closing the manhole lid properly. And third of all because the population density –although the Sikasso region has one of the highest densities in Mali- is still not high: this will result in high transport costs, increasing the fee to be paid to the biogas technician, and thus increasing the cost of maintaining the system.

There was little to no evidence of advanced composting techniques in the region: even though several families had heard of or even knew certain advanced techniques, their application was not practiced widely. The advantage of biogas slurry as an extra fertiliser and the systematic collection of manure would need extensive awareness raising and training.

Financially, the batch-fed biogas systems of 10 m3 researched would currently cost around € 880,-. This is too large an investment for the majority of the rural population. Even if a program would include subsidies to stimulate the first users to adopt the technology, and assuming that farmers can take out credits from the rural banks, it remains a large amount for most of the agro-pastoralists in Sikasso. Even a very large investment subsidy of € 220 (or 25% of the value of the biodigester) is considered to be insufficient to attract a significant number of potential farmers (a positive FIRR of 10% over seven years).

On top of the negative financial terms, the demand side is not sensitive to the usual sales arguments for biodigesters and the use of biogas: they seem to be less relevant for the rural context in Mali. Financially it would not improve their situation fast enough; improved cleanliness is less relevant as cattle are mostly outside the household; due to low-profile composting traditions the use of slurry is not considered as a valuable addition; and the health situation of women and children would not improve if biogas were only to be used for lighting.

Socially, people are more interested in gas for lighting than in gas for cooking. Previous biogas users in Sikasso already expressed their preference for lighting over cooking in 1993. During our research it became clear that with the rising kerosene prices, this demand has only increased. Wood scarcity is an officially recognized problem, but wood is perceived as a free resource by rural populations and therefore not valued in monetary terms. The scarcity apparently is not so urgent that cooking alternatives would be preferred. Large government and donor sponsored programs for improved cookstoves are carried out at the moment, and –if biogas is not an option- could be a less technology intensive manner for dealing with wood scarcity. Availability of already existing market based PV introductions in the region and Mali in general offer another viable commercial alternative when people are interested in (renewable) energy sources for lighting, but do not have the financial resources to make the large investment. Even though the customer should decide in the end, the preference for lighting over cooking with the biogas technology is an important factor to take into account.

With the preference for lighting instead of cooking, one of the most important incentives for women to work on feeding and maintaining the biogas system will be lost. As was seen in the biogas systems visited, it is mostly women who were responsible for maintaining the system, but the gas lamps would –for the large majority- be placed in the huts of the men in the household. In the one family where the biogas system still worked, women had the double task of looking for fuelwood for cooking, feeding the biogas system with dung and water, yet being the only ones in the household who did not have gas lamps in their hut, and thus did not benefit from their extra work. Introducing biogas in the Malian polygamist extended family household structures is therefore not an easy task in terms of gender balanced benefits. If a biogas installation would be installed, who –out of the many men, women and children of the family- would use the gas? Who regulates a sustainable and efficient use of the gas resource? The operation of a biogas system in a multi-unit household is an important and difficult organisational issue and could create social and operational problems.

RECOMMENDATIONS

The research team concludes that the technical feasibility of introducing a biogas dissemination programme with the current one batch-fed technology in Mali is low.

The livestock holding traditions, including the small number of animals at the household year-round and the large number of animals migrating temporarily during the dry season, do not allow for a biodigester which has to be fed daily. This would lead the team to recommend a batch fed biogas system.

This system however, is larger than a continuous fed digester with the same daily gas production and therefore more expensive, as shown in chapter 7. Costs and appropriateness of the advanced technology should be looked at in a critical manner: maybe a simpler model with other materials is an option. In social terms the introduction of biogas in large households with several wives and their children, does not automatically lead to benefiting all in the family.

Families have a clear preference for using biogas as an alternative for kerosene for lighting purposes over an alternative for fuelwood for cooking. Any biogas programme should follow the market in this. Forcing families to use the gas for cooking leads to disinterest and eventually abandonment of the technology. As a result no significant workload reductions or improved indoor cooking conditions for women can be expected.

Based on the above, the research team would not recommend Mali as a country for biogas implementation with the available technologies. If one would decide to go on with the introduction of batch-fed systems of 10m3, one has to realise that no large numbers will be reached in terms of biodigesters installed, and that those who will be installed will be part of a programme with high overhead costs, which in the beginning needs large subsidies. These systems will most likely not directly contribute to reducing the workload of women, nor lead to a more sustainable (household) environment. We strongly doubt this can be the basis for a biogas market in Mali.

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10. ANNEXES

1. Terms of Reference
2. People met and interviewed
3. Mission itinerary
4. Summary findings technical feasibility study Mali
5. Presentation biogas user Mr. Oumar Berthé
6. Prices of wood and charcoal
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ANNEX 1:

TERMS OF REFERENCE

Terms of Reference to assess the technical feasibility of implementing a biogas promotion programme in the Sikasso and Ségou regions in Mali

Introduction

Mali has been engaged in various rural energy access programs over the last years, both directly and in cooperation with the private sector. According to a recent desk study on biogas in Mali[20], there is potential for a large promotion programme in the southern regions of Sikasso and Ségou. The desk study looked at livestock practices and numbers, availability of water, population density and institutional factors. However, it is essential to corroborate this with a critical assessment of the socio-cultural, economic, environmental, technological, institutional and political factors on the ground in Mali in general and in the Sikasso and Ségou regions in particular.

Purpose

The purpose of the study is to comprehensively assess the strategic and operational feasibility of implementing a biogas promotion programme in the Sikasso and Ségou regions in Mali.

Goal of the Feasibility study

Asses the technical feasibility of and demand for implementing a biogas promotion program in the Sikasso region:

- A technical analysis of the potential of biogas systems in the cattle breeding context in the Sikasso region.
- A socio-economic analysis of cattle breeding families to analyze (demand and possibilities of) potential market segments in a biogas implementation market in the Sikasso region.

Activities

Before entering a full fledged in-depth study of biogas implementation possibilities and the market potential for this introduction, a first phase with a small team of experts will asses the technical feasibility of introducing biogas in the selected regions. Objective is to assess whether (and how many) farmers and cattle raisers have the available quantity of manure for and possible willingness to adapt to biogas. The data will be used to analyse whether this potential will be enough to start a full fledged feasibility study including market potential, market actor identification, financial feasibility etc.

[20] Mamadou Diallo, Maaike Snel, Frank van der Vleuten (2007). *Le potentiel pour le biogaz au Mali*.

To concentrate as much as possible, only Sikasso will be included. The research team does not expect large differences between the Ségou and Sikasso region. It is expected that the results of the Sikasso region will be sufficiently representative for both the Sikasso and the Ségou region.

The Feasibility Study includes:

1. First institutional orientation

The first component is a short Mali-wide institutional assessment. Efforts to implement biogas in Mali have been ongoing since the 1970s. It is therefore prudent to begin with an analysis of the successes and failures of introducing biogas technology. This assessment will also overview the following actors, at a national level:

- Government experiences with biogas
- NGOs experiences with biogas, including on-going initiatives.
- Biogas companies (public and private institutions) and technicians in the country
- Related/linked credit providers (housing finance) and technical schools in the country.

2. Technical feasibility Biogas

The second component is to research the technical possibilities of introducing the biogas technology in the region. This research will be concentrated in Sikasso. The technical feasibility study will:

- Analyze the technical feasibility of introducing biogas systems in Sikasso per market segment.
- Analyze the suitability of the particular cattle breeding practices for the introduction and sustainable use of biogas.
- Formulate recommendations on the most suitable type of biogas digester and integration of digester management with livestock management practices for the region
- Formulate minimum criteria for successful introduction and use of the recommended biogas digester model.
- Formulate recommendations on the type of requirements needed (technical, cultural and social) for sustainable use by end users of the biogas digester.
- Recommend priorities for support by a biogas programme related to the two points above.
- Analyse whether the researched technical potential supports the continuation of more in depth customer-research and market-study of a biogas promotion program.

3. Socio-economic analysis

The third component is a socio economic analysis of cattle breeding families to analyze (demand and possibilities of) potential market segments in a biogas implementation market in the Sikasso region.

- Profile of sample households in possible market segments. Include specific information on cooking and energy use; house building / septic tanks; credit / financing; communication/decision making; agricultural inputs and tools procurement per segment.
- Carry out interviews with cattle breeding families, individuals and if applicable, associations or companies to collect above information.
- Analyze the profiling and give recommendations based on socio-economic information about feasibility of biogas implementation in Sikasso region.

Deliverables

The feasibility study will result in a report including the institutional orientation, technical feasibility analysis, socio economic analysis and a joint recommendation of the three experts.

All deliverables will be presented to DGIS for comments. Final responsibility for production lies with Maaike Snel (program manager).

Timing

The fieldwork is planned in the first ten days of June.

The report of Phase 1 will be presented to DGIS June 30th.

Team composition Feasibility Study

Name	**Organisation**	**Function**	**Number of days**
Coordination			
Maaike Snel	ETC Energy	Project manager / socio-economic expert – Phase 1	10
Local situation Expert			
Mamadou Diallo	ICD	Local situation expert Phase 1	14
Market and financial expert			
René Magermans	ETC Energy	General backstopping - Phase 1	2
Biogas expert			
Jan Lam	SNV	Technical study biogas potential – Phase 1	10
TOTAL			**36**

ANNEX 2:

PEOPLE MET AND INTERVIEWED

PEOPLE MET AND INTERVIEWED Organisation/ description	Photo?	Name	Telephone #	Function	Where
Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER)		Mr Seydou KEITA	679 63 42	Directeur Energie Domestique	Bamako
Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER)		Mr Amadou Diallo	2238567/ 6796779	Ingenieur des Eaux et Forets, Chef de Service Gestion Durable des Ressources Bois-Energie	Bamako
Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale (AMADER)		Mr Amadou Kassambara	2238567/ 6711565	Responsible Schemas Directeurs d'Approvisionnement	Bamako
AMCFE - Association Malienne pour la Conservation de la Faune et de l'Environnement		Mr Ousmane Ouattara	6275199	Expert biogaz	Bamako (BP 1634 Kayes)
Association de Forgerons Diria de Koutiala	x	Mr Mama Sogodogo	5044750	Secretaire administrative	Koutiala
CMDT, Compagnie Malien De Developpement des Textiles	x	Mr Sibiry Goita	6148366	Responsible programme biogaz 1984-1992	Fana/ fieldwork
CMDT, Compagnie Malien De Developpement des Textiles		Mr Abdoulaye Traoré	6762644/ 2219525	Chef de Service Production Agricole Conseil	Bamako
Centre national de l'Energie Solaire et des Energies Renouvelables (CNESOLER)		Mme THERA Aminata FOFANA	669 67 99	Chef Section Bio-conversion et Energie Eolienne	Bamako
Centre national de l'Energie Solaire et des Energies Renouvelables (CNESOLER)		Mr Hamata Ag Antafaye		Directeur	Bamako
Cooperation Laitière Danaya Nono Koutiala	x	Mr Ely Togo		Directeur	Koutiala
Cooperation Laitière Danaya Nono Koutiala		Mr Bakary Traoré		Technicien d'élevage	Koutiala
COTAP - Coordination des ONGS intervenant dans l'assainissement	x	Mr Kader Dembelé	0	Vice president	Sikasso
CREPA - Centre Régional pour l'Eau Potable et l'Assainissement à faible coût		Mr Youssouf Cissé	2202039	Directeur	Bamako
DANIDA		Mr Jens Gregorson	5047929	DANIDA representative	Bamako
Departement d'Elevage et de Peche		Dr Keita		Conseiller technique élevage	Bamako
Direction Régionale de l'Assainissement et du Contrôle des Pollutions et des Nuisances	x	Mr Fine Mory Camara	6491044	Directeur	Sikasso

PEOPLE MET AND INTERVIEWED Organisation/ description	Photo?	Name	Telephone #	Function	Where
Direction Nationale de l'Energie (DNE)		Mr Moussa CISSE	630 87 37	Chef Division Infrastructures énergétiques, Directeur par intérim	Bamako
Direction Nationale de l'Energie (DNE)		Mr Tezana COULIBALY	645 54 26	Chef Division Maitrise de l'énergie	Bamako
Dutch Embassy		Mr Jaco Mebius	2219572/82	Responsable Sustainable Economic Development	Bamako
GTZ - Programme FAMALI	x	Moussa Doumbia	6755584/ 2235256	Consultant	Bamako
GTZ - Programme FAMALI	x	Benoit Lelong	6755585/ 2235256	Coordinateur	Bamako
Kafo Jiginew		Alou Sidibe		Directeur Général	Koutiala
Mali FolkeCentre		Mr Ousmane Ouattara	6710354	Expert biogaz pendant le programme	Bamako/ Falan
Ministère de l'Agriculture Cellule de Planification et de Statistique (CPS)	x	Mr Bocar Siré Ba	2230425/ 6730258	Agronome - informaticien	Bamako
Réseau des Prestateures de Koutiala - RPK		Mr Yaya Thaoré		Président	Koutiala
Système biogaz non fonctionant	x	Mme Kadiatou Keita		New tenant	Koutiala
Systeme biogaz non fonctionant	x	Mme Doumbia Djeneba Coulibaly		User of system	Falan
Système biogaz privé (opérationelle)	x	Mr Oumar Berthé et famille		Technicien of CMDT biogas team: mason	Gouan
Secteur Véterinaire de Koutiala		Mr Youssouf Marico		Chef de secteur	Koutiala
Service Local Production Industrielle Animale		Mr Chaka Cissé	6144371	Programme officer	Koutiala
SNV		Mr Souleyman Diarra	6442250	Conseiller technique élevage	Bamako
Yeelen Kura	x	Mr Amadou Diallo	6384535	Directeur Génerale	Koutiala

And different rural families, (cattle) farmers, wood and charcoal salesmen.

People met and interviewed during mission

Mr. Amadou Diallo

Yeelen Kura

Koutiala

Mr. Fine Mory Camara

Direction Regional Eau & Assainissement

Sikasso

Mr. Ely Togo

Milk cooperative

Koutiala

Mr. Kader Dembelé

COTAP

Sikasso

Mr. Benoit Lelong

GTZ FAMALI

Bamako

Mr. Sibiri Goita

CMDT Biogas

Fana

Mr. Moussa Doumbia

GTZ FAMALI

Bamako

Mr. Oumar Berthé

CMDT Biogas Mason + biogas user

Gouan

People met and interviewed during mission

Mr. Alou Coulibaly

Farmer & cattle owner

Koutiala

Mrs. Kadiatou Keita

Resident of house with non-functioning biogas system

Koutiala

Mr. Mama Sonodogo

Association Forgerons Foyers Améliorés

Koutiala

Mr. Keita

Wood and charcoal salesman National road

Bamako – Fana, Korokoro

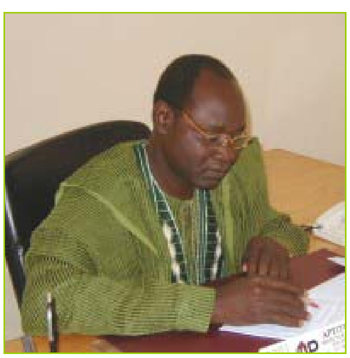
Mrs. Doumbia Djeneba Coulibaly

Ex-user of biogas system

Falan

Mr. Ousmane Ouattara
Mali Folkecenter

Bamako - Falan



Mr. Youssouf Cissé

CREPA

Bamako

Biogas research team

Mr. Jan Lam

SNV Cambodja

Biogas expert

Mr. Mamadou Diallo

ICD

Local expert

Mr. Samba Sissoko
Driver

Ms. Maaike Snel

ETC Energy

Socio-economic expert

ANNEX 3:

MISSION ITINERARY

Date	What activity / whom met	Where
JUNE	***ACTIVITÉ***	
1	Direction National d'Energie	Bamako
2	Internet and document research	Bamako
3	Internet and document research	Bamako
4	AMADER	Bamako
	Bureau Nationale de Statistiques	Bamako
	Ministère d'Agriculture, division d'Élevage	Bamako
	Bureau Nationale de Statistiques	Bamako
5	Travel towards Koutiala	Koutiala
	CMDT biogas team	Fana
	Visits and stops at rural families, wood salesmen.	On the way
	Yeelen Kura	Koutiala
6	Secteur Veterinaire	Koutiala
	Service Local Production Industrielle Animale	Koutiala
	Associations des Forgerons	Koutiala
	Reseau de Prestataires Koutiala	Koutiala
	Visit of operational household biogas system mr. Berthé	Gouan
7	Cooperation laitiere	Koutiala
	Visits cattle farmer families	Koutiala
	Travel to Sikasso	Sikasso
	Direction National de l'Assainissement	Sikasso
	CONAP	Sikasso
8	Travel Sikasso - Bamako	Sikasso
	DANIDA	Bamako
	CREPA	Bamako
	Bureau Nationale de Statistique	Bamako
	SNV	Bamako
9	MFC	Bamako
	Visit non operational biogas system	Falan
	First summary results	Bamako
10	Developing questionnaire Kafo Gijinew	Bamako
	First summary results	Bamako
11	CMDT	Bamako
	GTZ - FAMALI	Bamako
14	Dutch embassy	Bamako
9-Jul	Kafo Jiginew	Koutiala

ANNEX 4:

SUMMARY MISSION FINDINGS TECHNICAL FEASIBILITY BIOGAS MALI

Summary findings technical feasibility study Mali

Technical conditions

- Daily ambient temperature above 20°C throughout the year
  - *Biogas plants can operate in the whole country throughout the year*
- Daily availability of at least 20kg dung at a large number of farms
  - *Difficult during the dry season (November till June, and February till June in particular) because of temporary migration*
  - *Few animals at the house year round (traction animals and sometimes dairy cattle)*
  - *Dung collection happens once a year only, collected from the cattle pens*
  - *The Islamic and animistic population of Sikasso does not have pigs, only manure from cattle would be available.*
- Water availability: dung needs to be mixed with an equal amount of water and/or urine before feeding into a biogas plant
  - *Water availability is not a big problem in Sikasso, although water availability is difficult during the dry season*
  - *Rainwater harvesting is not commonly practiced.*
  - *Cattle are taken to watering points and greener pastures during the dry season.*

In 2006, 97.725 households in Sikasso owned cattle. On average they own 10 cattle, 3 traction animals, and only some own three or four dairy cattle. The dairy cattle and traction animals remain at the household all year long. The remaining 'prestige' cattle are taken out to graze during the dry season. Manure is not readily available at the household during the dry season. During the wet season cattle spend at least the night in a cattle pen next to the village or household compound, where manure could be collected. Water is not a big problem in the region, although women may have to walk to search drinking water. The non year round availability of manure makes that technically, a biogas system with daily feeding would not be ideal. A biogas system with batch feeding (once every six months) would technically have more potential.

Economic conditions

- Use of organic fertilizer is practiced and integrated farming systems are common
  - *Composting is known at farms, but not efficiently practised*
  - *Compost is thrown at a composting heap next to the household compound, at together with animal dung collected once a year and spread over the fields*
- Scarcity of traditional fuels like fuelwood and charcoal
  - *In Sikasso, women have to walk an average of 10 km to find wood*
  - *They still find wood, and collecting a large amount is seen as prestigious*
  - *Women search and stock woo during the dry season.*
  - *Fuel-wood is only sold to urban residents; rural people do not buy fuelwood.*
  - *Fuel wood prices in urban areas vary between 10 and 30 FCFA/kg*
  - *The daily requirement for an average household is 30 kg to prepare three meals*
  - *The introduction of improved cookstoves is not yet wide spread in rural areas, although government gives large subsidies.*

- Access to credit for farmers on reasonable terms
  - *149 micro finance access points in Sikasso (Kafo Jiginew)*
  - *Most investments are in small trade, transformation of agricultural products and festivities.*
  - *The loan requirement for a biogas plant is around FCFA 375.000*
  - *With a repayment period of 3 years, annual interest rates are around 15-20 %*
- Low return on investment because of high cost of biogas production
  - *High cost of building materials like cement and bricks*
  - *High transport cost of materials + masons due to low density of potential biogas farmers*
  - *Large plant is needed for modest daily gas production because of the batch method*

Social conditions

- An active role of women in domestic decision making
  - *The man is the official household and family head: he does all the public decision making*
  - *Decisions seem generally to be taken by the household head, but have to be explained and accounted for to the entire family (including brothers and wives): therefore internal consultations do take place*
- Role of women in livestock keeping and dung handling
  - *Not directly: herding cattle and ploughing are men's tasks.*
  - *Women sell milk and treat the milk if necessary*
  - *Batch-fed biodigesters are most likely operated by men: emptying the tank, transporting carts with manure is heavy work.*
  - *No barriers to participate in training programmes or to receive technicians on the farm*

Institutional conditions

- Political will to support a national biogas programme
  - *All governmental departments spoken to willing to support a biogas programme*
  - *CMDT willing to get involved again, but no commercial expertise*
  - *Other NGOs who have been active in biogas stress the need for very large investments and very long term programs for a programme to succeed.*
- Existence of farmers unions
  - *CMDT regroups cotton producers in Sikasso*
  - *Dairy cooperative exists in Koutiala, but on a small scale (107 members).*
  - *No information about other farmer's unions*

The findings are summarized in the following table:

Key Conditions for dissemination of Biodigesters	**Observations & Findings**
Technical Factors	
Even, daily temperatures over 20 ^{0}C throughout the year	+++
Full stabling of animals (zero-grazing) (cows & pigs)	-
At least 20 kg/day dung available per plant	-
Availability of water	0
Economic Factors	

Use of organic fertilizer is traditionally practiced	0
Scarcity of traditional cooking fuel, fuelwood & charcoal	+
Dairy farming is the main source of income	0
Users have access to credit	0
Social Factors	
Role of women in domestic decision making process	0
Role of women in livestock keeping and dung handling	-
Participation of women in training programmes	0
Institutional Factors	
Political will from the Government to support a national biogas programme	**+++**
Existence of farmers associations like dairy cooperatives	+
Accessibility of farmers through NGO's	**+**

ANNEX 5:

PRESENTATION BIOGAS USER MR. OUMAR BERTHÉ

EASE – End user profile

Mason and his family using biogas

Case: Mr Oumar Berthé – farmer, cattle owner, mason and biogas digester owner and user.

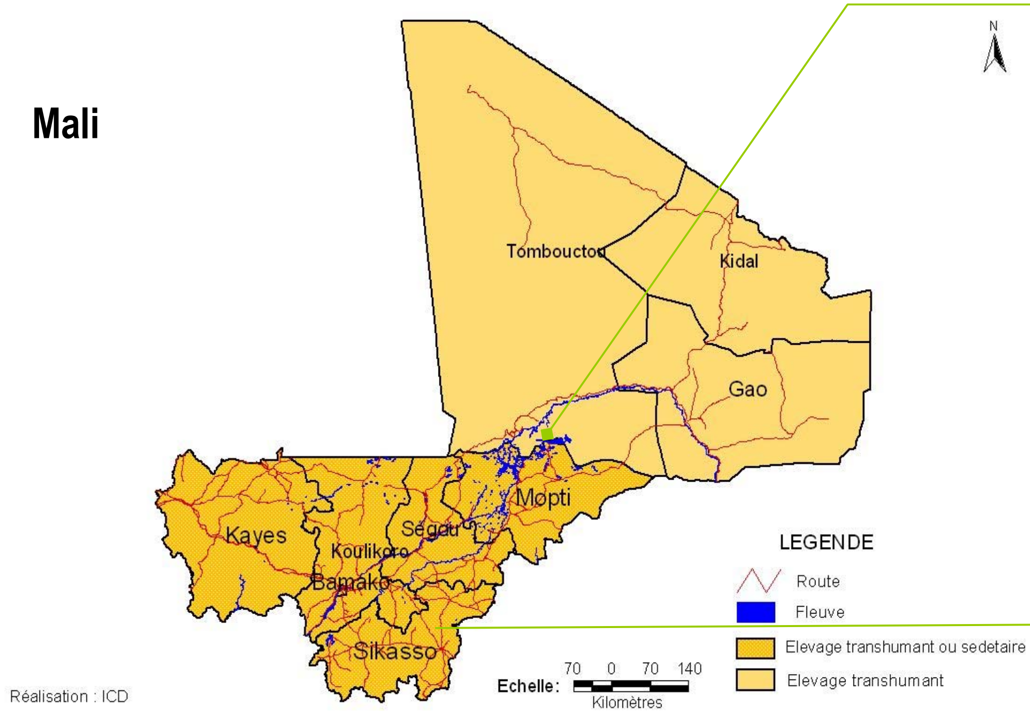
Gouan village, Sikasso region, Mali

Biogas since 1992

Text and pictures: Maaike Snel

Visited: 6th of June 2007

Farm location



Most livestock breeders in the north of Mali are nomads. Therefore, the north of Mali only practices nomadic livestock rearing.

In the south people are involved in agriculture, and have cattle on a semi sedentary basis.

The farm we present is located in Gouan in the southern Mali region of Sikasso.

Livestock and cattle rearing in Sikasso

During the wet season, families in Sikasso keep cattle …

… outside in the field during day time,

… fenced in at night.

During the wet season, Oumar's animals roam around with a herdsman or a youngster of the family during the day and return to a cattle pen near the village at night

During the hot dry season, from February to May, a herdsman takes Oumar's cattle further south in search of water and greener pastures. Animals do not return to the cattle pens at night.

The Berthé family

All children from Oumar, his two brothers and their wives (plus one visitor) …

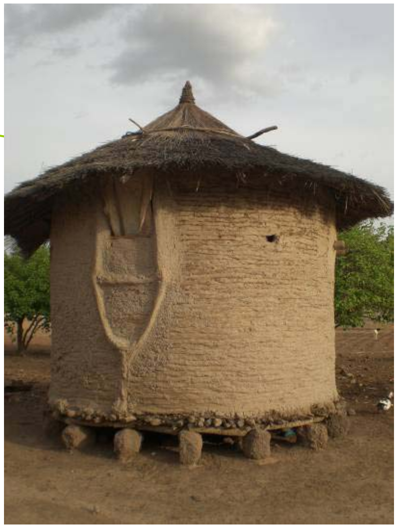
… three of the Berthé women working on bringing wood to the compound for dinner preparations.

… Oumar and two of his brothers …

Around the Berthé household

The Berthé family lives right next to Gouan's mosque

The only animals around were the four goats.



... Next to the household, a silo for storage of millet

... and some smaller ones for multiple storage after the harvest.

The Berthé’s biogas system

The biodigester consists of a bio digestion chamber with gas storage underground, an inlet for feeding manure and water (the square furthest away on the picture), a gas outlet (in the centre – the circle filled with water), and an outlet for the slurry (under the rectangular lid on the fore ground).

Oumar constructed the biogas digester and system himself, as he had done for about ten other families during the eighties. He placed his ‘signature’ on top of every biogas digester he constructed.

The biogas system functioning

The biogas digester Oumar uses is a batch system: he feeds the digester with manure (50%) and water (50%) which he mixes before entering.

The digester is filled for 85%. This means about four (donkey) carts of manure. After four months another 20 kilogram of manure and 20 liters of water are added weekly...

The system produces gas for about 6 to 8 months. After that time, Oumar opens the system and takes out as much slurry as possible from the outlet. He then opens the lid and manhole and empties the biogas digester from the top. He then has to close the lid again, which is very specialized work.

The children are responsible for searching the manure, which they normally collect in the cattle pen next to the household.

The women mix the dung with water and feed it into the digester.

The biogas system functioning

The underground biogas digester is covered by a manhole lid.

To protect the clayseal around the lid from drying out, a thin layer of water covers it. It also protects the plastic gas tube. Oumar shows where the gas tube leaves the digester.

One of Oumar's brothers adds water. After adding water, a thin layer of oil can be added, so the water does not evaporate too fast in the hot Malian climate.

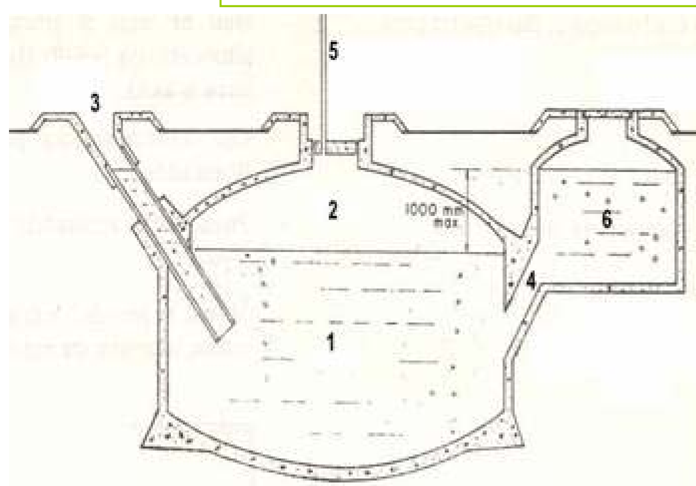
The biogas system functioning

The biogas digester produces gas and slurry.

The slurry leaves from a pit on the far end of the biodigester, the outlet chamber. It is connected to the biodigester underground with a passage, which –if blocked- can be freed by poking with a stick.

Oumar only feeds the system once every 6 to 8 months, and does not add large quantities daily. The pressure in the digester therefore remains more or less constant, and no slurry comes out of the outlet chamber spontaneously. This would however be the case if the feeding would be continuous.

This is a schematic representation of a (daily feeding) biogas system.



1= biodigester

2= gas holding part

3 = inlet

4= passage

5 =gas pipe (in batch system the manhole is on top of gas holding part)

6 = outlet chamber

The biogas system functioning

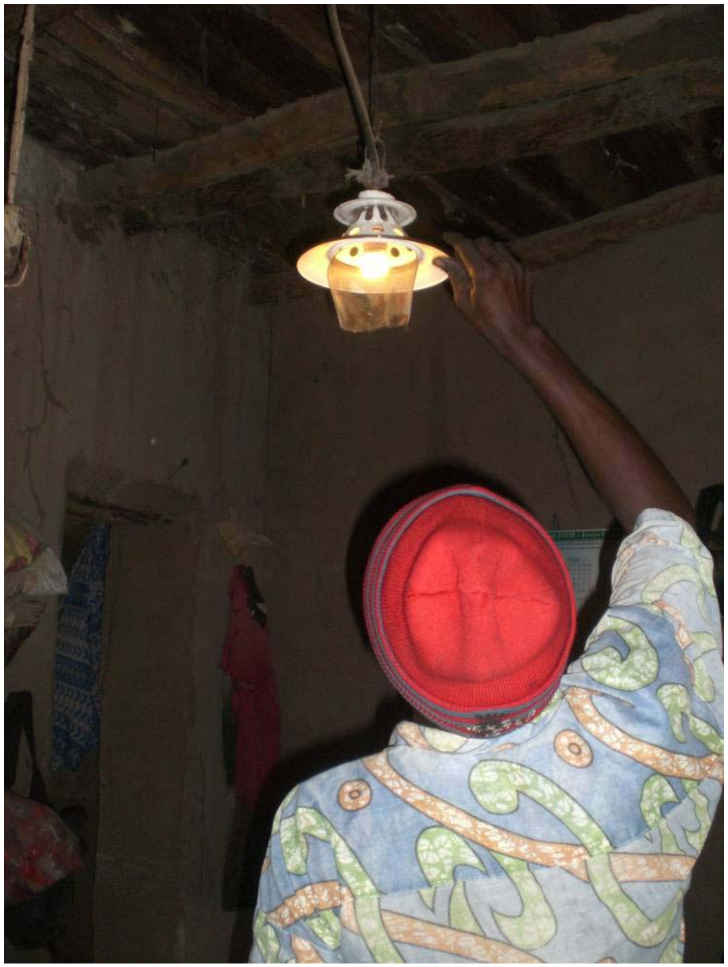
The Berthé family has chosen to use most of the gas for lighting instead of cooking. The biogas tube which transports the gas is branched and connected to several huts in the Berthé compound.

The gas is ‘turned on’ at night by switching this tap, so the biogas can flow to the connected lamps and burner.

A constant gas pressure is important for the quality of light and cooking.
The pictures on the right shows the gas pressure tool.

According to Oumar, there are hardly any gas pressure problems. However in general, irregular gas pressure is a frequent problem with these kinds of systems.

The biogas system – use of gas



The Berthé family has chosen to use the gas for lighting mostly. The increasing kerosene prices have largely steered this discussion.

There are seven gas lamps in the households.

Only one of them has been installed in the hut of a woman.

The biogas system – use of gas

The only burner which is connected to the biogas is for making tea, and sporadically for the preparation of a sauce. However, the location of the burner, the presentation during the visit, the cleanliness of both the burner and the surroundings make it clear that this burner is hardly used at all.

The energy and time women spend to collect firewood are not perceived as a cost.

Because only one woman has a lamp, and the burner is not really used, biogas has not improved the situation of the women of the Berthé household.

The Berthé women still walk an average of 10 km for their wood needed for cooking, still cook on traditional stoves and still use kerosene lamps for lighting.

ANNEX 6:

URBAN PRICES OF WOOD AND CHARCOAL

Prices of wood and charcoal in Segou region .

(DNSI, 2004)

Variation of charcoal sales prices in Ségou

Conditionnements	**Poids du charbon en kg**			**Prix du charbon en franc CFA**			**Prix moyen du kg**
	Mini.	**Moyens**	**Maxim.**	**Mini.**	**Moyens**	**Maxim.**	
Moyens sacs	35	36,5	38	1500	1759	2000	**48**
Petits sacs	29	29	29	800	962	1250	**33**
Gros sachets	0,8	1,27	1,9	100	100	100	**79**
Moyens sachets	0,4	0,67	1,3	50	50	50	**75**
Petits sachets	0,2	0,32	0,5	25	25	25	**78**
Moyenne							**63**

Variation of fuelwood sales prices in Ségou

Conditionnements	**Poids de bois (kg)**			**Prix du bois en franc CFA**			**Prix moyen du kg**
	Mini.	**Moyen**	**Maxim.**	**Mini.**	**Moyens**	**Maxim.**	
Camion/semi-remorque	7766	8496	9227	90000	100000	120000	12
Mini bus	2457	2457	2457	25000	27000	28000	11
Charrette	204	353	444	1000	3272	7000	9
Pousse-pousse	154	154	154	1750	1750	1750	11
Gros fagots	2,5	7,11	12,2	200	200	200	28
Moyens fagots	1,2	3,48	6,1	100	100	100	29
Petits fagots	0,5	1,74	3,1	50	50	50	29
Gros tas	0,4	1,06	1,8	30	30	30	28
Moyens tas	0,3	0,78	1,3	25	25	25	32
Petits tas	0,3	0,3	0,3	10	10	10	33
Total							**22**

ANNEX 7:

CALCULATION CONSTRUCTION COSTS BIOGDIGESTER PLANT MALI

Calculation Chinese model biogas plant in FCFA .

Cost calculation 10m3 Chinese model biogas plant in Francs CFA				
Construction Materials	**Quantity**	**Cost per Unit**	**Total Cost FCFA**	**Cost in €**
Cement bricks (solid) 22x11x5 cm	1400	100	140000	214
Cement, 50kg bag	22	6500	143000	218
Gravel 1-2 cm, m3	5	7500	37500	57
Sand, fine-medium	5	6000	30000	46
Iron reinforcement bar Ø6mm	8 kg	525	4200	6
Iron reinforcement bar Ø8mm	20kg	525	10500	16
Inlet pipe PVC Ø10cm	1	1800	1800	3
Acrylic emulsion paint, litre	2	2000	4000	6
Total material cost			**371000**	566
				0
Appliances, lumpsum 10% of total cost			**57625**	88
				0
Skilled labour, mandays	15	3000	45000	69
Unskilled labour mandays	30	1500	45000	69
Total labour cost			**90000**	137
				0
Guarantee and other charges 10% of total cost			**57625**	88
				0
Total plant cost			**576250**	880
Based on experiences in Cambodia and Rwanda, the cost of smaller plants as a				
percentage of the 10m3 plant is as follows:	**Plant size**	**Percentage**	**Plant cost FCFA**	**Cost in €**
	10m3	100	**576250**	880
	8m3	87	**501338**	765
	6m3	76	**437950**	669
FCFA 655 = 1 €				