MINISTRY OF INFRASTRUCTURE
KIGALI, RWANDA

National Domestic Biogas Programme Rwanda

Baseline Study Report

Final Version

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SNV Connecting People's Capacities

gtz Dutch-German Partnership Energising Development

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Baseline Study NDBP Rwanda

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Conversion units

1 ster = 1 m^3 packed wood = 0,56 m^3 bulk wood
1 FRw = 0,001797 US Dollar (USD) (31.10.2007)
1 USD = 556,330 Rwandan Franc (FRw)

Acronyms and Abbreviations

%	Per Cent
ADB	Asian Development Bank
APCAEM	Asian and Pacific Centre for Agricultural Engineering and Machinery
ARI	Acute Respiratory Infections
BNR	National Bank of Rwanda
BOP	Base of Pyramid
BRD	Rwandan Development Bank
cap	capita
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CTA	Centre Technique de Cooperation Agricole et Rurale ACP-UE
CO_2	Carbon dioxide
d	day
DFID	Department for International Development (United Kingdom)
DHS	Demographic and Health Survey
DNA	Designated National Authority
EDIAIS	Enterprise Development Impact Assessment Information Service
EDPRS	Economic Development and Poverty Reduction Strategy
EICV2	Enquête Intégrale sur les Conditions de Vie des Ménages 2
EIRR	Economic Internal Rate of Return
EnPoGen	Energy – Poverty – Gender approach
esp.	especially
FAO	Food and Agricultural Organization
FIRR	Financial Internal Rate of Return
FOREDEM	Fund for Refinancing and Development of Microfinance
FRw	Rwandan Franc
GDP	Gross Domestic Product
GDI	Gender-related Development Index
GHG	Green House Gas
GNI	Gross National Income
GPS	Global Positioning System
GTZ	Deutsche Gesellschaft fuer Technische Zusammenarbeit GmbH
h	hour(s)
ha	hectare(s)
hc	Health center
HDI	Human Development Index
HH or hh	Household(s)
HICN	Household in Conflict Network
HPI	Human Poverty Index
IBC	International Business Center Kigali

ICT	Information Communication Technologies
IDPM	Institute for Development Policy and Management
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
INGO	International Non Governmental Organization
IRST	Institut de Recherche Scientifique et Technologique
ISAR	Institute des Sciences Agronomiques du Rwanda
JMP	Joint Monitoring Project
KIST	Kigali Institute of Science and Technology
km, km^2	kilometre(s), square kilometre(s)
l	litre(s)
LWF	Lutheran World Federation
m / m^2 / m^3	metre(s) / square metre / cubic metre
M&E	Monitoring and Evaluation
M4P	Market for the Poor
MDG	Millennium Development Goals
MFI	Microfinance Institution
MINAGRI	The Ministry of Agriculture
MINECOFIN	Ministry of Finance and Economic planning
MINERENA	the former Ministry of Energy, Water and Natural Resources
MINICOM	Ministry of Commerce, Industry, Investment Promotion, Tourism and Cooperatives
MININFRA	Ministry of Infrastructure
MINISANTE	Ministry of Health
MINITERE	Ministry of Environment and Natural Resources
mio	Million
nd	no data
NDBP	National Domestic Biogas Programme
NEDA	National Energy Development Agency
NEPAD	New Partnership for Africa's Development
NGO	Non Governmental Organization
NMFCC	National Micro-finance Consultative Committee
NISR	National Institute of Statistics of Rwanda
Nr.	Number
O&M	Operation and Maintenance
PDD	Project Design Document
pm	Post Meridian (afternoon)
PPP	Purchase Power Parity
PRSP	Poverty Reduction Strategy Paper
R&D	Research and Development
RAMA	La Rwandaise d'Assurance Maladie
RARDA	Rwanda Animal Resources Development Authority, MINAGRI

REMA	Rwandan Environmental Management Authority
RISD	Rwanda Initiative for Sustainable Development
RMF	Rwandan Microfinance Forum
RPSF	Rwanda Private Sector Forum
SIDA	Swedish International Development Agency
SME	Small and Medium Enterprises
SNV	Netherlands Development Organization
SPSS	Soft ware: Statistical Package for the Social Sciences
t	ton(s) / tonne(s)
TaTEDO	Tanzania Traditional Energy Development and Environmental Organisation
TLU	Tropical Livestock Unit
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USD	United States Dollar
VER	Verified Emission Reduction
WB	World Bank
WFP	World Food Program
WHO	World Health Organization
WISE	Women in Sustainable Enterprise Development
WPI	Water Poverty Indicator
WRI	World Resource Institute
y	year

1. Executive Summary

This chapter provides an overview on the Baseline Study background and approach, and summarizes the findings and key recommendations.

1.1 Background

The National Domestic Biogas Programme in Rwanda (NDBP) is carried out by MININFRA, SNV and GTZ according to an Implementation Plan endorsed by the Government of Rwanda on 11/09/2006. The overall objective of the NDBP is to establish a country-wide programme on domestic biogas, with the aim to develop a commercially viable and environmentally sustainable market-oriented biogas sector. The expected benefits are (1) saving of conventional fuel sources, mainly firewood; (2) reduction of workload, especially of women and children; (3) improvement in health and sanitation conditions, benefiting especially women and children; (4) increase in agricultural production with proper utilization of slurry; (5) employment generation; and (6) reduction in green house gas (GHG) emissions. Although there are many Rwandan biogas experiences at public institutions like schools and prisons, a successful history of domestic biogas implementation does not exist thus leading to a number of challenges and risks for the NDBP, among others the uncertainty on effective demand, and the lack of rural based companies and masons.

The success of the NDBP will largely depend on innovative farmers willing to invest in a biogas plant. Provision of credit will be an important part of the NDBP since few households with otherwise suitable conditions for biogas production may have the required amount of money. Yet, biogas production itself is not considered as an income generating activity and till now banks and micro finance institutions have no experience proving loans to a farmer who wish to acquire a biogas plant.

1.2 Survey methodology

GTZ has been entrusted with the monitoring and evaluation of the NDBP, including the realization of a Baseline Study at household level and an Impact Assessment at the end of the programme. Based on analyses and experiences of SNV and MININFRA, the NDBP started programme activities in the four central districts of Gasabo, Kamonyi, Ruhango, Rulindo. The Baseline Study focused on these districts and added Gatsibo as neighbouring “control district”. Household surveys are a way of collecting representative, reliable and independent data. The sample of at least 1097 households has been calculated according to the estimated biogas market potential of 110,000 plants and the objective of 15,000 installations completed until 2011.

In total 1,106 household interviews have been conducted by trained interviewers between June 4 and July 26, 2007; this number corresponds to 7.3% of the estimated number of potential biogas client households. The basic interview principle followed the EnPoGen study approach[1] which values one household member as representative speaker for all the other members; information about a total number of 7,636 household members was obtained. Households have been selected on a voluntary base without any compensation. Primary data gathered in the household survey has been compared to secondary country data obtained in interviews to district authorities, reports received from SNV, MININFRA, National Institute of Statistics and via Internet.

1.3 Main survey results

The main findings are[2]:

(1) Average size of a household in surveyed district counts for 7 members; 73% already participated in additional training provided by different organizations, and 71% are members of local cooperatives or organizations thus showing interest in innovation and networking capacity.

(2) Domestic biogas generated from the dung of at least 2 cows could lead to substantial savings in fuel wood consumption which is estimated at 2,348kg firewood per year and household

(3) The surveyed NDBP target group own an average of 3 cattle/hh; currently more than 40% own 1-2 cows. 91% of the households in the selected NDBP districts keep their cattle in zero-grazing systems.

(4) 96.5% of sampled households practice subsistence or small scale market agriculture, 50% of them applying animal manure as fertilizer on about 1ha land.

(5) Among those 99% of households using firewood as cooking fuel, out of which 33% pay for their firewood; 69% of the firewood is collected within a distance of 1km or less; average consumption is 338kg/hh/month or 1.61kg/cap/d; 93% use kerosene for lighting, 24% use candles – 100% of households pay for lighting fuel.

[1] The Energy, Poverty, and Gender (EnPoGen) project of the World Bank's Asia Alternative Energy Programme (ASTAE) is part of the ongoing redirection of development strategies toward poverty reduction. Funded under the Bank-Netherlands Partnership Program (BNPP), EnPoGen is an attempt to examine the energy dimension of poverty, with special attention to its gender implications. The project has focused on Asia, where 1.2 billion people—60 percent of the world's population—live without access to modern energy services, mainly in rural areas.

[2] The details can be found in chapter 5

(6) 99% have a latrine or toilet; 89% are willing to use energy generated from animal and toilet waste for lighting and cooking purposes, and 90% would use the bio-slurry produced from animal and toilet waste as fertilizer on their fields although they are not yet used to it.

(7) 40% pay for water, fetching about 20 l/cap/d including water for cattle kept in zero-grazing; mean distance to and from water sources is about 1.3 km.

(8) 56% experience negative effects from in-door air pollution due to smoke from firewood and kerosene

(9) Responsibilities are shared (i) for cattle mainly between husband and wife, (ii) for cooking mainly between wife, daughter and worker, (iii) for fetching water mainly between children and workers, (iv) for fetching firewood mainly between workers, husband and wife.

Average time daily spent for (i) cooking: 4.17h, (ii) fetching water: 1.6h, and (iii) fetching firewood: 1.5h.

(10) The interviewed households are economically located in the lower-income segments with average monthly incomes between 25,000 and 250,000 FRw; their incomes correspond to the national rural averages; 77% generate income from sale of agricultural products; 68% earn from their livestock and 50% have diversified non-agricultural income sources.

(11) 48% received a credit before; payback period for 78% was up to 2 years; 84% of the households are willing and ready to apply for credit for biogas; estimated necessary credit sum for the investment in biogas varies significantly, with its peak at 500,000 FRw

(12) Priorities for livelihood improvements have been listed by households: livestock keeping (53%), cooking and lighting energy (15%), and agriculture and housing conditions (11%); willingness and ability to invest in a biogas plant are matching in nearly 100%.

(13) Replacing lighting energy has a higher priority for 86% of household than substitution of cooking energy, as all households pay for lighting energy like candles or kerosene.

(14) 79% of the first applicants for biogas plants would recommend the technology to others.

1.4 Lessons learned and challenges

The baseline survey provides a number of lessons and challenges that needs to be further considered within the programme. Many of these issues listed below are already being addressed in the NDBP implementation plan while others may need further attention.

(1) Activities of the NDBP

- Promotional campaigns at district level involving local authorities, cooperatives and community-based organizations should address the image of biogas plants as modern technology that increase the owner's social status and family health.
- Introduce biogas lamps into the programme, which are affordable, robust and easy to handle.
- User training should integrate cooking techniques, slurry application and hygiene topics.
- The credit and subsidy scheme should be linked to the certification of constructors and a system of quality control in order to avoid that households pay for a credit while the biogas plant does not perform at optimum.
- A quality oriented district-based after-sales-service should be installed as part of a well enforced quality control system from the beginning of the construction activities.
- An indicator based monitoring system should be established focussing on the programme objectives in the sectors (1) energy, (2) sanitation, (3) health, (4) environmental protection, (5) economy and income generation. In order to demonstrate NDBP's contribution to economic development and poverty reduction indictor targets should be oriented as far as possible on EDPRS[3] targets set in these sectors.
- NDBP stakeholders should decide in which sector agricultural aspects are to be integrated as bio-slurry application will play an important role for achieving food security and improvement of soil fertility.

(2) Selection criteria for potential implementation areas

The cattle keeping system should not be the only indicator for the local biogas market potential, because even under zero grazing conditions the available biomass could be insufficient for a satisfying biogas production.

[3] MINECOFIN: EDPRS Draft 08/2007

Parameters therefore should include besides sufficient cattle population (1) zero grazing system with at least 2 head of cattle, (2) use of animal manure as fertiliser, (3) firewood scarcity or costs of firewood, (4) availability and costs of water, (5) MFI or banks at village level, (6) cooperatives, NGOs or community groups with training and networking capacities.

(3) Subsidies and micro-financing scheme

Certain improvements linked to biogas installation could provide additional incentives for the credit and subsidy scheme such as:

- The efficient use of animal urine as mixing agent could be a way to save water[4]; this would implicate (1) to seal the stable floor in order to collect the urine, and (2) to connect the stable directly with the biogas plant. This will involve extra costs but also substantial benefits.
- Rainwater harvesting could help to save water, and reduce money and time spent for fetching water.
- Improved toilet facility directly connected to the biogas plant could be provided within the "construction package" if the plant owner applies for it.

Community-based structures are accepted in rural Rwanda and could serve as service and guarantee structure for micro financing systems in the biogas sector.

(4) Biogas plants as national investment

Biogas technology fits in national strategies for economic development and poverty reduction by (1) providing high quality fertiliser to farmers thus increasing agricultural yields and food security, (2) generating energy from farm resources thus reducing firewood and kerosene consumption, and (3) improving household's sanitation conditions and health thus reducing days lost for education and productivity. [5]

CDM offers an opportunity to increase economic returns on the biogas programme and NDBP is advised to monitor developments on the carbon credit market as new methodologies and buyers become available.

[4] SNV: Feasibility Study NDBP Rwanda 2005
[5] For further details see MINECOFIN: EDPRS Draft 08/2007

2. Introduction

This chapter provides basic information about Rwanda, its economy and poverty characteristics, and the National Domestic Biogas Programme.

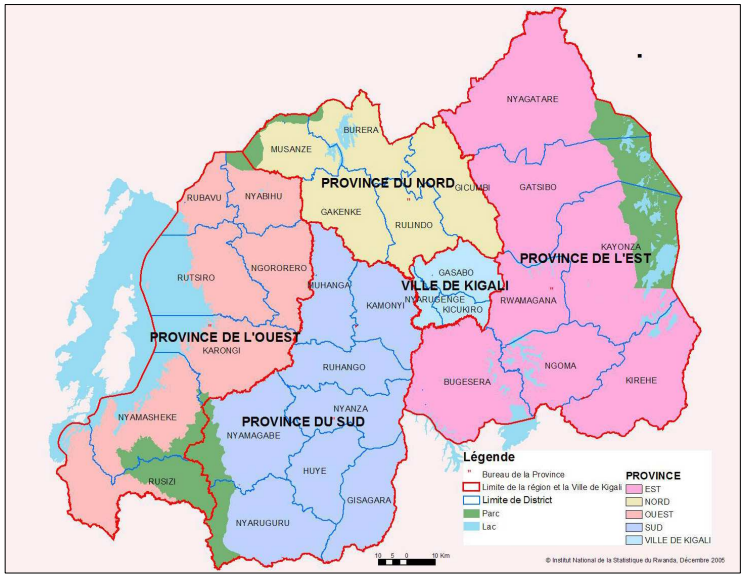
2.1 The country

2.1.1 Geography and administration

Rwanda is a landlocked country in the Great Lakes Region, bordering Uganda, Tanzania, Burundi and the Democratic Republic of Congo. Its population of about 9 million inhabitants on a land surface of 24,948km² makes it one of the most densely populated countries in Africa with about 397 inhabitants/km². With a population growth of 2.8% per year and an effectively useful surface of 18.740km² this density goes even up to more than 500 inhabitants/km². Since the Administration Reform in 2006[6], the Republic of Rwanda is subdivided in 5 provinces, 30 districts and 418 sectors being further subdivided in 9,165 cells and imidugudu. Imidugudu are centres being established to gather the traditionally dispersed settled rural households around basic infrastructure like schools, health centres, markets and roads[7].

Figure 1: Administrative map of Rwanda

(Institut National de la Statistique du Rwanda, 2005)



[6] From 2002 to 2006, the country has been structured in 12 provinces and 106 districts. Most data available for comparison of survey results to national data relate to the "old" administrative boundaries thus making it difficult to come up with precise ratios.

[7] MINECOFIN: EDPRS Draft 08/2007

Out of the 30 districts, 5 districts have been surveyed to obtain the data for this report: Gasabo, Gatsibo, Kamonyi, Ruhango et Rulindo, as in all of them apart from Gatsibo, families have already applied for the NDBP programme.

2.1.2 Economy

The country's economy is dominated by agriculture and livestock husbandry. The most important agricultural export products are coffee and tea; the locally consumed crops are mainly potatoes, manioc, sorghum, bananas and beans. Few internationally demanded mineral resources and a small industrial sector do not provide numerous opportunities for alternative employment creation other than in the agriculture and livestock sector.

According to statistics from MINAGRI in 2006 there were a total of 1,122,179 cattle in Rwanda, the mean number of cattle in cattle raising households being 2.7 animals.

MINAGRI statistics from 2002 place the number of cattle owning households in the whole country at 315,000 households whereas the EICV2 Survey counts cattle owned by approximately 43% of all non-poor households, and even among 27% of the households classified as poor. This percentage will most probably increase further due to the "one cow per poor household" programme of MINAGRI which aims at supplying one cow to every poor household suffering from malnutrition and possessing less than 0.75 ha of cultivable land.

Overall livestock ownership on national level is given in the table below, and the following map visualizes the livestock distribution in the country.

Table 1: National livestock data

Livestock	Local breed	Improved breed
Cattle	1,035,402	86,777
Goat :	2,640,362	15,436
Sheep	683,616	11,751
Chicken	1,714,989	2,936
Pig	527,531	
Rabbits	418,361	

(MINAGRI Agricultural Survey 2006)

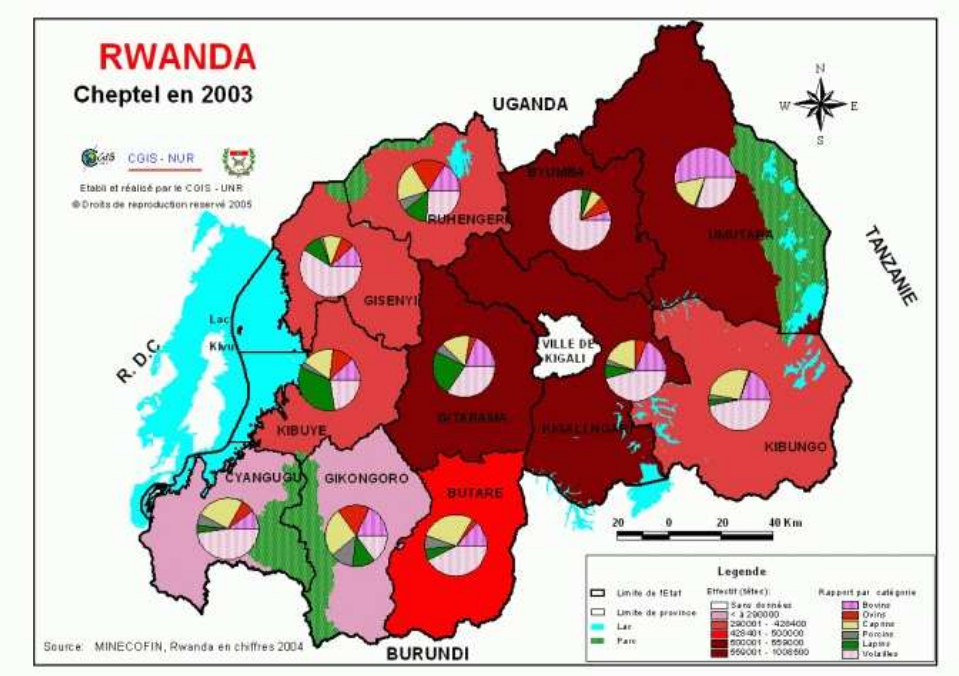


Figure 2: Distribution of cattle in Rwanda according to region in 2003
(MINECOFIN, Rwanda en chiffres, 2004)

Livestock policy obliges cattle owners to keep their cattle in permanent stabling, so-called “zero-grazing” system. That means the farmers need to grow fodder and fetch additional quantities of water for their animals instead of leading them to pasture and watering points. This policy is implemented in the surveyed districts to varying degrees ranging from about 45 to 95%.

2.1.3 Poverty

According to a survey conducted in 2006 by the National Institute of Statistics of Rwanda

- 83% of the population lives in rural areas
- 87% of the Rwandan population is engaged in agriculture, mainly for household subsistence
- 62% of the population is classified as being poor.

In 2002, the first Poverty Reduction Strategy Paper (PRSP) defined individuals as poor if they are confronted by a complex of inter-linked problems and cannot resolve them, do not have enough land, income or other resources, and as a result live in precarious conditions, unable to satisfy basic needs including food, clothing, medical care, and children’s schooling.

Two poverty lines were established: (1) households are deemed to be poor if their total annual expenditure is less than 64,000 FRw per adult equivalent in 2000 prices, and (2) they are deemed to be in food poverty if their expenditures fall below 45,000 FRw per adult equivalent per annum.

At the time of the first PRSP in 2002, 60.3% of the population of 7.98 million was estimated to live below the total poverty line. Using a somewhat different definition, the percentage of the population in poverty in 1985 was 45.7%, while the figure had soared to 77.8% after the genocide in 1994.[8]

The PRSP identified countrywide six categories of households without distinguishing between urban and rural livelihoods. The poorest were in the category Umutindi nyakujya, those in abject poverty: they need to beg to survive, have no land or livestock, lack shelter, adequate clothing, and food. They often fall sick and have no access to medical care. Their children are malnourished and the families cannot afford to send them to school. The richest, Umukire, have land, livestock and often salaried jobs. They also have good housing, often own a vehicle and deals with the banks in both lending and borrowing.[9]

Urban and rural poverty

The most obvious regional gap in poverty is the extreme one between Kigali and the other provinces. The incidence of poverty in urban-Kigali population was 12.3%, compared to the national average of 60.3%. In terms of real expenditures of households 75% of people in Kigali-urban were in the top quintile[10] for the country, while the poorer provinces[11] like Gikongoro and Kibuye only had 7.2% and 9.9%, respectively, in the top expenditure quintile. Gikongoro had the highest percentage of population in the lowest quintile of the country at 32%.

As much as 96% of the food-poor lived in the rural areas. The connection between rural poverty and agricultural productivity is very strong, and the high level of poverty in rural areas is largely due to the failure of past agricultural policies. More specifically, this has resulted in a rapid decline in soil fertility, low levels of agricultural extension and veterinary services, and a very low degree of commercialisation. The

[8] Ministry of Finance: A Poverty Profile for Rwanda, 2002 - The poverty line was set in 2000 at 64,000 FRW per adult equivalent per year, based on a daily food intake of 2,500 kcal (resulting in a 45,000 FRW food poverty line) and 29.4% non-food expenditures.
[9] SIDA, Country Economic Report, 2005
[10] Quintile: A method to measure the average (mean) household income of residents, ranking them from poorest to wealthiest, and then grouping them into 5 income quintiles (1 being poorest and 5 being wealthiest), each quintile containing approximately 20% of the population….See also details in Annex 7.2
[11] The following data refer to the administrative boundaries before 2006

PRSP 2002 notes that rural poverty is prevalent because of the absence of market centres, price fluctuations, and lack of credit.

Due to a lack of small and medium-scale enterprises, and only small manufacturing activity, alternative non-agricultural income sources and employment opportunities are scarce, and many are left with the only option of subsistence farming. About 90% of the working population are employed in agriculture; almost all of them classified as self-employed or unpaid, signalling that the overwhelming majority is family members engaged in family farming. Moreover, there are few secondary activities, and although different estimates suggest that the rural underemployment is significant, only 1% of the labour force in the rural areas was openly unemployed, as compared to 4% in urban areas. Factors such as higher growth, increased productivity and more export from agriculture are recognized as crucial for poverty reduction.

Poverty definition standards

Poverty is defined according to international standards in four dimensions[12]:

- Gross Domestic Product (GDP) per capita: income level and purchase power (PPP-US$, 1 USD a day) – Rwanda ranked at 149 among 172 countries
- Human Development Index (HDI): life expectancy at birth, literacy rate at the age of 15 and older, and living standard – Rwanda is ranked at 158 among 177 countries
- Human Poverty Index (HPI): adds to the GDP and HDI dimensions of health, access to improved water source and the proportion of children under age 5 who are underweight – Rwanda is ranked at 37,3 among 67 countries
- Gender-related Development Index (GDI): measures achievements in the same dimensions using the same indicators as the HDI but captures inequalities in achievement between women and men – Rwanda is ranked at 28 among 136 countries.

[12] UNDP Human Development Report 2006: The HDI measures average achievements in a country, but it does not incorporate the degree of gender imbalance in these achievements. The gender-related development index (GDI), introduced in Human Development Report 1995, It is simply the HDI adjusted downward for gender inequality. The greater the gender disparity in basic human development, the lower is a country's GDI relative to its HDI. Rwanda's GDI value, 0.449 should be compared to its HDI value of 0.450. Its GDI value is 99.8% of its HDI value. Out of the 136 countries with both HDI and GDI values, 27 countries have a better ratio than Rwanda's.

- The Gini-coefficient[13], the measure of inequality in income and wealth distribution, had risen from 0.29 to 0.45 from the mid-1980s to the time of the first PRSP. This is a very large increase, although the figure for the 1980s seems suspiciously low for an African economy. The level of inequality was also reflected in the average expenditure per adult equivalent. The poorest quintile had real expenditures of 21,106 FRw, while that of the richest quintile was almost ten times higher at 200,462 FRw per year in 2004[14].

Poverty indicator "Access to safe water"

The report of the UN Millennium Project Task Force on water and sanitation and the WHO/UNICEF JMP *Meeting the MDG Water and Sanitation Target: A Mid-Term Assessment of Progress* provide key insights into how water and sanitation relate to poverty. Four key dimensions of poverty are used for monitoring the impact of access to safe water on poverty reduction: (1) enhanced livelihoods security, (2) reduced health risks, (3) reduced vulnerability, (4) pro-poor economic growth[15]. According to the international Water Poverty Index[16], established on a data base of 100 countries, Rwanda presents a value of 39.4 and is ranked on place 94.[17]

According to the EICV2 Survey 2006, about 62% of the rural population has access to a safe water source. 0.2 % of them have a tap connection in their compound, whereas 61.8% have to fetch water either from a protected spring or a public tap or they have to buy it from a vendor delivering it to their home. Other sources of water which are considered to be not safe for drinking water are rivers, lakes, pools, unprotected sources or boreholes on which 38% of the rural population is still depending. As per information from MINITERE, 63% of the rural population is

[13] The Gini coefficient is a measure of statistical dispersion most prominently used as a measure of inequality of income distribution or inequality of wealth distribution. It is defined as a ratio with values between 0 and 1. Thus, a low Gini coefficient indicates more equal income or wealth distribution, while a high Gini coefficient indicates more unequal distribution. 0 corresponds to perfect equality (everyone having exactly the same income) and 1 corresponds to perfect inequality (where one person has all the income, while everyone else has zero income). The Gini coefficient requires that no one have a negative net income or wealth. The Gini coefficient was developed by the Italian statistician Corrado Gini and published in his 1912 paper "Variabilità e mutabilità" ("Variability and Mutability").

[14] SIDA, Country Economic Report 2005

[15] WHO: Setting the Scene: Water, Poverty, and the MDGs, 2007 http://www.who.int/water_sanitation_health/publications/aww1.pdf

[16] The purpose of the Water Poverty Index (WPI) is to express an interdisciplinary measure which links household welfare with water availability and indicates the degree to which water scarcity impacts on human populations. The index is composed of five main components: (1) resources (measuring internal water resources and the of external water inflows, (2) access (access to safe water, access to sanitation, access to irrigation, (3) environment (water quality, water stress, regulation and management, informational capacity, and biodiversity), (4) capacity (GDP/capita), under-5 mortality, UNDP education index, and Gini coefficient), and (5) water use (domestic, industrial, and agricultural water use per capita): Lawrence et al. 2002. The Water Poverty Index: International Comparisons http://www.nwl.ac.uk/research/WPI/

[17] For comparison: Burundi WPI 40.2, Nepal WPI 54.4, The Netherlands WPI 68.5, Germany WPI 64.5, and Switzerland WPI 72.1 - http://www.nwl.ac.uk/research/WPI/

sufficiently supplied with water, which means the quality is acceptable, the water supply is permanent, there is at least 20l available per person and day and the source is not further away from the household than 500m. Still the majority of rural households spend several hours every day fetching water, not only because of the distance to the water source, but also because of the need to queue for their turn with long waiting periods, or because children are sent to fetch water who cannot carry the big jerry cans and have to go several times.

Poverty indicator "Education"

Currently there are 85% of rural children of primary school age enrolled in primary schools but additionally there are also children beyond primary school age enrolled there. 8% of rural children are enrolled in secondary school.[18]

Poverty indicator "Health"

According to MINISANTE 375 health centres and 34 district hospitals cater the population with medical services. They can be more easily attended by about 47% of the population that is now covered by health insurance. [19]

2.1.4 Environment concerns and energy supply

Rwanda's key environmental challenges concern deforestation, soil erosion, over grazing, misuse of wetlands and poor waste and waste water management.[20]

Due to high demand for household fuel wood as a basic source of energy by 95% of the population - both rural habitants and low income earners in town, Rwanda lost 50.2% of its forest and woodland habitat between 1990 and 2005.[21] Forests were also cleared in search for agricultural land and shelter for returnees after the 1994 genocide. This has had negative impacts on the environment such as soil erosion, and loss of biodiversity. Furthermore, demand for other timber products like charcoal, firewood for brick production, construction material, and poles have greatly led to deforestation.

5,450km^2 of the country's surface are covered by natural (221,000ha) and replanted (324,000ha) forest and woodland, representing about 0.25% of the total territory[22]. More than 9,000ha have been replanted in 2006, and 3,500km of roadsides has

[18] NISR Preliminary Report EICV2, 2006
[19] SNV Feasibility Study NDBP Rwanda, 2005
[20] Rwanda Development Gateway www.rwandagateway.org/article.php3?id; last reviewed 10.11.2007
[21] UNDP Human Development Report Rwanda, 2007;
[22] Rwanda News Agency 21-11-2006, Interview with Minister Bazivamo Christopher

been lined with trees. A forest survey is ongoing and its results are expected in early 2008.[23]

Energy demand and supply

95% of the population uses firewood as cooking fuel; collecting or buying firewood has become more difficult and/or expensive, because the Government has banned cutting wood or producing bricks for everyone not obtaining permission at the sector office first.

Only about 1% of the rural population is connected to the electric grid. [24] For lighting purposes, candles, kerosene and torches are dominating, leading to strong in-door pollution, inconvenient light conditions for studying, reading or domestic works after sunset, and a potential risk of fire.

2.2 The National Domestic Biogas Programme

The National Domestic Biogas Programme in Rwanda (NDBP) is carried out by MININFRA with the support of SNV and GTZ according to an Implementation Plan prepared in 2006 and endorsed by the Government on Sept. 11, 2006. [25] The overall objective of the NDBP is to establish a country-wide programme on domestic biogas, with the aim to develop a commercially viable and environmentally sustainable market-oriented biogas sector.

The NDBP is presently in its pilot phase, which aims at the construction of 100 biogas plants by the end of 2007. According to the Implementation Plan, by the end of 2011 about 15,000 family-sized quality biogas plants will have been built under the NDBP.

As the expected results of the NDBP are focussing on the reduction of biomass resource depletion and a significant improvement in the quality of life of the participating families, the benefits relate to:

(1) saving of conventional fuel sources, mainly firewood;

(2) reduction of workload, especially of women and children;

(3) improvement in health and sanitation conditions, benefiting especially women and children;

(4) increase in agricultural production with proper utilization of slurry;

[23] Information received from MINITERE, Department of Reforestation and Agro Forestry, on 06-09-2007
[24] MINECOFIN: EDPRS Draft 08/2007
[25] Endorsement letter, ref. No 523/UPPR/06

(5) employment generation;

(6) reduction in green house gas (GHG) emissions.

Potential benefits

The National Domestic Biogas Programme in Rwanda aims to achieve the potential benefits outlined above, each of which is described in more detail below:

- The most important potential benefits derive from the fact that biogas replaces firewood, charcoal or kerosene as sources of cooking or lighting fuel. This saves natural wood reserves from being cut down and burnt. Not cutting the trees also prevents soil from being eroded by heavy rainfall.
- Biogas is a sustainable source of energy which is renewable much faster than firewood. Methane which is produced during anaerobic fermentation of biomass in and outside of a digester is a very powerful Green House Gas, but the methane which is collected in the digester and consequently burnt is not released in the atmosphere.
- With a biogas plant in place the farmer family does not need to spend time and money gathering or buying firewood. Time spend to feed the biogas plant corresponds to the time spend for cleaning the stable and therefore does not require additional time. Thus, the farmer family can make use of the time saved for other purposes, for example for alphabetization, or other educational or productive activities. By this means, a biogas plant can generate improved living standard and additional income. It might also allow children to attend school who have formerly been too occupied to do so.
- Biogas used as cooking fuel drastically reduces smoke in the kitchen. Wood usually produces harmful smoke, in which women need to work for cooking several hours every day. The burning of biogas therefore noticeably reduces the number of smoke borne diseases for the concerned women or children. For them cooking with biogas is a lot easier also because they do not need to worry to keep the fire burning, placing wood constantly and because cleaning the dishes becomes less burdensome, as there is less soot covering them. The ease of lighting a biogas stove, compared to lighting a fire might also motivate families to prepare breakfast in the morning, especially for school children which they might not do now, because of lack of time.
- If a biogas lamp is connected it provides much brighter light than the traditional kerosene lamps agatadoa mostly used by rural households. This enables the children for example to study even after sunset.

- When the family's toilet is directly connected to the digester, and cow dung is not littering the stable or compound floor, benefits of the biogas system include cleanliness and sanitation, with even broader impact on health improvement, as no pathogenic residue remains after fermentation, and neither groundwater nor soil will be polluted.
- The fermented bio-slurry which leaves the biogas plant is qualitatively a better fertilizer than plain collected cow dung; it has been proven to increase soil fertility and to improve agricultural conditions. This will lead to increased production yields.
- Economical benefits at national level, besides saving expenditures for firewood, reforesting or kerosene import, are to be found in employment creation in the construction sector. The NDBP aims at the creation of a biogas market sector promoting the foundation of decentralized small and medium biogas construction companies, which would then employ masons and technicians.

Potential challenges

Although there are many Rwandan biogas experiences at the institutional level like schools or prisons, the absence of a history of domestic biogas is just one of a number of challenges and risks for the NDBP which are already recognized by the programme designers[26]:

- lack of firm data for reliable predictions on effective demand; as there is no market intelligence for such a new product as biogas;
- little information available on the presence of companies and masons that fulfil the conditions to participate in biodigester construction trainings; most of the registered construction companies are situated in urban centres;
- high material and transport costs, particular in rural areas;
- financial institutions are willing to participate in the NDBP but it is uncertain whether farmers are willing and able to accept the high interest rates.

The success of the NDBP will largely depend on innovative farmers willing to take a risk by investing in a biogas plant. In analogy with what happened in other countries, it is expected that these initiatives will have a trigger effect by convincing others to accept the technology. Provision of credit will be an important part of the NDBP since few households with otherwise suitable conditions for biogas production may have the required amount of money. Yet, biogas production itself is not considered an

[26] MININFRA: Implementation Plan NDBP, 2006

income generating activity and the conditions for micro loans do not favour biogas farmers while on the other hand the lending institutes lack funding and have difficulties in liquidating collateral of non-performing loans.

3. Objectives, approaches and methodologies

This chapter provides background information about the process of questionnaire development, sample selection, and interviewer training and accompaniment, and data entry and processing. Furthermore it summarizes the procedure for data analyses and the key questions followed to obtain the presented results. For more details on methodologies and concepts applied for survey and data analysis please refer to Annex 7.2.

3.1 Objectives of the Baseline Study

According to the NDBP work plan and supported by GTZ, monitoring and evaluation is an integral part of the programme, including the realization of a Baseline Study and an Impact Assessment at the end of the implementation period.

The Baseline Study serves to[27]:

- establish a reliable database on energy needs of rural integrated farming households[28] in Rwanda and thereby for the planning of the NDBP, e.g.
    - to determine parameters and criteria for subsidies the Programme should grant to households to make biogas plants affordable for the relevant number of households,
    - required complementary activities,
    - verification of the appropriateness of planned interventions;
- provide indications as to which areas/regions of the country should predominantly be targeted under the NDBP;
- provide a data basis for monitoring and evaluation of programme activities;
- provide benchmark data for an Impact Assessment of the NDBP at a point in time that remains to be defined.

The NDBP has a country-wide scope; hence the Baseline Study is in principle to cover the whole country to arrive at representative data for the national level. Based on analyses and experiences of SNV and its partner institutions, the NDBP will first be active in the four central districts: Gasabo, Kamonyi, Ruhango, Rulindo. The

[27] Terms of Reference for Senior Expert, gtz 2007, see Annex 7.6

[28] "Integrated farming" refers in this context to the integration of cattle husbandry and agriculture in the livelihood system thus providing a certain level of sustainable income diversification to the rural household.

Baseline Study is to provide the stakeholders with basic information about their potential clients, and furthermore with criteria where the dissemination program could be successfully implemented throughout the country.

3.2 Approaches

The National Domestic Biogas Programme aims to contribute to improving the economic, social and environmental conditions of life in Rwanda. In order to demonstrate that the project does indeed make these contributions, a plan for measuring the progress and success is required. This measuring process – or Monitoring and Evaluation System – should be built upon quantitative and/or qualitative indicators agreed by responsible stakeholders. Ideally, these indicators will be measured at the beginning of the project, during the project and at the end of the project, and - in the best case - several years later.

Documenting conditions at the beginning of the programme is important because it provides a picture of the status quo, a baseline from which to measure progress. To this effect, a survey has been carried out to thoroughly assess the individual household situation regarding:

- energy,
- sanitation,
- health,
- environmental protection and agriculture,
- income generation.

The findings from this survey are compared with secondary data sources from district and national level as far as they exist and have been accessible to the authors, allowing to put the sample into a country wide perspective.

Given the fact that the NDBP Rwanda receives technical assistance from the Nepalese Biogas Programme, international expertise from this chapter of the Renewable Energy sector has been used in the development and analysis of the baseline, thus relating the Rwandese activities to “lessons learned” from biogas dissemination programmes in other countries, in particular of the recent developments in some Asian countries.

The Baseline Study includes seven phases:

1. Desk study of relevant documents, like National Poverty Reduction Strategies, results of National Surveys, National Domestic Biogas

Programme plans to be referred to during the development of the questionnaire and the later analysis of the household data.

2. Questionnaire developed in English, French and Kinyarwanda. It consists of 15 modules which shall be used for indicator development for future impact assessment surveys. For those households which have already applied for a biogas system in 2007, a 16th module is added. These modules are formulated and codified in order to facilitate
   - the definition of the required activities of the National Domestic Biogas Programme,
   - the definition of required subsidies to the families for biogas installations,
   - the definition of micro-financing needs,
   - the measurement of impacts of a biogas system in the livelihood of a family throughout the programme period.
3. 1,106 household interviews in selected sectors and imudugu and relevant data collection at district level. Following the EnPoGen study principle[29], one member of the household acts as representative of the household as a whole. Nevertheless, emphasis has been given to the participation of women in the interview.
4. Data entry, cleaning and processing in SPSS
5. Data analysis and discussion of first results with programme stakeholders in order to define updated needs for programme implementation
6. Workshop on September 12, 2007 in Kigali with presentation and discussion of first results
7. After discussion of results and recommendations based on in-depth data analysis the report was finalized end of November 2007.

[29] The Energy, Poverty, and Gender (EnPoGen) project of the World Bank's Asia Alternative Energy Programme (ASTAE) is part of the ongoing redirection of development strategies toward poverty reduction. Funded under the Bank-Netherlands Partnership Program (BNPP), EnPoGen is an attempt to examine the energy dimension of poverty, with special attention to its gender implications. The project has focused on Asia, where 1.2 billion people—60 percent of the world's population—live without access to modern energy services, mainly in rural areas.

3.3 Methodologies

It was agreed to set up the Baseline Study in those district where the NDBP plans to start up, in order to provide baseline data for monitoring already in the initial phase of the programme. These 4 districts are located in 3 provinces, namely:

- Northern Province: Rulindo,
- Southern Province: Kamonyi, Ruhango (and Nyanza),
- City of Kigali: Gasabo.

In addition, with the purpose of criteria selection for programme dissemination in other regions of the country, household surveys have been conducted in one district not yet considered in the NDBP, with high cattle population but different husbandry system. Gatsibo district in Eastern Province has been selected by MININFRA as a typical cattle holder district with free roaming system. Data from these interviews could serve in future as reference data to compare the basic impacts of different cattle keeping systems on rural livelihood systems (i.e. time, money and efforts spent for animal husbandry), and provide further information of required activities for the potential country-wide implementation of the NDBP.

101 households among the 150 biogas pioneering households, which have been assessed by the NDBP development team, with the support of SNV, as suitable for biogas production, were interviewed as a separated group, in order to facilitate a close follow-up throughout the programme period to this first group of biogas users. To compare their livelihood development with biogas within the next years to neighbouring families without biogas, all surveyed households in those sectors which have not (yet) applied for a biogas plant, but presenting similar socio-economic conditions as the applicants could be categorized as control group[30] to the "biogas households"; this will provide a data base for future impact assessments of the NDBP.

Having questionnaires, the methodology for approaching the households and the SPSS matrix for analysis in place, the partners in NDBP could extend the Baseline Assessment to more districts in line with programme progress.

[30] Scientific definitions of control group: A sample in which a factor whose effect is being estimated is absent or is held constant, in order to provide a comparison (McGraw Hill Dictionary 2003); subjects in the study who do not receive the intervention being studied. The subjects will have similar characteristics as the subjects in the experimental group except for the fact they did not receive the intervention (Center for Public Education, 2007). In the case of NDBP, those households surveyed in the Baseline Study that do not have a biogas plant in the moment of impact assessment will be a control group to those households surveyed in the Baseline Study operating a biogas plant in the moment of impact assessment. The group of biogas plant owner could then be further subdivided in the group of first applicants and "newcomers" in the programme.

3.3.1 Questionnaire development

To provide the required basic data, the following topics had to be considered in the questionnaire for household data collection:

1. General information about household and family members: age, sex, education, occupation, training and engagement in community groups
2. Natural local resources / environment
3. Livestock management system
4. Agriculture
5. Energy supply and consumption
6. Housing and sanitation conditions
7. Water supply and grey water discharge
8. Waste management
9. Food preparation and consumption
10. Health
11. Work distribution and organization in the family
12. Family economy: income and expenditures
13. Family economy: credits and savings
14. Local infrastructure
15. Future plans and projects, willingness and ability to invest
16. Expectations and experiences with biogas system

The questionnaire in English, French and Kinyarwanda was developed to be applied also in future impact assessment and monitoring surveys, facilitating appropriate modifications according to the priorities of the households resulting from the baseline data. As the Baseline Survey was not meant to be used for promoting biogas technology, only for those households which have already applied for a demonstration biogas system the 16th module has been added. This last module can be integrated in future Biogas User Surveys[31].

3.3.2 Survey process

Survey preparation

Based on recent statistics, the findings of the Feasibility Study and the Implementation Plan for the NDBP the representative number of interviews has been calculated as follows:

[31] French version of questionnaire in Annex 7.3

Table 2: Calculation of sample size

Current technical potential in households (Feasibility Study 2006)	110000
Projected biogas plants till end of 2011 - about 13% of technical potential	15000
Baseline data required for kick-off of M&E – at least 5% of households to be addressed by NDBP in regions with zero grazing husbandry system	750
Baseline data control group in regions with free roaming husbandry system – at least 10% of number of all households to be interviewed during baseline assessment	75
Baseline assessment to the group of First Applicants for biogas, selected by SNV and MININFRA as demonstration group, and an according number of households in the same sector as control group to these first applicants	272
Total Baseline data interviews at least	**1097**

IBC Kigali has been contracted to support GTZ in conducting the interviews with the households providing 3 teams with 4 at least bi-lingual interviewers [32] each, accompanied by a supervisor (1 from GTZ, 2 from IBC) and drivers.

After pre-testing the questionnaire in 2 villages with the support of IBC supervisors on May 28, 12 IBC experienced interviewers received training for conducting the baseline interviews on May 30, 2007. These services of these trained interviewers can also be called upon for future surveys. The translation of the questionnaire in Kinyarwanda was completed on May 31, 2007.

Survey execution

Having received the agreement for conducting the survey from MININFRA and the National Institute of Statistics of Rwanda (NISR), the GTZ / IBC-teams approached the districts in the following way:

1. Contact between MININFRA and district mayors to receive introduction visits of interviewer teams: presentation of programme, survey and questionnaire.
2. Contact to the Sector Executive Secretaries was initiated by IBC, who were then met by the interviewers in the field. They selected households to be interviewed. A basic selection criterion was cattle ownership.
3. In total 1106 interviews have been conducted in 6 districts between June 4 and July 26, 2007. The questionnaires have been completed by the interviewer while

[32] Kinyarwanda – French, Kinyarwanda - English

progressing according to the questions. The households participated voluntarily in the interviews. They have not received any compensation in cash or kind for their efforts to be interviewed during 1.5 to 2 hours.

4. The following table shows the distribution of the surveyed households in the districts. The uneven number of interviews in the districts is due to the fact that on top of the general number of 188 interviews to be conducted in each district, and 75 interviews to be conducted in Gatsibo, the first applicants to the NDBP have also been interviewed. Most applicants are residing in Gasabo, Ruhango and Rulindo districts. Interviews in Nyanza were conducted because 5 families have applied for a biogas plant there. As only two of them were found at home, several neighbours have been interviewed instead. For better interpretability the results for Nyanza will be included into Ruhango, its bordering district.

Table 3: Interviews conducted in the districts

Province	District	Nr. of Sectors surveyed	Nr. of household interviews	Number of NDBP-applicants among interviews
Northern	Rulindo	16	251	15
Kigali	Gasabo	8	290	63
Southern	Ruhango	9	193	6
Southern	Kamonyi	12	193	15
Southern	Nyanza	1	7	2
Eastern	Gatsibo	5	172	0
Total	**6**	**51**	**1106**	**101**

5. Data entering done by IBC team was concluded at August 15th, 2007. Data was entered into a prepared SPSS matrix.

3.3.3 Data analysis

Data analysis presents qualitative and quantitative results and considerations. Social, ecological and economical findings are edited as “Lessons learned”, leading to conclusions and the formulation of recommendations for programme activities which should be considered in the definition of precise indicators for programme planning, monitoring and evaluation.

Using SPSS package, means, medians, frequencies, cross-tabulations and other descriptive statistical parameters were generated. One way analysis of variance was carried out where appropriate to detect differences and relations between and among

data sets and cases. Summarised datasets were further processed by EXCEL to produce tables and graphs.

Primary data gathered in the household survey has been compared to secondary country data obtained in interviews to district authorities, reports received at NSI and MININFRA, and via Internet. Furthermore, NDBP relevant documentation has been handed over by SNV, and international biogas literature has been consulted as far as required for calculation of potential biogas system impacts.

Different international references have been applied for categorizing the findings; among those the "Base of Pyramid" or BOP concept [33] results as most suitable concept to identifying appropriate measures in line with the market oriented NDBP approach. The "Base of Pyramid" concept focuses on the low income population strata which form the broad base of the economy pyramid in each country. Poor but heavily involved in national markets, these people deserve attention both from national policy and international donors in order to overcome the poverty trap and to improve national economy. BOP advocates a new way of looking at markets – primarily focusing on the market represented by the 4 billion consumers at the base of the economic pyramid worldwide. BOP has increased in popularity as a way of thinking, and as a business model promoted by the World Bank (WB) and the World Resources Institute (WRI) and since the first major article on the topic in 2002.[34]

[33]. For more information go to references in Annex 7.2
[34] Prahalad, Hart: The Fortune at the Bottom of the Pyramid, 2002

4. District profiles

General social, economical and ecological conditions in the surveyed districts selected as start-up and control areas for the NDBP; references and comparison are made to the country wide situation.

As district level data are not (yet) available to the public or via NSI, interviews have been carried out with district authorities in order to obtain updated data. Still several data categories of interest for NDBP have not yet been gathered and analysed by Rwandese authorities; in case this Baseline Study contains the first data collected on a specific topic, this fact is mentioned in the indicated place[35].

4.1 Kamonyi

Kamonyi district is located west of Kigali on the way to Gitarama and forms part of the Southern Province. Its capital Kamonyi is located about 8km north of the main road. The district is subdivided in 12 sectors which have all been surveyed, namely: Gacurabwenge, Karama, Kayenzi, Kayumbu, Mugina, Musambira, Ngama, Nyamiyaga, Nyarubaka, Rugalika, Rukoma and Runda. Kamonyi is populated by 265,365 inhabitants who are raising a total of 50,614 cows. 4,797 of them are of an improved breed, and 98% of all cattle are kept in permanent stabling. About 90% of the district's population lives on agriculture and produces mainly manioc, maize, beans, sorghum and coffee.

Figure 3: Kamonyi District

Shown within South Province and Rwanda

Every month about 4ha of wood are cut in this district for firewood, which depletes the total forest resources of 3,180 ha. Documentation on reforestation efforts are not yet available, but might be published in the framework of the national forest survey – to be published in 2008.

[35] All maps showing the districts within their province and the country are cited from www.wikipedia.org

Kamonyi provides 84 primary schools for 68,237 students and 14 secondary schools for 5,922 students. 11 health centres and 1 hospital are established in the district. Water supply is assured through 551 protected sources in good condition.

4.2 Gasabo

Gasabo district is located in Kigali Province, this being the reason why only 8 of its sectors can be classified as rural, whereas the other 7 are part of the city of Kigali or its suburbs. The district capital Ndera is situated at the outskirts of Kigali. The proximity to Kigali city allows even part of the rural population to commute there for work every day. The 8 surveyed sectors in this district are: Bumbogo, Jali, Gikomero, Jabana, Ndera, Nduba, Rusororo and Rutunga.

Figure 4: Gasabo District

Shown within Kigali Province and Rwanda

426,299 people are living in the whole district out of which 68% are occupied in the agricultural sector. In the whole of Gasabo district there are 15,893 cattle raised, the zero-grazing policy of the government being established by 80%.

77 primary schools can be found in the district with a total of 64,145 students enrolled, and 29 secondary schools that are attended by 10,254 students.

The district occupies the northern half of Kigali province, which had its boundaries extended under local government reorganization in 2006. Gasabo includes major suburbs of Kigali, sections of a ring of hills which surround the city, and some villages to the north and east of those. Rwanda's wealthiest area, Nyarutarama lies also in this district, as are the office of the President in Kacyiru and most of the ministries.

With 3 hospitals and 10 medical centres Gasabo is probably best equipped with medical services compared to the other surveyed districts.

4.3 Ruhango and Nyanza

Ruhango District is situated in the Southern Province, its capital Ruhango being at about 80km from Kigali. Ruhango is mainly famous for its manioc production but also other crops like maize, soybeans, pineapple and sweet potatoes, beans and sorghum are cultivated on a total agricultural surface of 226km². 90% of the population in this district earn their living from agriculture but there are also 44,008

cattle raised out of which 3,174 are of an improved breed and perform increased milk production. According to the district authorities, 95% of the cattle are kept in zero-grazing.

The 9 sectors of Ruhango which have all been surveyed, namely Bweramana, Byimana, Kabagari, Kinazi, Kinihira, Mbuye, Mwendo, Ntongwe and Ruhango are inhabited by a total of 250,391 people.

Figure 5: Ruhango District

Shown within South Province and Rwanda

Almost 95% of them depend on firewood for their daily cooking, which they are cutting or collecting from a total of 1,268ha of forest. Only 2% of the population is connected to the electric grid. Water supply to the population is ensured through 392 protected water sources in good condition.

There are 75 primary schools in Ruhango which are attended to by 64,715 students and 21 secondary schools at which 13,406 students are enrolled. Medical care is provided at 13 health centres and 1 district hospital. Roughly estimated by the district authorities about 57% of Ruhangos population can be classified as poor.

Figure 6: Nyanza District

Shown within South Province and Rwanda

Nyanza

Bordering to Ruhango southwards is the district of Nyanza where seven households have been interviewed additionally as some of them have already applied for a biogas plant with SNV. They are connected to cooperatives in Ruhango and Kamonyi through which they came to know about the NDBP. The district lies due-north of the provincial capital Nyanza, straddling the major road from Kigali to Bujumbura.

4.4 Rulindo

The district of Rulindo is located in the Northern Province of Rwanda adjoining to the Province of Kigali. Its capital is Tare. Rulindo is home to Agashya, the country's leading producer of fruit juice, which is mainly manufacturing passion fruit, pineapple and strawberry squash as well as several kinds of fruit jam and honey. Besides fruits the district produces beans, sorghum, different tubers, bananas and vegetables on 226km² of agricultural surface. The district is subdivided into 17 sectors, out of which 16 have been surveyed: Base, Burega, Bushoki, Cyinzuzi, Cyungo, Kinihira, Kisaro, Masoro, Mbogo, Murambi, Ngoma, Ntarabana, Rukozo, Rusiga, Shyorongi and Tumba.

The mountainous landscape is covered by 4,600ha of forest which is mainly used for firewood but also for brick production.

261,018 inhabitants live in Rulindo which leads to a high population density of 448 inhabitants/km² compared to 397 inhabitants/km² as the national average. 95% of these people are occupied in agriculture and can sell there products on the 9 agricultural markets in the district. There are also 25,677 cattle raised out of which 90% are kept in permanent stabling already.

Figure 7: Rulindo District

Shown within North Province and Rwanda

The district is equipped with 86 primary schools, attended to by 66,860 students, and 27 secondary schools educating 7,745 students. 12 health centres are taking care of the medical needs of the population, which by 60% is estimated as being poor. 420 protected sources for improved water supply have been installed in the district.

4.5 Gatsibo

Gatsibo District is located in the Eastern Province of Rwanda, its capital being Kabarore. The eastern part of Gatsibo up to the Tanzanian border is still part of Akagera National Park whereas the area adjoining west to it, today Rwimbogo sector does not belong to the National Park anymore since 1994. Since then this sector, as well as most of Gatsibo district in general, is inhabited by people who returned to Rwanda from Tanzania and Uganda after the war. Therefore this district is mainly Anglophone. Gatsibo differs from the other surveyed districts not only in language and the climate which is considerably drier than the Middle and Western parts of Rwanda, but also in the architecture of the houses, the clothes, and most importantly in cattle raising practices. Whereas the average cattle raiser in Rwanda has 2 to 3 cows in permanent stabling close to his house for dairy and meat production, in Gatsibo more than half of the total cattle is kept on pastures far away from the owner's house; animal husbandry is focussing on meat production. Thus this district is not yet a prior target area of the National Domestic Biogas Programme, even though the total number of cattle in Gatsibo is considerably higher than in all other surveyed districts.

Figure 8: Gatsibo District

Shown within East Province and Rwanda

Gatsibo is divided into 14 sectors, out of which 5 were surveyed: Rwimbogo, Kabarore, Kiziguro, Kiramuruzi and Ngarama. There are about 65,000 households in Gatsibo out of which 1,820 are raising a total number of 68,900 cattle. About 80% of these cattle are traditional longhorn cows which produce very little milk and are mainly raised for meat production. The owners of the biggest cattle herds, 50 cows and more, are often wealthy government or military officials. This also explains why about 20% of Gatsibo's households can be classified as wealthy: but still 86% of them are working in agriculture. The main agricultural crops are Sorghum, Mais, Manioc, Beans, Bananas, Rice and Coffee which are locally sold on 17 agricultural markets. About 4ha of forest are cut every month to supply the population with firewood.

More than 80,000 pupils are enrolled in 74 primary schools and about 11,000 students are attending one of the 27 secondary schools in Gatsibo. Medical services are obtainable at 16 health centres throughout the district.

4.6 Overview on district and country data

Data analysis of nationwide conducted surveys is still ongoing; results are not yet published and transmitted to the districts. In addition, administrative boundaries have been changed in 2006, and accessible national survey reports refer to former boundaries. Therefore general data obtained from interviews with district authorities are also incomplete because access to demographic and socio-economic information within the districts still varies significantly. The following table summarizes the data obtained from interviews at district level and relevant statistics for the country. [36].

Table 4: Overview and comparison of official country data and sampled districts

No.	Kamonyi	Gasabo	Ruhango	Rulindo	Gatsibo	Rwanda
Total sectors	12	15	9	17	14	415
Surveyed sectors	12	8	9 + 1 in Nyanza district	16	5	51
Households	45,000	62,051	55,438	41,877	65,118	1.8 mio[37]
inhabitants	265,365	426,299	250,391	261,018	283,456	9,907,509 [38]
Population density	405/km²	430/km²	399/km²	448/km²	318/km²	397/ km²[39]
% of HH living below poverty line	nd	nd	57	65	10	56[40]
% of poor HH	nd	nd	nd	nd	30	nd
% of HH of lower middle class	nd	nd	nd	15	25	nd
% of HH of upper middle class	nd	nd	nd	18	15	nd
% of wealthy HH	nd	nd	nd	2	20	nd
primary schools	84	77	75	86	74	2,262[41]

[36] If no other reference is given, data sources are interviews with district authorities
[37] Calculated based on the average household size of 5,5 persons
[38] CIA World Fact Book 2007
[39] CIA World Fact Book 2007
[40] MINECOFIN: EDPRS Draft 08/2007 including data from EICV2 2005/2006
[41] www.rwandagateway.org/education

No.	Kamonyi	Gasabo	Ruhango	Rulindo	Gatsibo	Rwanda
pupils in primary school	68,237	64,145	64,715	66,860	81,932	1,857,841[42]
secondary schools	14	29	21	27	27	504[43]
pupils in secondary school	5,922	10,254	13,406	7,745	11,082	218,517[44]
Health Centres & Medical Staff	11 hc and 1 hospital	10 hc and 3 hospitals	13 hc and 1 hospital 194 staff	12 hc & 141 staff	16 hc	375 hc and 34 district hospitals[45]
Health Insurance	nd	76.9 %	nd	nd	nd	37.8%[46]
Number of Cattle	50,614	15,893	44,007	25,677	68,938	1,122,179[47]
Cattle raising HH	nd	nd	nd	25,126	1,820	Any livestock: 71%
Mean cows / hh	nd	2	0.7	0.6	2	nd
Improved cattle	4,797	nd	3,174	971	13,234	86,777[48]
Goats	11,236	4,582	8,884	4,517	78,657	2,655,798[49]
Sheep	16,566	3,589	nd	22,413	4,124	695,367[50]
Pigs	25,050	7,895	37,573	6,883	5,000	527,531[51]
Chicken	114,103	12,568	nd	45,141	77,845	1,717,925[52]
Rabbits	nd	14,589	nd	28,473	10,964	418,361[53]
Population working in agriculture	90%	68%	90%	95%	86%	90%[54]
Agricultural surface	nd	nd	626.8km²	226km²	792.65km²	1,213,571 ha[55]

[42] NISR, 2005
[43] www.rwandagateway.org/education
[44] NISR 2005
[45] MINISANTE DHS 2002
[46] International Social Security Review
[47] MINAGRI Agricultural Survey 2006
[48] MINAGRI Agricultural Survey 2006
[49] MINAGRI Agricultural Survey 2006
[50] MINAGRI Agricultural Survey 2006
[51] MINAGRI Agricultural Survey 2006
[52] MINAGRI Agricultural Survey 2006
[53] MINAGRI Agricultural Survey 2006
[54] NISR Preliminary Results EICV2, 2006
[55] Or 74% of land surface: MINAGRI Agricultural Survey 2002

No.	Kamonyi	Gasabo	Ruhango	Rulindo	Gatsibo	Rwanda
Cultivated products (first priorities) besides bananas	Manioc, maize, beans, sorghum, coffee	nd	Manioc, maize, soybeans, ananas	Beans, sorghum, vegetables, potatoes	Sorghum, maize, beans, cassava, rice, coffee	Beans, sweet potatoes, peanuts, sorghum
Economic activities in the District	Agriculture & animal husbandry	Agriculture & animal husbandry	Agriculture & animal husbandry	fruit juice, handicraft, bricks	Trade, mining, handicraft	----
Situation of Forests	3180ha,	nd	1268ha	4600ha	nd	5,450km^2
Wood cut / month	4ha	nd	nd	nd	47,242 m^3	nd
Zero-grazing	98%	80%	95%	90%	48%	6%
Energy Supply Situation	nd	nd	94.8% wood; 2% electricity	nd	20% electricity	5% of country population consumes 80% of country electricity (Kigali)
Situation of Water Supply	551 protected sources ; 1139 to be (re)constructed	nd	392 good 218 to be improved 315 to be set up 19 by gravity 3 pumps 243 wells	131 springs 290 taps	60% have access to public water supply	62% of rural population with access to safe water

5. Analysis of the survey results

Each of the following sub-chapters will contain the main aspects:

- *Current situation (baseline) and comparison with national data as far as available*
- *The aimed impact of NDBP*
- *Lessons learned about challenges and opportunities for the NDBP*

An overview on the main survey results is provided in the Table 5, following the structure of the questionnaire that was applied for the structured and standardized household interviews.

Table 5: Main findings

Nr.	Topics from questionnaire	Findings
1	General information about household and family members: age, sex, education, occupation, training and engagement in community groups	• Average number of household members: 7 persons. • 73.6% already participated in an additional formation. • 71.1% are members in local cooperatives or organizations. This indicates interest in learning and innovation, and networking capacity.
2	Natural local resources / environment	• Domestic biogas generated from the dung of at least 2 cows could save 2,348kg firewood per year and household
3	Livestock management system	• The average number of cattle in the surveyed households: 3 cows; currently more than 40% of the households own 1-2 cows. • In the district where NDBP started, zero grazing is practiced by 91% of the households. • In more than 90% stables are up to 10m from the house, 21.6% have cemented floors facilitating the collection of cow dung and urine.
4	Agriculture	• 96.5% of the households practice small scale subsistence agriculture applying animal manure as fertilizer; • 65% estimate their total available agricultural surface up to 1ha.
5	Energy demand and	• Cooking fuel: 99.5% firewood - statistical average used

Nr.	Topics from questionnaire	Findings
	supply	per household per month 338kg or 1.61 kg/cap/d. • 67% of the households do not pay for firewood. • Stoves: 68% use improved stoves. • Lighting fuel: 93% kerosene
6	Housing and sanitation conditions	• 99.3% has some type of latrine or toilet. • 89.7% are willing to use energy generated from animal and toilet waste for lighting and cooking purposes. • 90.6% are willing to use the bio-slurry fermented from animal and toilet waste as fertilizer on their fields.
7	Water supply and grey water discharge	• Water use: 20 l/d per inhabitant including water for cattle kept in zero-grazing. • Mean distance to and from water sources: about 1.3 km. • 40% of households pay for water. • Waste water discharge: poured inside or outside of the compounds or in pits
8	Waste management	• Organic, animal and agricultural waste: composted and fertilizer on fields
9	Food preparation and consumption	• Main energy consumption: firewood for up to 3 cooked meals per day in 51% of the households; • Most households consume maize, rice, manioc, potatoes, beans, vegetables and plantains.
10	Health	• Main health concern: malaria • 99% of rural households cook with solid fuels; 56% experience negative effects from indoor air pollution caused by smoke, like Acute Respiratory Infections • Training required on improved kitchen management, including improved ventilation at the cooking place
11	Work distribution and organization in the family	• Responsibility for … cattle: mainly shared between husband and wife … cooking: mainly shared between wives, daughters and workers … fetching water: mainly appointed to children and workers … firewood: mainly collected by workers, husbands and wives

Nr.	Topics from questionnaire	Findings
		• Average time daily used for cooking: 4.17h • Average time daily spent fetching water: 1.6h • Average time daily spent fetching firewood: 1.5h
12	Family economy: income and expenditures	• Economic position of the interviewed households: low income segment ("Base of economic Pyramid") • 76.9% generate income from sale of agricultural products; 67.5% earn from their livestock and 50.3% have diversified non-agricultural income sources • 87% own a radio, 40% own a mobile phone
13	Family economy: credits and savings	• 48% received a credit at least once; payback period for 78.9% up to 2 years • 77.3% have a saving account • 67% don't pay for firewood • 40% pay for water
14	Local infrastructure	45% of the surveyed households belonging to the group of potential NDBP customers are living in 3km distance to service infrastructure like schools, health centres and tarmac road
15	Future plans and five priority projects, willingness and ability to invest	• First priorities for future improvements: livestock keeping 53%; lighting and cooking energy 15%; agriculture 11%; housing conditions 11%. In total, 86% of surveyed households ranked lighting and cooling energy supply as one of the most important priorities for improvements. • Willingness and ability to invest in a biogas plant are matching in nearly 100%; 84% of the households are willing and ready to apply for credit for biogas. • Estimated necessary credit sum for the investment in biogas varies significantly, with its peak at 500,000 FRW.
16	Expectations and experiences with biogas system	• Lighting is most household's first priority for biogas. • 79% of the first applicants for biogas plants would already recommend the technology to others

5.1 Household characteristics

5.1.1 Current Situation of Households

During this Baseline Study, 1,106 households have been interviewed; this number corresponds to 7.3% of the estimated number of potential biogas client households or about 1% of the statistically existing rural households in Rwanda.

Household Composition and Location

In the surveyed households at least one member was interviewed, mostly the head of the household, following the EnPoGen study approach which values one household member as representative speaker for all the other members. The interview partners have provided information about a total number of 7636 household members. The average number of household members resulted in 7 persons per household, whereas the national average counts 5,5. This could be caused by the fact that national data always include rural and urban households, while the NDBP baseline study only covers rural areas.

In 84.8% of cases the head of the household is male, in 15.2% of cases female. The average household head is 47 years of age.

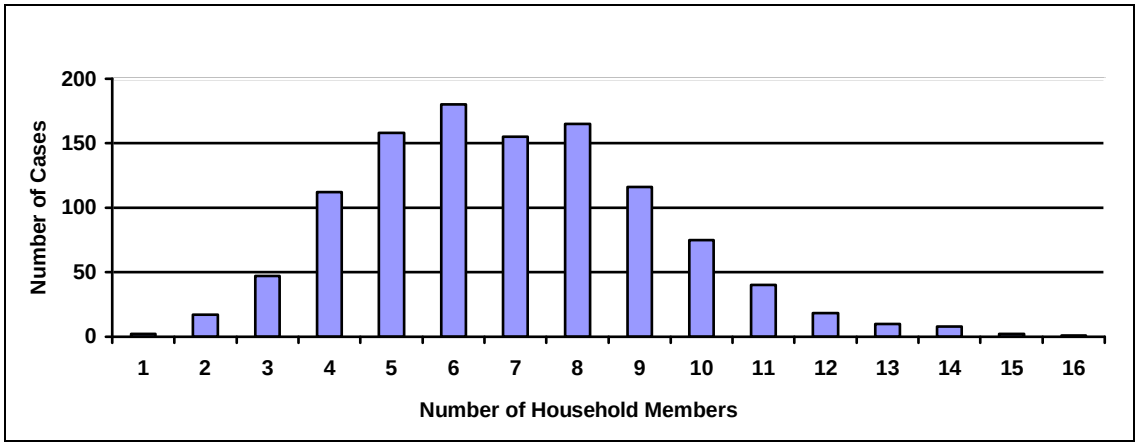


Chart 1: Household size

Of all surveyed household members 40.52% are children up to 14 years of age which leads to a mean number of 3 children per household. This corresponds to national statistics[56] . It also explains why about 49% of all household members are currently students. As to be expected in rural areas, agriculture and animal husbandry are the predominant income generating activities of the households.

[56] Earth Trends 2003

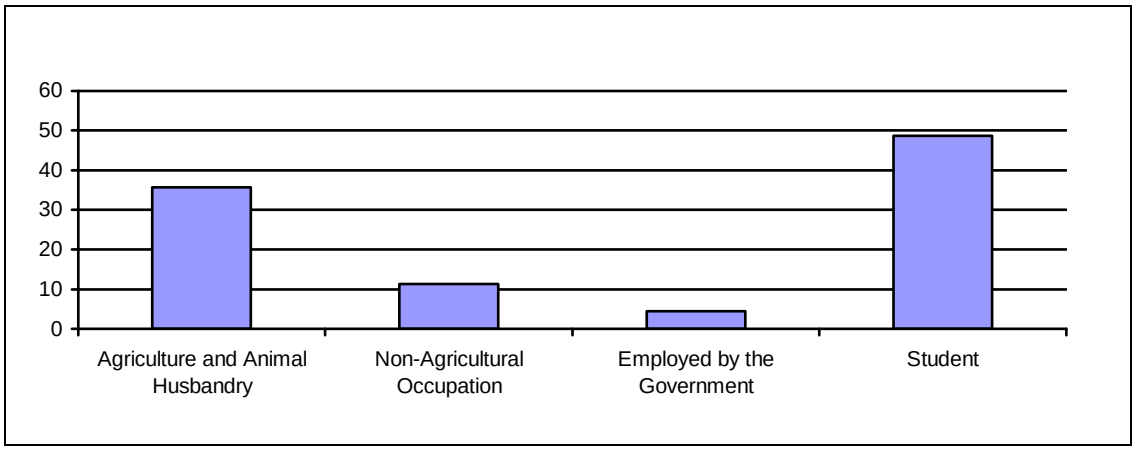


Chart 2: Main occupation of household members

57% of all surveyed household members are educated up to primary level; 18% of them are even educated further, summing up to a total of literate household members of 84%. As this percentage includes also children aged younger than 15, the result corresponds to official estimation of literacy which is given at 70% for the year 2003.[57]

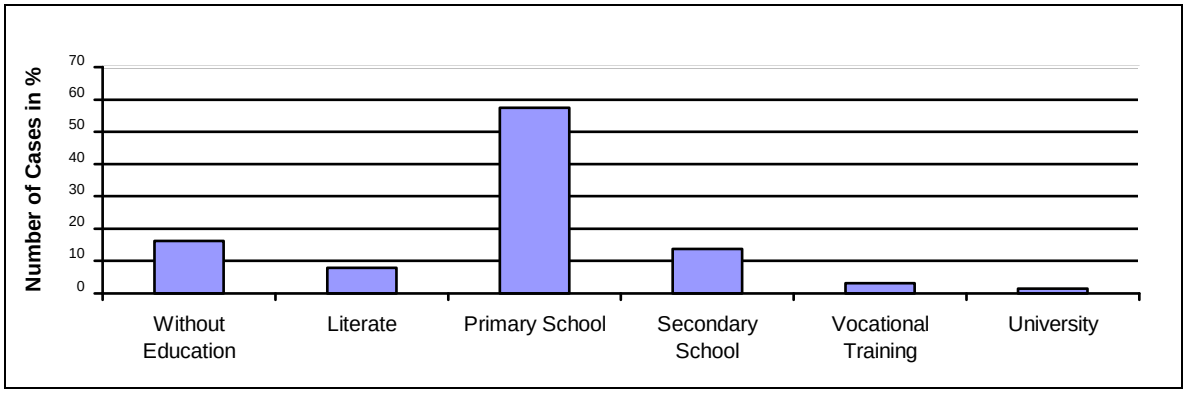


Chart 3: Education level of household members

73.6% of the households have already participated in an additional formation conducted by NGOs, the government or other institutions, like cooperatives. 71.1% of all households maintain membership in local cooperatives or organizations, which are mainly concerned with agriculture, animal husbandry and micro-credit. This indicates (1) interest in learning, improvement of skills, and innovation in livelihood and (2) a broad networking capacity of the targeted cattle owning households.

[57] CIA World Fact Book 2007

Table 6: Additional formation: contents and participation

Content of additional formation	Participant households
Agriculture	33,8%
Animal husbandry	35,3%
Health	17,5%
Sanitation	5,8%
Nutrition	3,3%
Environment	7,3%
Water	3,4%
Energy	1,6%

Settlements in rural Rwanda are traditionally dispersed: farmers living on the hill sides, their homes surrounded by banana plantations and fields while pasture grounds are in the valleys or on the top of the hills. Access to the compound is often only possible on narrow foot paths. Since several years the government promotes the development of imudugudu – centralized settlements where infrastructure like schools, shops, markets, pharmacies and health centres are set up in order to motivate farmer families to leave the hill sides.

The location of houses in relation to basic local infrastructure, like small grocery shops, the market, primary and secondary schools, health centres, banks, masons and other craftsman, the sector office and the tarmac road indicates their accessibility for public and private services. A mean distance to all of these has been calculated to estimate the centrality or remoteness of households. In general most of the cattle owning households have been found to be dispersed rather than in village centres.

For NDBP, easy access to the farms is important to facilitate for constructors the transport of material and the supervision of several construction sites thus reducing costs for plant owners.

Chart 4: Average distance to local infrastructure

Animal Husbandry

Since the NDBP is to supply households with biogas plants that are mainly fed with cow dung, the potential customers are cattle raising households. Therefore all of the 1,106 surveyed households own at least one cow; the mean number of cattle per household is 3 cows. Cattle are raised and kept for milk as well as meat production. Besides cattle households own goats (53.2%), chicken (35.4%), sheep (13.7%), pigs (6.5%), and rabbits (5.5%). According to MINAGRI[58], 71% of all households in the country raise animals. The number has increased rapidly since 2002, and a further increase up to 90% in the year 2011 is planned according to EDPRS[59] by means of the "One Family – One Cow" programme that will provide 600,000 cattle to poor households.

The following table displays the distribution and the total number of cattle in the sample in relation to the registered cattle in the surveyed districts: Households participating in the survey own 2.2% of the total cattle population in their districts.

Although these districts are identified as those with the highest biogas potential, their cattle population represents only 18.3% of national cattle population. This fact could be seen as indicator for an even higher country wide biogas market potential than calculated in the Feasibility Study.

[58] MINAGRI: Agricultural Survey 2006
[59] NEPAD: EDPRS brief – Intensification and Development of Sustainable Production Systems, 2007

In 2005, the total number of cattle in Rwanda was about 1.13 million[60]. As the NDBP focuses on households with at least 2 cows in a zero- or semi zero grazing system, the number of potential clients with secured biomass availability could significantly increase over time.

Table 7: Number of cattle in sample households, districts and the country

Number of cattle	**Number of Sample Households by District**						
	Gasabo	Gatsibo	Kamonyi	Ruhango	Rulindo	Total hh	*Total %*
1	13	3	13	6	9	44	*3.98%*
2	**122**	**52**	**58**	**82**	**99**	413	***37.34%***
3	**73**	32	**52**	**53**	**64**	274	***24.77%***
4	**37**	18	**31**	26	**38**	150	*13.56%*
5	22	10	14	19	15	80	*7.23%*
6	11	10	12	4	9	46	*4.16%*
7	3	6	3	3	6	21	*1.9%*
8	4	3	5	6	4	22	*1.99%*
9	3	3	3	0	2	11	*1.00%*
10 – 50	2	29	2	1	5	39	*3.53%*
51-88	0	6	0	0	0	6	*0.54%*
Total hh	290	172	193	193	251	1.106	*100%*
Total cattle in sample	905	1484	659	651	849	4,548	*2.2% of total in districts*
Total in district	15.893	68,938	50,614	44,007	25,677	205,129	*18.3% of total national*
			Total in country			1,122,179	*100%*

The most important factor for the operation of a biogas plant as it will be disseminated by NDBP is the amount of cow dung available per household and day. The available amount is not only dependant on the number of cattle but also on the amount of fodder and water the animals receive or have access to, and the stabling system. The current prevalence of different stabling practices in the sampled districts is shown in the following table.

[60] MINAGRI: Agricultural Survey 2006

Table 8: Stabling systems

Stabling Practices	Percentage of Households in Districts						
	Gasabo	Gatsibo	Kamonyi	Nyanza	Ruhango	Rulindo	Total
Zero grazing (Permanent Stabling)	**97.6%**	63.1%	**95.3%**	**100.0%**	**94.8%**	**99.6%**	91.7%
Semi zero grazing (Stabling at night)	1.7%	31%	4.8%	0%	4.7%	0.4%	7.1%
Free Roaming	0.7%	6.0%	0%	0%	0.5%	0%	1.2%

Countrywide 6% of cattle are currently kept in zero grazing systems. Through promotion events within the "One Cow per Poor Household Programme" the Government of Rwanda aims to increase this percentage at about 25% until 2011[61]. As a biogas system performs best if cattle are kept in zero grazing units, biogas technology introduction could play an incentive role in the improvement of animal production.

The collection of cow dung and urine could be further facilitated if the floor of the stable is cemented. That is the case in 21.6% of all sampled households; this finding leads to the conclusion that zero grazing practices should be still improved to simplify cow shed cleaning work and protect groundwater from concentrated urine infiltration.

The biogas production from cow dung is best usable by the plant owner household if the stable and the connected biogas plant are close to the main house and kitchen, to limit the length of the gas pipeline. In the sampled districts the distances from house to stable have been measured. Although there are no national data available on this topic, visits in other provinces have proven that this distance is basically related to the settlement pattern, the land limitations and the animal husbandry system: the furthest stables are all located in Gatsibo, where herders take care of the cattle far away from the owners' home.

[61] NEPAD: EDPRS brief – Intensification and Development of Sustainable Production Systems, 2007

Linked with the prevalent cattle husbandry system the following table could be used as example for the national cattle keeping situation. In the case of zero grazing, the mean distance between house and stable is 3 meters.

Table 9: Average distance between house and stable (% of households in each category)

Districts	Distance to Stable				
	0.1-3m	**3.1-10m**	**10.1-100m**	**101-1000m**	**>1000m**
Gasabo (zg)	61.4%	34.7%	3.1%	0.4%	0.4%
Gatsibo (fr)	37.1%	41.3%	7.8%	7.8%	6%
Kamonyi (zg)	52.3%	42.5%	3.4%	1.7%	0%
Ruhango (zg)	57.6%	38%	1.9%	1.9%	0.6%
Rulindo (zg)	62.2%	31.1%	3.3%	3.3%	0%
Total	**54,7%**	37.5%	3.8%	2.8%	1.3%

Prevalent cattle husbandry system: zero- grazing – (zg) free roaming (fr)

Those households who have already applied for a biogas plant know to measure the quantity of cow dung available per day: one full basket equals to about 20 kg of cow dung collected in the stable at least once a day. The same kind of basket is used by all households for cleaning the cow shed and for transportation of the dung to a collection point or “compost heap”. Therefore surveyed households have been asked how often per day they fill up this basket with dung from their cattle. From this daily collected amount of dung the available biomass for digester feeding can be estimated.

High amounts of daily dung production per cattle indicate good zero-grazing practices: in the sampled district most households estimated to obtain more than 20kg of dung every day with a median quantity of 35kg of dung every day. As the NDBP will disseminate biogas plants with construction volumes which need to be fed with at least 20kg cow dung per day, the following chart shows the ratio of households in the sampled districts with a production of more and of less than 20 kg cow manure per day. These data are currently only based on estimation given by the interviewed households. However, randomized samples have been measured with “dung baskets” to verify the amount.

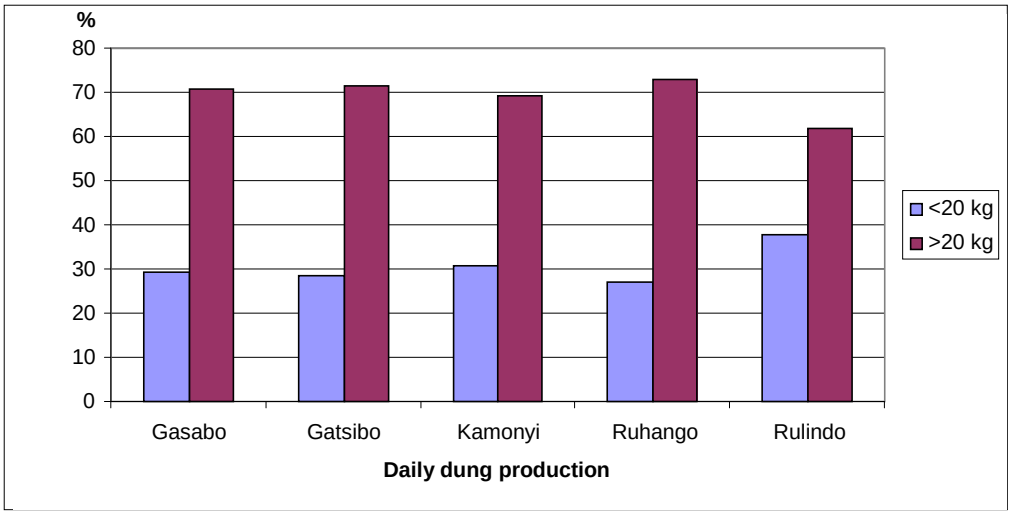


Chart 5: Daily available cow dung on sampled farms

Based on the number of cattle owning households at district level, the percentage of implemented zero-grazing systems, and the daily dung production the potential biogas plant market could be determined. However, the cross evaluation of zero grazing system numbers and the estimated dung production reveals that the cattle keeping system should not be taken as the only indicator for the local NDBP market potential, because even with this system the available biomass could be insufficient for a satisfactory biogas production.

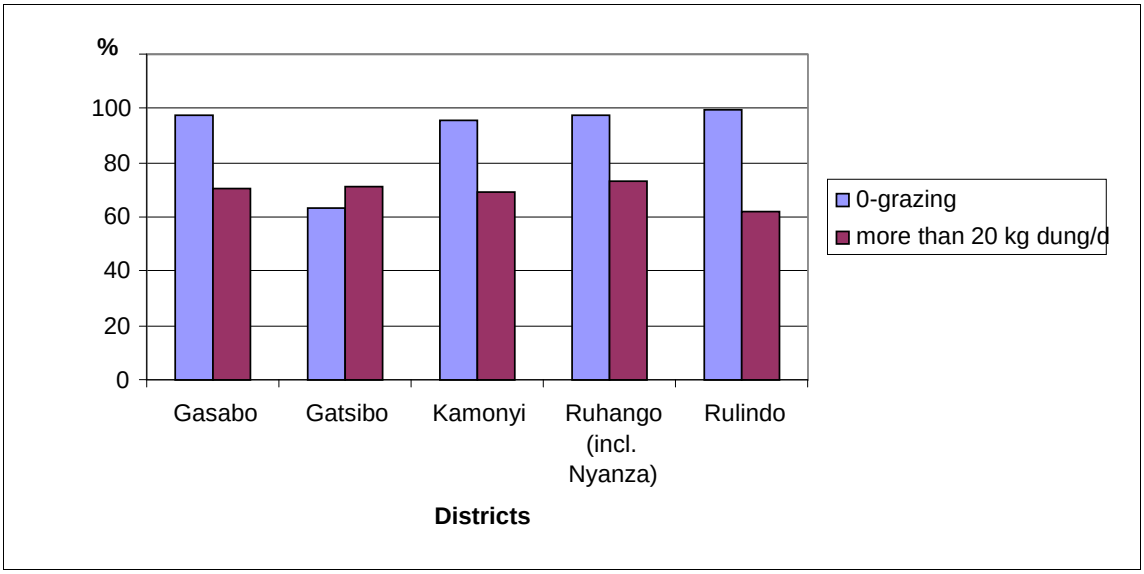


Chart 6: Ratio between zero-grazing systems and daily dung production

The responsibility for the cattle within the household is often shared between husband and wife. Men and women seem to be equally involved in cattle keeping. This information is important for the NDBP as programme activities should therefore address women and men equally, and involve both gender in training courses.

Chart 7: Responsibility for cattle

Agriculture

Main cultivated agricultural crops in the surveyed districts are beans, tubers, cereals, fodder plants and bananas. The percentage of production in the sampled farm households is presented in the following chart.

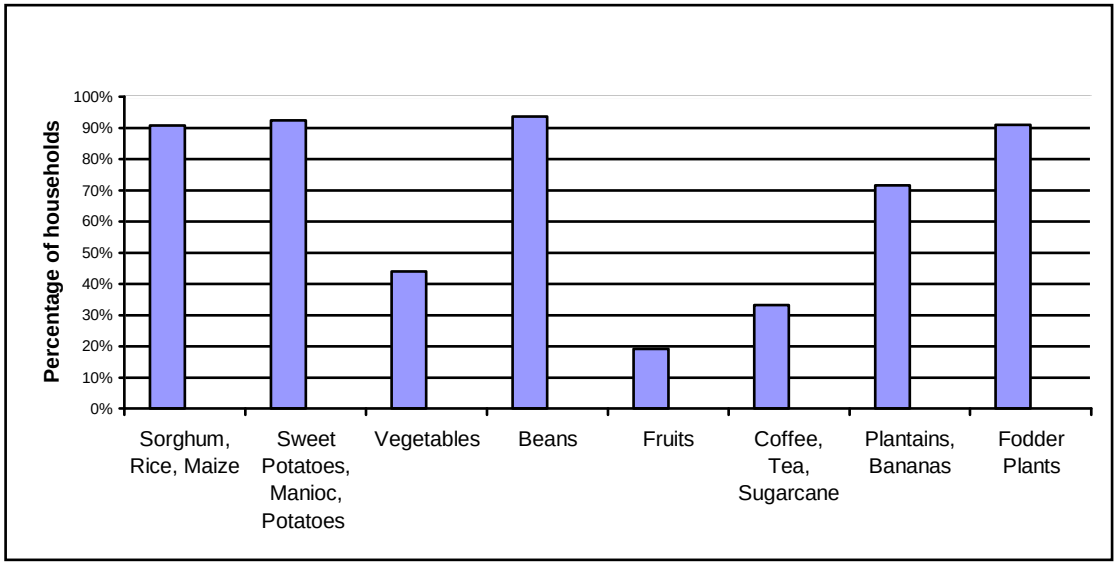


Chart 8: Main agricultural produce of the sampled households

These crops are cultivated on an average of 1ha farmland per household in 2 seasons, thus the total available soil per household counts for 2ha. On the national average cultivable farmland per household is about 0.7ha[62], varying from 0.34ha in the region of Cyangugu and 1.14ha in the region of Umutara.

Beans are cultivated by almost 89% of all farms throughout the country. Improved seeds are available for beans, maize, rice, cassava and Irish potatoes, but mostly only in the central regions in order to supply the market of Kigali with food. Crops with importance on local markets and for subsistence are beside the already mentioned specifically bananas (as fruit, plantain or for wine and beer production), peanuts, soybeans, peas, sorghum and sweet potatoes[63]. The following table shows the available land for cultivation in the surveyed districts.

Table 10: Average size of seasonal cultivated surface in sampled districts

Districts	Agricultural Surface			
	0.1-1 ha	1.01-2 ha	2.01-4 ha	>4 ha
Gasabo	32.1%	32.5%	25.4%	10%
Gatsibo	32.9%	35.3%	24.6%	7.2%
Kamonyi	29.5%	30.6%	30.1%	9.8%
Ruhango	31.6%	27.8%	28.9%	11.8%
Rulindo	39.1%	32.9%	21.8%	6.2%
Total	33.1%	31.9%	26%	9.1%

More than 50% of the households use cow manure as fertilizer on their fields, 39% use cow manure and compost, 6.5% use compost only and 3,5% can afford to use chemical fertilizer. Chemical fertilizer is used more frequently for growing cash crops; about 18% of the farmers who grow coffee or tea use it. These data are confirmed for nationwide fertilizer handling[64]. It is part of the EDPRS and the national “Strategy for the Use of Fertilizers” to “promote the use of fertilizers to ensure people’s food security and to dynamize the agricultural production in order to increase economic growth and to reduce poverty”[65].

[62] MINAGRI: Agricultural Survey 2006
[63] MINAGRI: Agricultural Survey 2006
[64] MINAGRI: Strategy for the use of fertilizers, 2007
[65] MINAGRI: Strategy for the use of fertilizers, 2007

Domestic chores: responsibilities and time spend per day

Domestic work and responsibilities are distributed among household members, as the following chart shows; although in a lot of households all chores are shared.

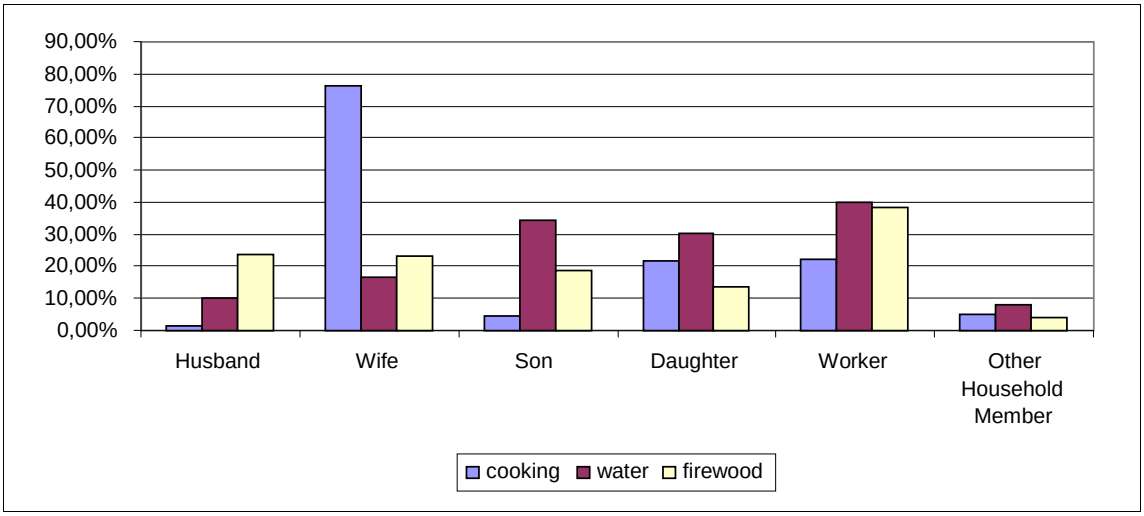


Chart 9: Responsibilities for cooking, and water and firewood supply

The above chart shows that cooking is mainly a responsibility of wives, daughters and workers, while fetching water is mainly a task appointed to children and workers. This is important as according to SNV Training Manual[66] more water will be needed if a biogas plant is installed. Fetching wood is mainly an activity of workers, but all other family members also participate. The next charts and tables further illustrate how much time per day is currently invested in each of these tasks.

To know this distribution is relevant for the NDBP as the operation of a biogas plant will occupy also work and time from different household members; the responsibility for operation should be clearly assigned to specific household members.

[66] SNV Trainee's Manual for Training of Trainers for Construction and Supervision of Biogas Plants, 2007 - how much additional water will be needed will be determined by the technical department of NDBP

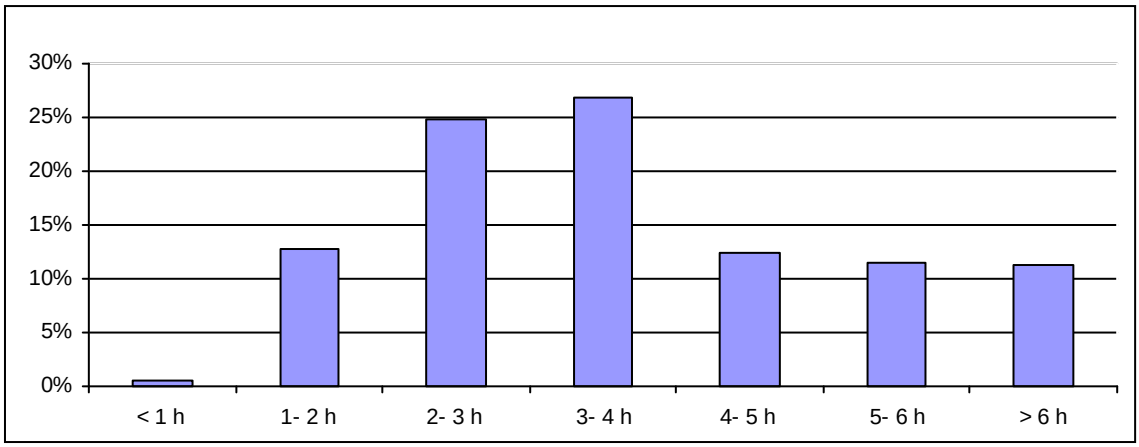


Chart 10: Time spent for cooking

The average time used for cooking is 4.17 hours a day, while the average time spent fetching water is 1.6 hours, and fetching firewood 1.5 hours.

Table 11: Hours spent fetching water per day

	< 1 h	1- 2 h	2- 3 h	3- 4 h	4- 5 h	5- 6 h	> 6 h
Gasabo	65.2%	23.2%	7.6%	2.9%	0.7%	0.4%	0%
Gatsibo	63%	25.5%	5.5%	3.0%	1.2%	1.8%	0%
Kamonyi	59.8%	24.3%	6.9%	4.2%	1.6%	3.2%	0%
Ruhango	66.5%	18.1%	7.1%	6.6%	1.1%	0.5%	0%
Rulindo	66.8%	25.5%	4.7%	1.7%	0.4%	0.9%	0%
Total	**64.7%**	**23.2%**	**6.4%**	**3.5%**	**0.9%**	**1.2%**	**0%**

Table 12: Hours spent fetching wood per day

	< 1 h	1- 2 h	2- 3 h	3- 4 h	4- 5 h	5- 6 h	> 6 h
Gasabo	67.8%	24.7%	4.2%	1.8%	0.7%	0.7%	0%
Gatsibo	77.4%	14.8%	1.3%	2.6%	2.6%	0.6%	0.6%
Kamonyi	67%	22.2%	4.3%	3.2%	2.7%	0%	0.5%
Ruhango	70.1%	19.3%	4.8%	1.6%	0.5%	2.1%	1.6%
Rulindo	72.1%	18.9%	4.1%	1.2%	1.6%	0.8%	1.2%
Total	**70.6%**	**20.5%**	**3.9%**	**2%**	**1.5%**	**0.8%**	**0.8%**

In general 65.8% of husbands are working actively in animal husbandry while only 49.2% participate in agricultural work. Their wives are slightly more involved in

agriculture (62.5%) than in animal husbandry (57.7%). 14% of the children are contributing to animal husbandry activities and 7.5% to agricultural activities. While agricultural workers are mainly hired for agricultural work, the majority of workers who are also involved in animal husbandry stay with the household, and subsequently participate in a number of different tasks. This explains why 65.9% of them are working in agriculture and 55.2% in animal husbandry.

The main income generating activities in agriculture require time as follows:

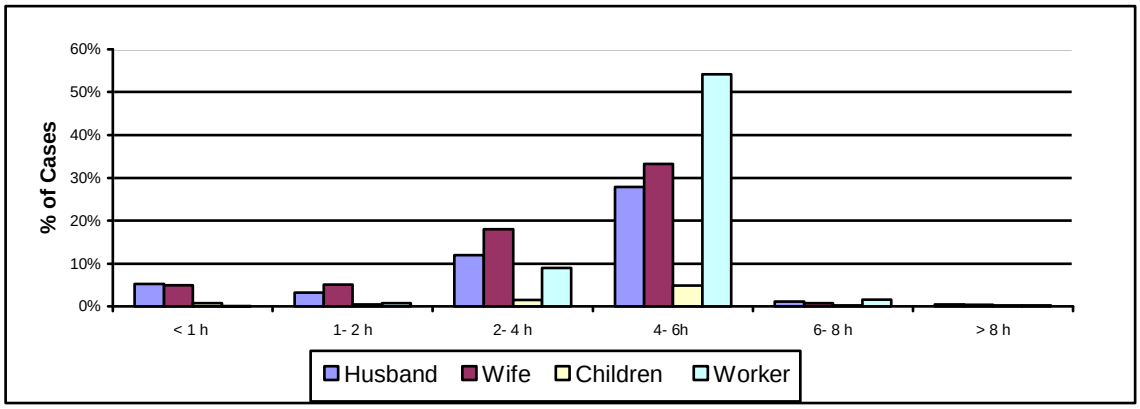


Chart 11: Time spent in agricultural activities by household members per day

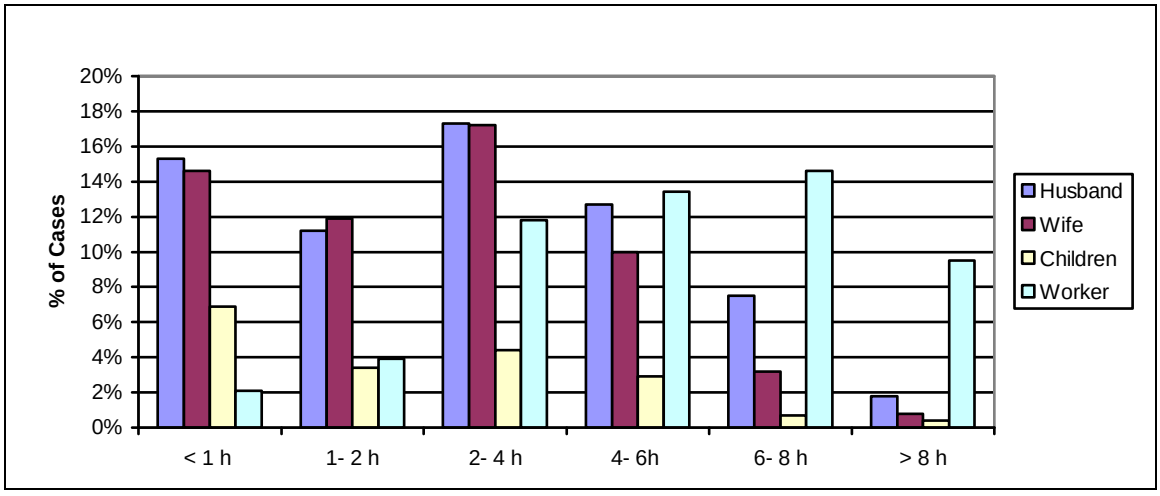


Chart 12: Time spent in animal husbandry by household members per day

The average minimum cost of labour is between 150 FRw and 400 FRw per day for temporary work paid in cash or in kind[67]

5.1.2 Aimed Impact of the NDBP on Household Situation

The aimed impact of the NDBP on the livelihood system and organization of the households as portrayed above consists in providing the farmers with more convenience, more time for other activities, more light in the evenings, better health, high quality fertilizer to increase their agricultural yield, food security, and in motivating farmers to keep their cows in permanent stabling. If the cows are fed well this might also increase the milk production with further impact on nutrition status and daily income generation through sales of surplus milk.

5.1.3 Lessons learned about challenges and opportunities for the NDBP

There are various baseline results about the current household situation that should be taken into consideration for the implementation of the NDBP:

- Since the majority of interviewed household members has at least a minimum level of education up to primary school, and more than 70% of households have already participated in additional formations, it should be convenient for the NDBP to build on that prior knowledge to conduct Biogas User and Maintenance Trainings.
- The NDBP should try to include the heads of the households as well as wives and workers because they are also responsible for cattle and will therefore most probably also be in charge of the feeding and maintenance of the biogas plant.
- More than 70% of the surveyed households are members in local cooperatives. They should be addressed by the NDBP for promotion of the programme, especially because among the members of these cooperatives the level of mutual trust is considerably high: working together towards the same goal – as it happens within formally installed groups like cooperatives – requires and forges the community spirit.
- Cattle raising conditions in the surveyed districts are rather favourable for the implementation of the NDBP since 91% of them already practice zero grazing in stables which in more than 90% of the cases are up to 10m from the house. Even though the average number of cattle in the surveyed households amounts to 3 cows per household, the programme should take into consideration that currently

[67] MINAGRI: Agricultural Survey 2006

more than 40% of the households still own 1-2 cows only, and therefore at this moment may not have enough biomass for reliable and sufficient biogas production .

Dung from 2 cows managed in zero-grazing system[68] can potentially produce 427m^3/y of biogas. Cooking on biogas will shorten cooking times from currently more than 4h to significantly less time, as the biogas flame heats up the pot from the first moment of ignition; additionally, training in "modern" cooking techniques of the person who is responsible for cooking, would reduce the time spent for this task. The following table compares the theoretical calorific value of firewood and biogas. In case an improved stove is used (69%), the conversion efficiency depends on the model.

Table 13: Calculation for firewood equivalent by biogas, based on sample data

Type of source	Amount per year	Conversion factor/unit	Calorific Input	Conversion efficiencies	Calorific Output
Firewood for cooking	4,056 kg	4,5 kWh/kg	18,252	6%	1,095 kWh/y
Improved firewood stoves[69]	4,056 kg	4,5 kWh/kg	18,252	15%	2,737 kWh/y
Biogas from 2 cows	427 m^3	6 kWh/m^3	2,562	54%	1,384 kWh/y

- Furthermore, the NDBP will have to consider lighting issues – as it will be discussed in Chapter 5.2. With improved lighting provided by biogas lamps another impact might be the prolonged study time available for children after sunset.
- Looking into the future development of national livestock policies, the programme "One Cow per One Poor Household" could be considered as a long time support for raw material production for biogas generation. Cows are able to give birth once a year if they are well fed. If good quality fodder and water are sufficiently available, the number of cows per family might increase rapidly within short delay. Even if a certain percentage of these families should not be able to keep the

[68] According to FAO 2004, one cow in Rwanda equals to 0,9 Tropical Livestock Unit i.e.200kg animal live weight; 1 TLU produces 237m3 biogas per year

[69] Conversion efficiency value average from literature: TaTEDO 2005: Rural Energy and Stove Development in Tanzania

offspring or have within a few years at least 2 cows and the capital to invest in a biogas plant, it can be assumed that thanks to the training support of HEIFER INTERNATIONAL PROJECT, LUTHERAN WORLD FEDERATION and others, a considerable number of households will be enabled in the long run to improve their energetic and agricultural conditions.

- In Gatsibo district, cattle raising is different from the other surveyed districts not only in the number of cattle owned, but also in stabling practices. Only 60,3% of the surveyed households practice zero-grazing in Gatsibo, and stables and cow herds are further away from the owners houses. Even though, conditions in the western sectors of Gatsibo district are already favourable for NDBP activities
- The majority of farmers practice small scale subsistence agriculture applying animal manure as fertilizer on their fields. In the survey 65% of them estimated their total available agricultural surface up to 2ha during 2 seasons (i.e. 1ha land) for subsistence and market production. Since the NDBP is aiming at supplying the farmers with improved fertilizer i.e. the bio slurry leaving the biogas plant, the fertility on these small plots will be improved. Even though it remains to analyse,
    - how easily farmers will adopt fertilizing techniques with liquid slurry instead of dried cow dung,
    - how much additional food can be produced through improved organic fertilising,
    - how much additional income can possibly be earned if the available agricultural surface remains very limited.
- 67% of the surveyed households have been found to be at an average distance of up to 3km away from basic infrastructure institutions. This indicates that most of them should be in a reachable distance for potential construction companies. Nevertheless the NDBP should take into consideration that most of the surveyed households are not located within village centres but rather dispersed.
- In the context of national settlement policies, the foundation and improvement of centralized infrastructures in “imudugudu” aims to move rural households from the hills into villages[70]. It is not yet clear if farmers will be allowed to take their animals with them when moving, or if the animals have to be kept on the hills. This decision is crucial for the NDBP as the production of biogas raw material (cow dung), the generation of biogas (biogas plant) and the use of the gas (kitchen and house) need to be in short distance from each other.

[70] MINECOFIN EDPRS Draft 08/2007

- NDBP further aims to reduce the workload on households, who do not have to spend time collecting firewood once the biogas plant is functional: an in-depth analysis of sharing work and responsibility in the applicant's household is therefore a must, as gender roles and tasks are not always distributed in the same way.
  - The task of cooking will be considerably made more healthy, easy and comfortable. It might also reduce the hours spent cooking because lighting a biogas stove is less time consuming, than lighting wood, and once lit, the biogas flame burns without requiring the periodical addition of fuel like a wood fire. One more advantage is the immediate and constant heat production of the biogas flame. Since the average household is currently cooking for 4 hours a day, the NDBP needs to provide enough gas to satisfy these cooking needs if wood is to be substituted completely; in this calculation a reduced cooking time has to be considered as effect of the higher heat efficiency of biogas compared to firewood.
  - Collecting firewood is a task for the whole family, but mainly for paid workers. That means the reduction of workload will evenly be distributed on family members and workers. The time saved per day will be up to an hour in 70% of all cases. The consequences on work distribution and potential changes in employment should be discussed with the household in advance.
  - Fetching water for the household is mainly a task of children and workers. Because additional water will be needed for a biogas plant, the workload of children and workers to fetch water will increase. So far it cannot reliably be estimated how much more time will be spent on fetching additional water though, as the amount of additional water depends on the amount of dung to be mixed with. NDBP should further look out for alternative mixing agents like urine or grey water from food preparation in order to reduce the amount of additionally required water.
- It remains to be seen for what purpose the additional available daily time will be used, or how much of it will be needed to fetch additional water. Since agricultural surfaces are limited it is unlikely that more hours can productively be dedicated to agricultural cultivation if not intensification can take place and increased involvement in the markets. It is more likely the productive and economic benefits will derive from extending the working day through providing improved and additional lighting, which will enable household members to use the hours after

sunset for homework: for studying, producing handicrafts, tailoring, and domestic chores.

5.2 Energy demand and supply

5.2.1 Current situation

Economic development and poverty reduction depends on affordable and sustainable access to modern energy facilities. Only 5% of the population is connected to the grid and 60% of these live in Kigali. VISION 2020 is the Government's development agenda focused on achieving economic growth and on poverty reduction. EDPRS is the medium term programme 2007 to 2011. Energy policy is centred on[71]:

- achieving better use of energy resources, and
- harnessing energy resources to improve living conditions and human welfare

Energy demand at household level in rural areas of Rwanda focuses on cooking, lighting, information and entertainment, productive and transport purposes. Asked for their energy needs and energy sources acquired for their satisfaction, the sampled households listed their priorities corresponding to the countrywide situation in rural households where wood is the staple fuel and environmental disaster looms as deforestation continues[72].

Table 14: Main energy sources used for different purposes in rural households(%)

Energy source	Cooking	General lighting	Lighting for education	Produc-tive use	Entertainment / radio
Electricity	0.2	6.6	2.4	0.4	1.3
Candles	0.3	**24**	4.2	0	0.2
Dry Cells	0.3	**33.1**	0.4	0	**84.6**
Kerosene	0.7	**92.5**	**21.6**	0	0.4
Wood	**99.5**	0.5	0.1	0	0

In view of their importance as energy providing materials and systems charcoal for cooking and Solar Home Systems for lighting are neglectable. There is no or only low external energy use for productive activities; this indicates that the main energy input for productive use is human and animal power. It becomes further obvious that

[71] IFAD: www.ruralpovertyportal.org/.../rwanda E1.doc, 2007
[72] See Footnote 71

transport fuels like diesel or petrol are not really a concern for the sample households, as most of the rural households do not own motorized vehicles. If they do so, they already belong to one of the upper quintile[73] or economic stratum.

Given the predominating fuel demand for cooking, lighting and information needs, the following analyses concentrates on firewood, candles, kerosene and dry cells as most important energy sources for rural households.

Firewood demand and supply

Households apply a variety of units - fagot, tree and ster - to measure their daily, weekly, monthly and yearly firewood consumption. The data given by the sample households about their firewood use have been converted in kg. Eucalyptus is the most commonly used firewood in Rwanda[74] and literature values have been applied for weight and volume conversion[75]:

- 1 fagot = 20 kg; 5 fagot = 100 kg
- 1 ster = 350 kg; 1 tree = 2,450 kg
- 1 ster = 1 m^3 well packed wood = 0.56 m^3 bulk (loosely packed) wood

The statistical total average of firewood used per month by the sampled households amounts to 338kg or 11.3kg per day and household. Calculating with 7 persons per rural household the average firewood use per day and capita counts for 1.61kg. This corresponds closely to the country data of 1.93kg/cap/d[76]. Although this may be a surprising result, only 67% of the households use up to 350kg, which corresponds to the officially estimated amount[77]. About 30% of the households in the sampled districts use more than 500kg firewood per month.

[73] Definition Quintile: A method to measure the mean household income of residents, ranking them from poorest to wealthiest, and then grouping them into 5 income quintiles (1 being poorest and 5 being wealthiest), each quintile containing approximately 20% of the population. The income quintile measure is derived from census data. Income quintiles are often used as a proxy measure of socio-economic status.
[74] http://perso.orange.fr/mhalb/kivu/de/de_3g_pfunda.htm: Energieversorgung der Teefabrik Pfunda
[75] Deutsches Institut für Wirtschaftsforschung (DIW), Berlin, 2000, in “Energiedaten 2000” Herausgeber Bundesministerium für Wirtschaft und Technolgie (BMWi)
[76] SNV: Feasibility Study for NDBP Rwanda, 2005
[77] Information given by Silas Ruzigana, MININFRA, on 12-09-2007

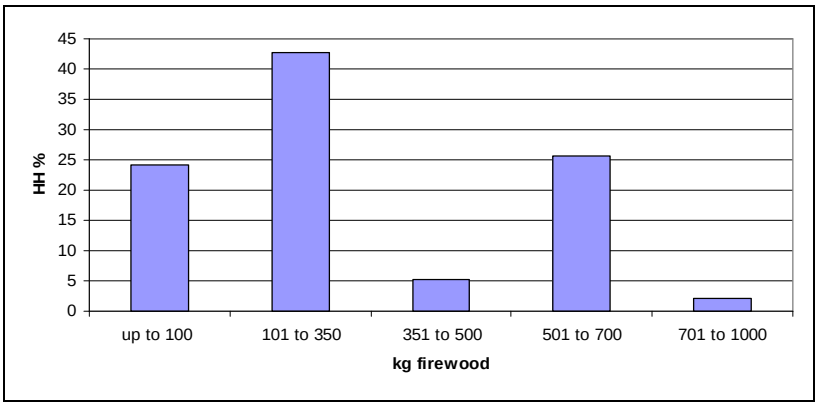


Chart 13: Consumption of firewood per month

This dependency on firewood creates an unsustainable situation as the demand with at least 1,6kg/cap/day largely surpasses the production of 0.46kg/cap/d[78]. In view to environmental protection and anti-erosion the government is trying to curb the rate of deforestation amongst others by banning the felling of trees without a permit. This rule applies to all trees including the ones in privately owned forest.

70% of the households collect firewood, and about 30% use several ways to provide their home with fuel wood for cooking.

Table 15: Main firewood sources for household supply (%)

Means of purchase	Households (%)
Only collected	70.3
Only delivered	6.4
Only purchased on market	8.5
Only from own forest	0.6
Other sources or variety of sources	14.2

Distance to firewood sources varies between 0km in case of delivery and estimated 10km in case of collection, resulting in an average of 1.5km to walk for firewood provision, i.e. 0.75km each direction.

[78] SNV: Feasibility Study for NDBP Rwanda, 2005

Table 16: Distance to and from firewood sources

Distance to and from firewood source	Households (%)
1m – 100m	16.3
100m – 500m	26.3
500m – 1km	26.8
1km – 2km	17.3
2km – 5km	10.9
> 5km	2.4

Firewood costs

67% of the households do not pay for firewood. In 32% of the surveyed households costs for firewood supply are part of household's basic expenses. This includes costs for workers who collect the firewood for the household. Expenses for firewood are analysed in Chapter 5.4 based on data given by the surveyed households and according to their means of firewood supply.

Problems with firewood supply and use

Households stated a number of problems concerning firewood supply for daily cooking. The most heard difficulty (56%) referred to indoor air pollution due to smoke.

Table 17: Problems with firewood supply and use

Problems	% stated by households
(1) Difficult to obtain	18.8
(2) Very expensive	24.8
(3) Complicated to use	26.8
(4) Indoor air pollution due to smoke	56

The listed problems are related to the governmental policy concerning deforestation (1 +2), and the use of freshly cut wood (3 +4).

However, up to now firewood resources are available throughout the year, with local shortages in specific cases. Regarding the development in availability of firewood producing forest resources, the interviewed households expressed very

heterogeneous experiences: 13.5% estimated a decrease, 35.8% an increase, 28.3% didn't notice any change, and 22.3% had no opinion about forest resources. The problems encountered with forest resources have natural and men made reasons. The competition between agricultural and forest land use becomes obvious in answers like "trees destroy the fields", "trees affect soil fertility" and "no land for new forests". But there is also a broad awareness on forest protection needs, presented in answers like "forest are still too young to be cut", "not enough tree nurseries", "wood thieves", "insufficient forest and firewood".

Energy demand for cooking needs

The current cooking fuel demand in rural households is driven by up to three cooking sessions per day.

Table 18: Frequency of meals, warm meals and cooking sessions

	Once (households %)	Twice (households %)	Thrice (households %)
Meals per day	3.0	45.3	51.3
Warm meals per day	2.6	49.7	47.2
Cooking per day	3.0	45.3	51.3

Currently, the statistically average time required for cooking sums up to 4.17 hours per household.

Cooking fuel demand depends also on the method of preparation applied for specific food. Beans, tubers, cereals and other vegetables are mostly boiled or fried in oil in a pot, often without cover in order to allow frequent stirring and control. Furthermore it is still not very common to soak beans in water before cooking them, a technique which could significantly reduce the required cooking time and fuel.

Table 19: Selection of most important cooked foodstuff in sampled households

Food stuff	consumed by households %	Average quantity consumed per month per household (kg)
Sorghum, maize, rice	89.7	27.8
Sweet potatoes, manioc potatoes	98.8	126.75
Vegetables	84.0	29.98
Plantains	83.36	62.0
Beans	98.4	25.2
Meat		8.4

Food stuff	consumed by households %	Average quantity consumed per month per household (kg)
Beef	59.0	
Goat	11.7	
Pork	0.9	
Chicken	5.9	
Rabbit	2.7	
Sheep	1.3	

Firewood consumption and energy efficiency is greatly influenced by the stove or cooking device used for food preparation. Households are using several stoves for cooking, not only one type of stove for all kind of food preparation. The current distribution is shown in the following table.

Table 20: Rate of diversification of stoves used by households for cooking

Stove	<100% used by household	<75% used by household	<50% used by household	<25% used by household	<5% used by household
Traditional stove	26.76%	0.81%	2.07%	2.71%	0.54%
Improved stove	68.81%	1.63%	1.63%	0.99%	0.00%
Biogas stove	0.00%	0.00%	0.00%	0.00%	1.00%
Other cooking devices	0.45%	0.00%	0.18%	0.72%	0.18%

The efficiency of the stoves varies according to construction material and quality: traditional stoves perform a maximum efficiency of 10%, improved stoves work at maximum with an efficiency of about 30%[79]. The percentage of distribution and use of improved stoves by far the majority of households in the surveyed districts indicates further that the rural population is already aware of the wood resource depletion and the need to use the resources efficiently.

LPG is not a real alternative fuel for rural households: the distribution network outside of Kigali is almost inexistent.

Energy demand for Lighting and entertainment

As night falls at 6 pm, lighting and entertainment needs, i.e. information by radio and TV are quite pressing. Lighting needs are currently covered by a variety of energy sources like candles, torches powered by dry cells, and kerosene lamps; their use is

[79] TaTEDO: Rural Energy and Stove Development in Tanzania, 2005

directly related to in-house pollution which causes respiratory and eye problems. Energy needs for entertainment (esp. radio) are covered by dry cells and in some cases by car batteries.

Table 21: Energy sources for lighting and entertainment

Energy carrier	Households (%)	Average of quantity used per household per month
Candles	24.5	10.50 pieces
Dry cells	84	7.46 pieces
Kerosene	93	4.69 litre

All households declared expenditures for lighting energy. Price of kerosene per litre is about 1USD resulting in an average annual expenditure of 57USD per household. In contrast to the data quoted in the Feasibility Study 2005, none of the households mentioned oil as energy source for lighting[80].

1m^3 of biogas can give as much light as a 60-100 Watt bulb for 6 hours[81].

5.2.2. Energy demand and supply: Aimed impact, and lessons learned on challenges and opportunities for the NDBP

One of the expected results of the NDBP is focussing on the saving of conventional fuel sources, mainly firewood and kerosene.

Household biogas plants are basically constructed to contribute to energy provision for cooking and lighting. The biogas plant therefore has to deliver up to 3 times during the day sufficient gas to substitute as much firewood as possible. The level of potential substitution depends also on the food stuff and the way it is prepared.

For boiling water and food, appropriate energy and time saving cooking techniques should be taught to the food preparing responsible women and men (see details in Chapter 5.1), like soaking beans in water before cooking, and covering the pot when not stirring the food. These aspects of user training are still missing in the training material prepared by NDBP. However, the introduction of biogas stoves as modern cooking devices seems to be facilitated by the fact that households are already used to vary the stove type according to food preparation.

The energy objective of NDBP relates also to the protection and saving of natural forest reserves from being cut down and burnt. According to the data given by

[80] SNV: Feasibility Study for NDBP Rwanda, 2005: *"Throughout the entire country, the main sources of lighting energy are oil (64%), wood (17.5%) and kerosene (10%). Even in Kigali city, only 37% of the households use electricity (2002 population and housing census)".*
[81] Pace Project Action Sheet 66: Biogas; www.paceproject.net

NDBP[82] 1m^3 biogas will replace 5.5kg firewood as fuel for cooking; firewood saving therefore results in 2,348.50kg per year if the household generates biogas from the dung produced by 2 cows. If combustion efficiency of the biogas stove is perfect, the statistical average amount of 338kg per month of firewood burnt per household could be replaced at about 60% by biogas, or one average tree per year could be saved by each family. [83]

Concerning the efficient use of available energy resources, the NDBP is challenged to consider basic information on these topics in its training courses to technicians and users. Especially in cases where households do not need to pay for firewood, the level of ignorance of the interrelation of resource depletion and resource wasting should be significantly lowered during the programme period.

Having clean and bright light makes an enormous difference in everyday life. Particularly children will benefit from the light, as they will be able to read and write without disturbance of fumes or fear of fire.

The financial benefit to households associated with biogas lighting will be caused by the reduction in kerosene expenditures, which are assumed to decline by 75%[84].

5.3 Water, sanitation & health

5.3.1 Current situation water supply

Water supply is crucial for well being and health, but also for agricultural production and livestock keeping. In rural areas to be targeted by the NDBP, households supply themselves, their animals and gardens from different sources with the needed water. The mean quantity fetched per day and household is about 130l, which seems to be quite high compared to official data estimating the daily water consumption at about 8.15 litres per inhabitant in rural areas[85]. The data given by sampled households correspond approximately to the international standard of 20l/cap/d, but these water amounts include also water for cattle kept in zero-grazing.

[82] SNV Trainee's Manual for Training of Trainers for Construction and Supervision of Biogas Plants, 2007
[83] Energieportal www.energieportal24/de: 1 ster corresponds to (1) 1m^3 of well packed wood, (2) 0,56 m^3 of bulk wood (loosely packed wood), (3) about 350 kg firewood (eucalyptus); 1 tree is counted for 2400 kg of firewood:
[84] Winrock International: Cost-Benefit Analysis Biogas, 2007
[85] USAID Eastern and Central Africa 2005; www.ecatradehub.com

Table 22: Average quantity fetched per day and household from different sources

Water source	Average (l)
Public tap	130.39
Protected source	118.85
Bought from vendor	143.33
Electrogaz	201.19
River	91.54
Unprotected source	108.00
Bore hole	123.57
Well	129.93
Swamp	108.08
Rainwater	133.69

Depending on the water source, the fetched quantity varies significantly: the closer and the cleaner the water source, the higher is the used quantity.

To reach appropriate water sources, households have to travel (back and forth) a mean distance of about 1.3km. As described in Chapter 5.1 mainly children and worker accomplish the task of fetching water. The following table lists the wide range of distances from houses to water sources.

Table 23: Distance to and from water source

Water source	Average distance back and forth (km)
Public tap	1.10
Protected source	1.57
Bought from a vendor	0.68
Electrogaz	0.25
River	1.41
Unprotected source	1.75
Bore hole	2.89
Well	3.71
Swamp	1.45
Rainwater	0.02

Households have to pay for water provision from vendors, protected sources, public taps and Electrogaz. At protected sources the price per 20-l-jerrycan is at 20 FRw. However, it depends largely on the willingness of the users, if they pay the correct sum to the sector office. In fact, people are paying for obtaining water from all kinds of sources because the expenses for water from sources like rivers or swamps include worker's charge for fetching water.

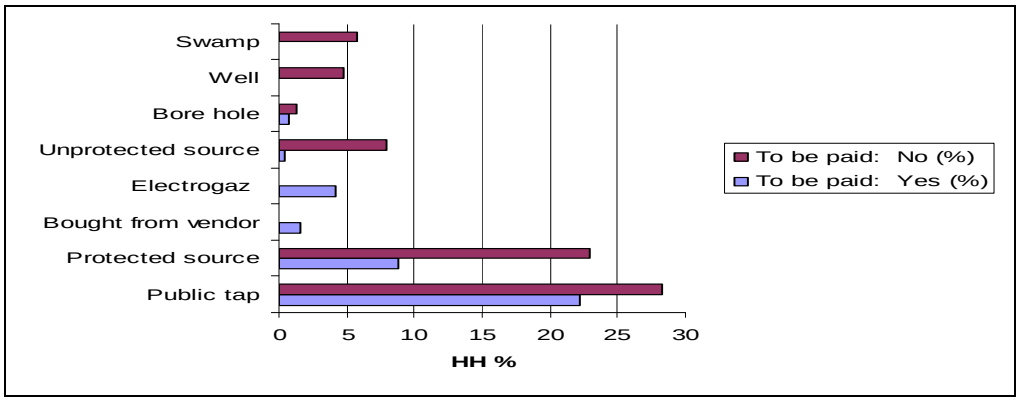


Chart 14: Payment for water

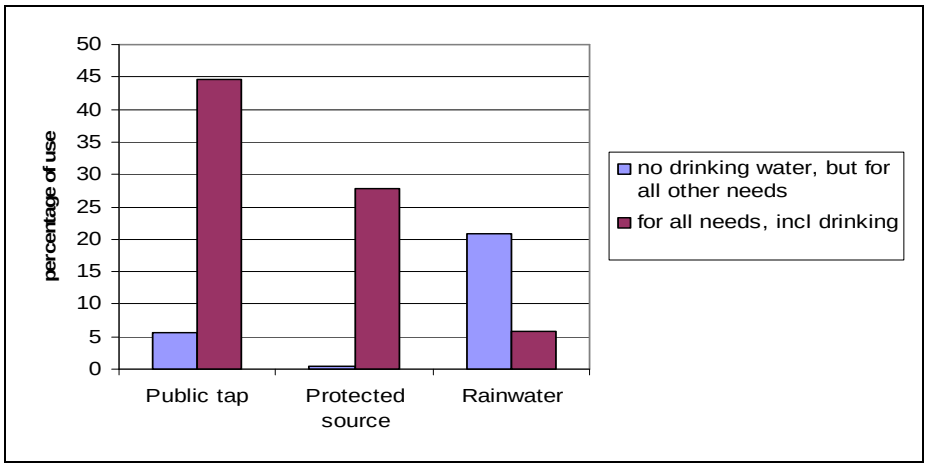


Chart 15: Use of water from different sources for different purposes

Rural households are not satisfied with the local water supply, because provision requires a lot of work and also money. Besides, the available water amount and quality is said to be in some cases unsatisfying.

Table 24: Degree of satisfaction with water supply

Degree of satisfaction	Percentage
Less than satisfied	62.0
Satisfied	32.7
More than satisfied	2.6

5.3.2 Water supply – challenge and opportunity for NDBP

Water is not that accessible in rural Rwanda. This is very important for the NDPB because the selected biogas system will require a certain amount of water each day according to information given by people responsible for the programme. According to the NDBP Training Manual, the mixing ratio of dung to water should be 1:1, i.e. 20 kg dung mixed with 20 litre of water.[86] A challenge for NDBP will be to motivate the farmers to fetch additional water, or to initiate employment creation to supply biogas plant owners with daily required water amounts. Considering time, distance and expenditures already spend for water supply it is to assume that most of the households will encounter problems to accomplish this technical guideline. Furthermore it has to be considered by the programme that water fetching – if not done by workers - is a daily task of the household's children. Increasing water demand will probably increase their workload.

Ways out of this "water trap" are indicated in the programme's Feasibility Study where urine is mentioned as mixing agent[87]. The efficient use of animal urine would implicate (1) to seal the stable floor in order to collect the urine, and (2) to connect the biogas plant directly with the stable.

Furthermore, it is recommended that the NDBP enters in a strategic alliance with the Rwanda Rainwater Harvesting Association promoting rainwater harvesting at household level. This could improve the availability of clean and free water in rural households. The association is represented by the Directorate of Water & Sanitation at the MININFRA[88].

5.3.3 Sanitation, waste water and waste discharge

Toilets

Toilets or latrines – even at a very low standard – are already introduced in 99.3% of households in rural Rwanda. Improvement in sanitation technology is required to be

[86] SNV: Trainee's Manual for Training of Trainers for Construction and Supervision of Biogas Plants, 2007
[87] SNV: Feasibility Study for NDBP Rwanda 2005
[88] Contact in 2007 : Mr. Vincent de Paul Kabisa, nilerwa@dgnet.org

the next step to take in rural development, as only 38% of the households have access to hygienically and environmentally safe sanitation[89], and satisfaction with the current sanitation situation is not very high.

Table 25: Toilet situation

Toilet situation	Very good	Poor	Bad	Clean	Dirty	Smelly	With door	With window	With water	With hand washing facility
%	6,8	**56,4**	10,7	24,6	3,3	0,8	7,8	1,6	0,3	0,2

Connection to a biogas plant and the use of biogas and bio slurry produced from animal and human waste does not cause problems to the great majority. [90]

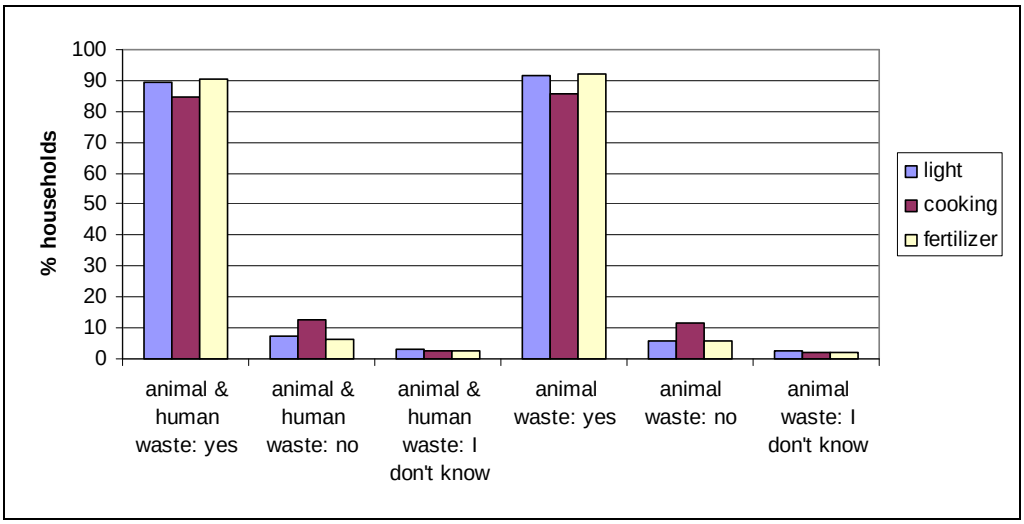


Chart 16: Opinions about connecting toilets to the biogas plant and the use of biogas for cooking and lighting, and bio slurry for fertilisation

Wastewater

Wastewater produced by rural households is commonly poured inside or outside of the compound or in pits. Reuse is practiced very seldom for limited irrigation of flowers, shrubs or trees in the compound (0.9%), for watering compost pits (2.9%), irrigation of vegetables (4.8%) or fields (5.9%).

[89] WHO 2007: http://www.afro.who.int/home/countries/fact_sheets/rwanda.pdf

[90] *It had been discussed with stakeholders, if extra subsidy of $ 50 – 100 for toilet connection to biogas plant should or could be considered.*

Table 26: Wastewater situation

Waste water discharge	Very good	Poor	Bad	Clean	Dirty	Smelly	Complicated	Convenient
%	4.1	35.6	1.0	51.6	2.8	1.0	0.5	0.4

Over 50% of the households have obviously no problems with the current waste water discharge system, while 35% judge the discharge as a “poor” system, creating breeding ground of flies and mosquitoes.

Solid waste

Waste produced by the households is handled in very different ways. Uncontrolled discharge of waste is not very common, but burning and burying is practiced for principally recyclable waste fractions.

The organic part is mostly re-used as fertilizer in garden and fields, with or without composting.

Table 27: Waste handling

	Waste			
Disposal %	Organic kitchen waste	Other household waste (paper, metal, glass, plastic)	Animal waste	Agricultural residues
Garden compost	39.5	8.0	25.5	26.7
Uncontrolled discharge	0.5	8.8	0.0	0.1
Burned	0.1	**43.7**	0.2	0.4
Buried	3.3	30.4	2.7	1.8
As fertilizer on fields	**88.5**	8.6	**93.8**	**86.5**
Reuse	0.6	1.0	0.8	10.9

5.3.4 Sanitation – impacts aimed by NDBP

When the family’s toilet is directly connected to the biogas digester, and cow dung is not littering the stable or compound floor, benefits of the biogas system include cleanliness and sanitation, with even broader impact on health improvement and – as side effect – increased production of farm made fertilizer.

5.3.5 Sanitation – challenges and opportunities for NDBP

As 99.3% of the targeted population has already constructed some type of latrine or toilet, NDBP can rely on this level of awareness and introduce further improvements in hygiene and environmental protection. Given the fact that malaria is wide spread among rural population the safe discharge of waste water should be an important topic in NDBP training courses for technicians and users, teaching them how to avoid breeding grounds for flies and mosquitoes.

Open, uncontrolled waste and wastewater discharge should be targeted, and reuse possibilities could be outlined according to local conditions.

It has been reconfirmed by the stakeholders that NDBP as programme will integrate aspects relating to livestock, energy, agriculture, and sanitation in order to contribute significantly to an improvement of the overall living conditions of rural Rwanda.

89.7% of surveyed households are willing to use energy generated from animal and toilet waste for lighting and cooking purposes. 90.6% of them are also willing to use the bio-slurry fermented from animal and toilet waste as fertilizer on their fields, although they are not yet used to it.

5.3.6 Health – current situation

Households have been asked to judge the health situation of their family. The results reveal that far most of the rural households feel healthy. According to official data, life expectancy for men counts 44 years, and for women 47 years[91].

Table 28: Opinion about household's health situation

Opinion on household's health status	Households %
Very healthy	12.8
Healthy with some days of illness	**80.3**
Very ill	6.7
I don't know	0.2
Total	100.0

Health problems and affected household members

Predominant illnesses in rural areas are acute respiratory infections, intestinal worms and malaria[92]. The present baseline survey underlines these results: it is obvious that children and women are mostly affected by these illnesses. It further reveals that

[91] WHO 2007, http://www.afro.who.int/home/countries/fact_sheets/rwanda.pdf
[92] WHO 2007, http://www.who.int/whosis/

whereas adult women are more affected by illnesses than adult men, in childhood the immune system to protect the organism against illnesses seems to be less developed among boys than among girls.

Table 29: Affected persons and main diseases

Illness	Affected persons (rank)	(% of incidence)
Malaria	1. son	(51.3%);
	2. daughter	(49.9%);
	3. wife	(43.2%);
	4. husband	(33.1%);
	5. others	(9.8%)
Intestinal worms and parasites	1. son	(25.6%);
	2. daughter	(23.4%);
	3. wife	(16.3%);
	4. husband	(12%);
	5. others	(3.1%)
Acute Respiratory Infections (ARI)	1. daughter	(16.3%);
	2. son	(15.7%);
	3. wife	(12.7%);
	4. husband	(10%);
	5. Others	(2.6%)
Eye infection	1. wife	(5.4%);
	2. son	(4.8%);
	3. daughter	(4.1%);
	4. husband	(3.5%);
	5. Others	(0.8%)
Stomach problems	1. wife	(6.7%);
	2. husband	(5%);
	3. daughter	(3.2%);
	4. son	(1.9%);
	5. Others	(0.6%)

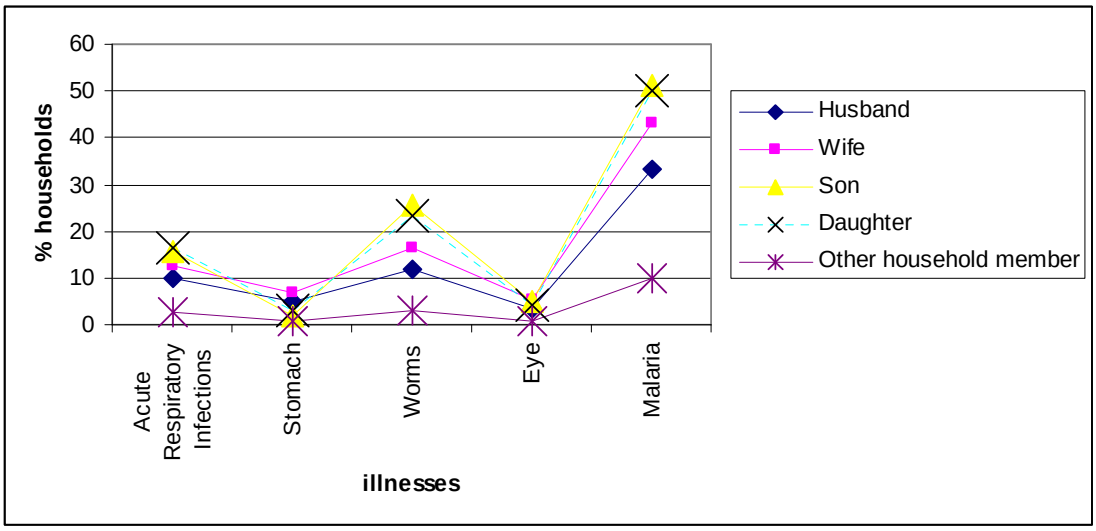


Chart 17: Main illnesses and affected household members

Treatment

To facilitate treatment in case of illness, families should be inscribed in a health insurance, mostly in the governmental sponsored institution “Mutuelle de Santé”. This insurance system relies on the community and the contribution families pay in advance and annually. By pooling their resources, all “mutuelle” members receive services at their designated health centre. Encouraged by the Ministry of Health, these mutual community based insurances are designed to enhance the performance of primary health care providers while reversing the low usage of services, especially family planning and reproductive health care, a trend due in large part to widespread poverty.

Table 30: Inscription in Community-based Health Insurance

Inscription	Household (%)
Yes	**96.0**
no	3.8
Missing	0.2
Total	100.0

Health centres and hospitals are mainly approached for disease treatments; household remedies are frequently used for respiratory, skin and eye problems. Pharmacies and private clinics are less represented.

5.3.7 Health – aimed impact by NDBP

Improvement of hygienic conditions, especially of women and children, by eliminating indoor air pollution and by stimulating better management of dung - the stable is cleaned and the dung fed into the digester on a daily basis - and night soil by toilet attachment to the biogas digester, NDBP tends to impact on rural health conditions.

5.3.8 Health – challenges and opportunities for NDBP

By far the majority of rural households cook with solid fuels, i.e. firewood, and use kerosene for lighting. Both fuels emit substantial amounts of important pollutants, including respirable particles, carbon monoxide, toxic organic and polyaromatic compounds[93]. Exposure to smoke from cooking fires is associated with Acute Respiratory Infection (ARI) and other health impacts. Globally indoor air pollution from biomass fires is estimated to cause 36% of all lower respiratory infections and 22% of chronic obstructive pulmonary disease, accounting for 1.6 premature deaths each year[94].

By introducing biogas as cooking fuel, NDBP is challenged to provide training for users – esp. for women - on improved kitchen management, including time reduction of cooking process and improved ventilation at the cooking place. As biogas burns smokeless, eye irritations and ARI illnesses should be significantly reduced.

By introducing biogas as lighting fuel, NDBP is challenged to provide training for users on safe handling of biogas lamps and a variety of benefit of bright light in the evening hours after sunset. According to experiences in other countries like China and Burundi a positive side effect of light from biogas lamps is the heat produced by the biogas flame, which increases the room temperature in cold nights.

Health of biogas owning households could be improved by changes in nutrition that could be induced by increased agricultural yields due to bio slurry application. NDBP is therefore challenged to integrate agricultural know-how in its training and extension activities.

In regard to sanitation, NDBP will have to consider existing toilet culture, and provide training to plant owning households for further sensibilisation on personal hygiene and environmental (groundwater) protection.

[93] WHO/USAID: The burden of disease from Indoor Air Pollution in Developing Countries, 2000
[94] GTZ ProBEC www.probec.org, review 04.10.2007

5.4 Household Economy

5.4.1 Current economical situation

The economical situation of the surveyed households is very important for estimating the actual market potential i.e. the ability of households to invest in biogas plants.

Assets

The surveyed households have been asked to estimate their economical position in comparison to their local environment: 76.2% estimate their position as economically average. Only 22.1% would estimate their households as being poor, while latest available figures from National Institute for Statistics found 60% of the households to be below the poverty line[95]. 1.7% of the surveyed households classified themselves as being economically fortunate. This might be due to the fact that only cattle owning households have been interviewed, but it seems also quite convincing that in the social environment of a low income population those who have just a little bit more than others judge themselves as wealthy. The following chart gives an overview over assets as indicators for the economical situation of the household.

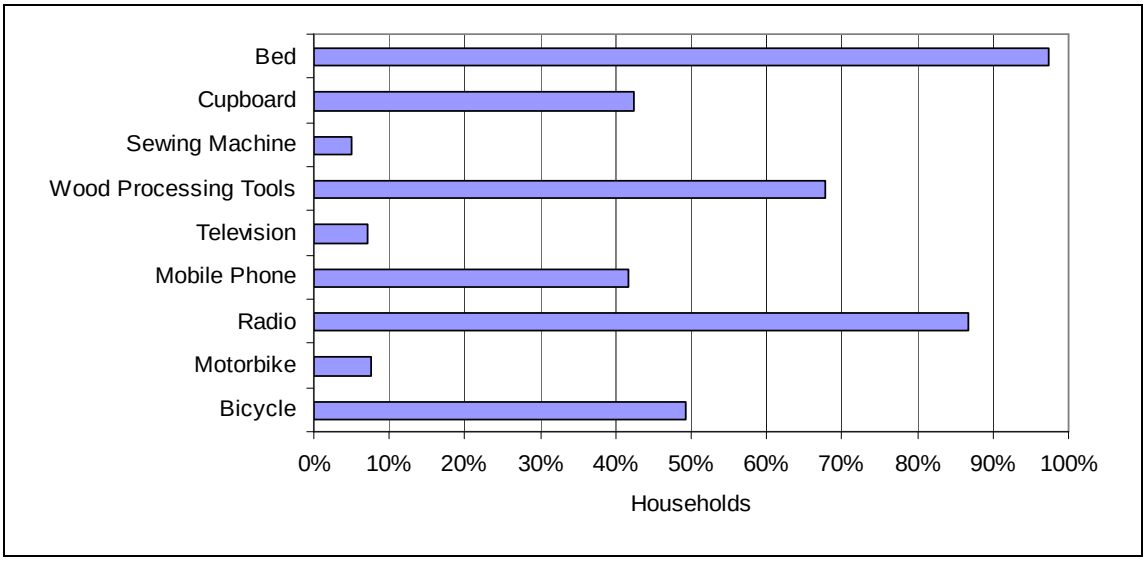


Chart 18: Assets owned by more than 5% of sampled households

By their values these assets represent a considerable amount of investment in durable goods. In order to give an indicator for the purchase power of the economic group targeted by the NDBP, prices for basic assets have been collected in Kigali and rural settlements resulting in those price ranges which are given in the following table. Regarding furniture prices it has to be taken in consideration that in rural areas

[95] NISR: Preliminary Results EICV2, 2006

furniture is often produced locally at a minimum price, and varies significantly in presentation and quality. Price research has been oriented on the quality experienced in rural households.

Table 31: Price ranges of main assets owned by sampled households

Asset	Price range
Bed	At least 5.000 to 15.000 FRw
Cupboard	At least 10.000 FRw
Sewing machine	At least 37.500 to 100.000 FRw
Wood processing tools	Depends on the degree of mechanisation
TV set	At least 150.000 FRw
Mobile phone handset	At least 15.000 to 150.000
Radio	At least 4000 to 6000 FRw
Motorbike	At least 500.000 to 1.000.000 FRw
Bicycle	At least 56.000 to 120.000 FRw

The following chart further illustrates the number of beds in the surveyed households as indicator for decent living; 3% do not own a bed but sleep on the floor. It is also practiced that all children in a household share one bed, so that not every household member sleeps in his own bed[96].

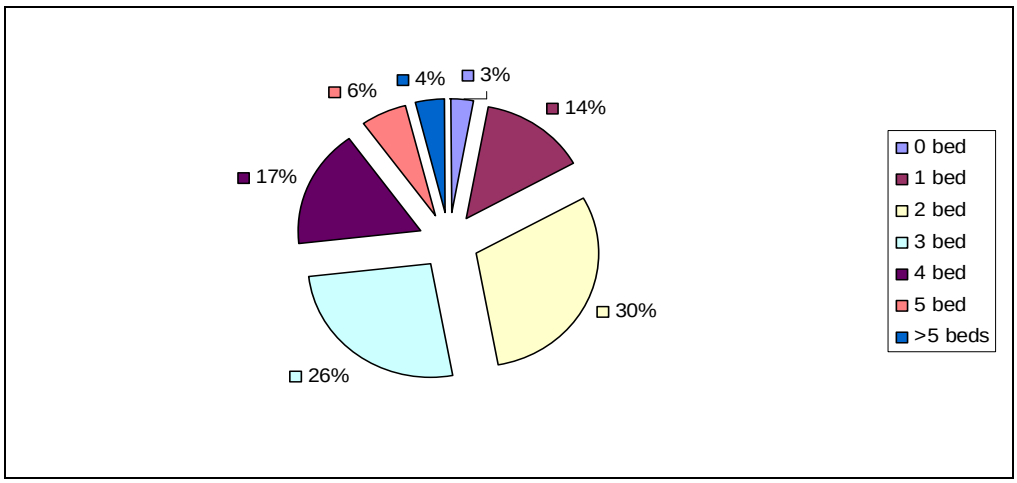


Chart 19: Number of beds per household

[96] Concerning the asset "bed" as meaningful indicator for household economy, local cultural perceptions have to be considered for further interpretation esp. during impact assessment

Income

Besides on ownership of specific assets, households have also been interviewed about their financial income in total, specific income from selling agricultural products, milk or animals, and from non agricultural work. This information has been compared with their data given on specific expenses for health, workers, cooking and lighting energy and water - among others.

76.9% of all interviewed households generate income from the sale of agricultural products; 67.5% earn from their livestock and 50.3% also have diversified their income sources by generating non-agricultural income.

The self-estimated monthly income is contrasted with the sum of all specific incomes mentioned, and the monthly expenses. The following table shows that the 3 different amounts do not match exactly. This might be due to mis-estimation by the farmers, their unwillingness to give exact information about their income or incomplete statements. Farmers also sometimes specify what they spent last month, even though that might not be representative for every month. The table still gives a rough idea about the income and expenditure range.

Table 32: Overview on income estimations (% of sampled households)

	< 25.000 FRw	**25.001 – 50.000 FRw**	**50.001 – 100.000 FRw**	**100.001 – 250.000 FRw**	**> 250.000 FRw**
Monthly Income – Self Estimated	52%	27.2%	14.2%	4.5%	2.1%
Monthly Income – Calculated Sum	45.2%	25.3%	19%	8.9%	1.6%
Monthly Expenses – Calculated Sum	33.6%	33.3%	25%	7.7%	0.4%

In order to locate the economic position of the interviewed households as sample for cattle owning families and potential participants and clients in the NDBP, the given income data have been screened with national economic data on income groups applying the “Base of Pyramid” model (BOP) developed by the World Resource Institute.[97] BOP advocates a new way of looking at markets – primarily focusing on the market represented by the 4 million consumers at the base of the economic

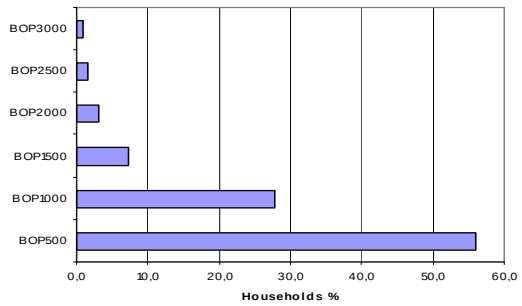
[97] World Resource Institute, 2007: The Next 4 Billion

pyramid worldwide. This approach enables to identify the size of the target group for market oriented economic development as one strategy for poverty reduction. While the development community has tended to focus on meeting the needs of the poorest of the poor — those people with purchasing power below USD1 a day, a much larger segment of the low income population both deserves attention and is the appropriate focus of a market-oriented approach as it will be applied by NDBP for country wide biogas system dissemination. These low income households constitute the so called "Base of Pyramid" or BOP economic segment of the country's economic pyramid[98].

The following tables and charts compare official national data with those obtained in the NDBP baseline survey in the sampled districts in order to check the appropriateness of the BOP concept for the NDBP; some specific recommendations for the NDBP market-oriented approach will be further developed.

Table 33: BOP Low Income Population in Rwanda

BOP(USD) per year	Total (mio)	Share (% of national rural)
BOP3000	0.1	0.9
BOP2500	0.1	1.5
BOP2000	0.2	3.1
BOP1500	0.6	7.3
BOP1000	2.2	27.7
BOP500	4.5	56.1
BOPtotal	**7.7**	**96.5**



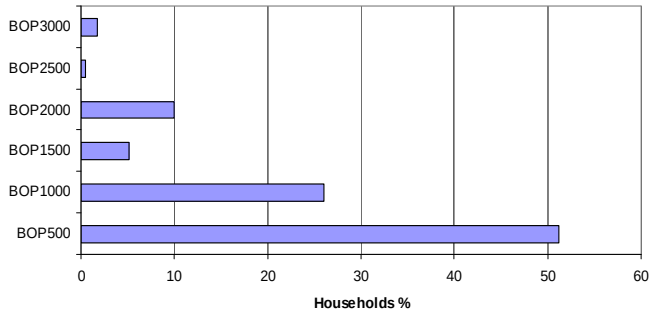
(WRI 2007, The Next 4 Billion – country fact sheet based on data from 2005)

Categorizing the households sampled in the NDBP Baseline Study results in the finding that 94.7% of the potential biogas programme target group belong to the country's BOP segment.

[98] Prahalad, Hart: The Fortune at the Bottom of the Pyramid, 2002

Table 34: Sampled households grouped according to BOP categories

BOP(USD) per year	(up to) FRw/month	% of sampled hh
BOP3000	150,000	1.80
BOP2500	125,000	0.50
BOP2000	100,000	10.00
BOP1500	75,000	5.20
BOP1000	50,000	26.00
BOP500	25,000	51.20
BOP total		**94,7**



Comparing official country data from 2005 with NDBP baseline data from 2007 leads to the conclusion that the economic conditions of the cattle owning target group of NDBP corresponds to and represents largely the living standard conditions of rural low income population in Rwanda. The following chart demonstrates the data performance:

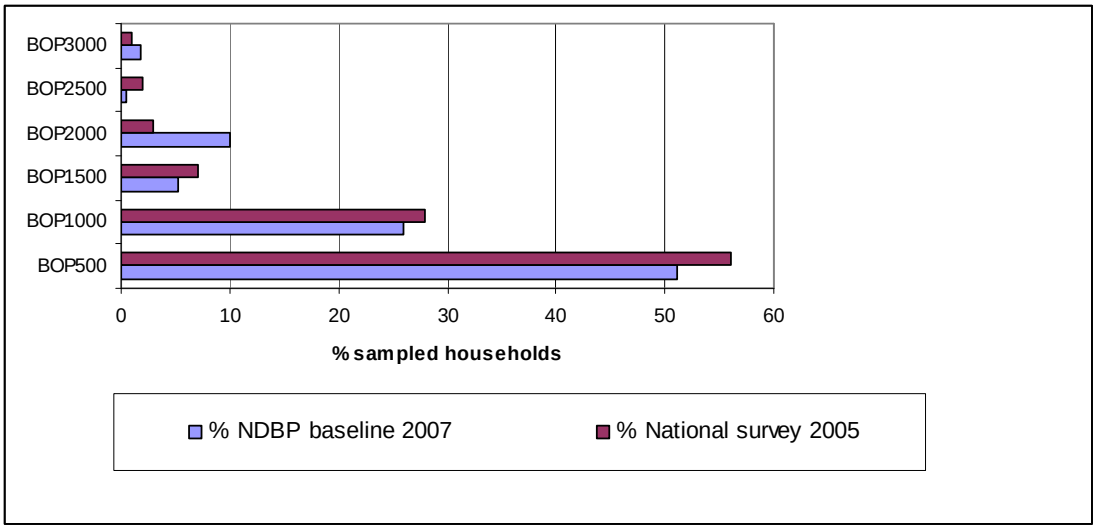


Chart 20: Comparison of national low income data and NDBP baseline sample

5.3% of the sampled rural households earn more than BOP level; this result further indicates that the baseline sample corresponds to national data, where 3.5% of urban and rural outside of the low income population has been identified. Slight differences in single BOP segments are probably due to the general limitations of income data collection. Furthermore these results demonstrate also the relevance of the baseline

sample for the NDBP at countrywide level. It underlines that income generation in rural areas in Rwanda is based on both agriculture and animal husbandry, and that cattle owning households rely on income from agricultural crop, too.

Expenditures

To be able to estimate potential savings or costs after installation of a biogas plant, current expenses for firewood, water and lighting energy are detailed below. Based on data analysis the chart demonstrates that all households have expenses for lighting, but about 67% do not pay for firewood and 60% do not pay for water.

By experience, reported households expenditures on energy should be regarded as a minimum estimate of actual expenditures, because surveys may not have collected information on all types of energy source spending[99].

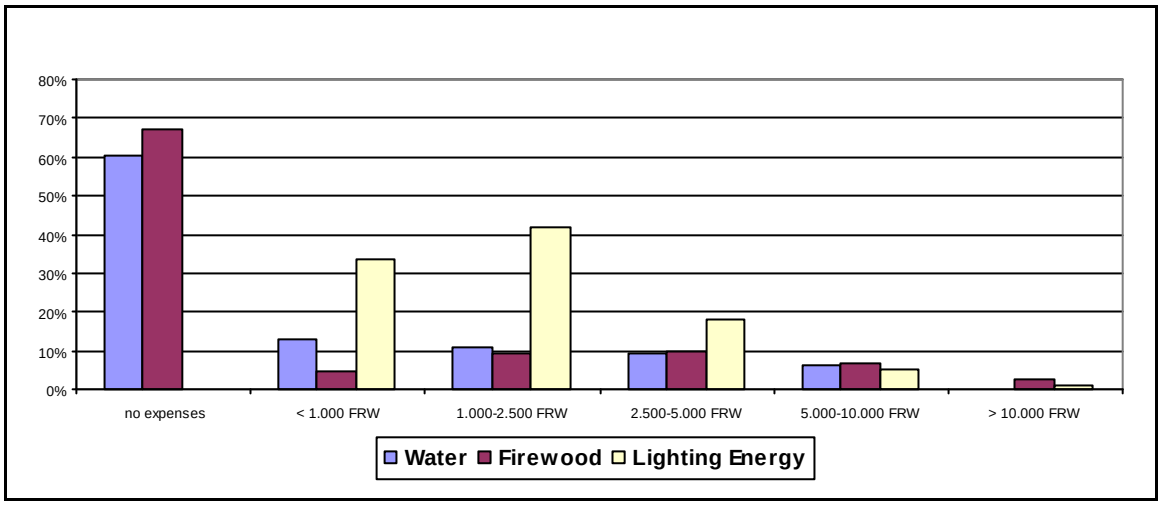


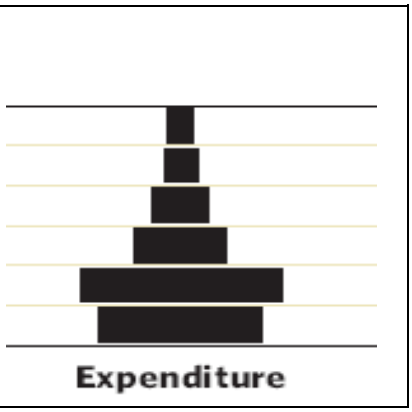
Chart 21: Expenses for energy and water per month and percentage of households

Applying the BOP approach for economic data analysis, expenditures from sampled households have been categorized according to income groups and compared to national data. The following table gives the official country data on expenditure from the different BOP levels. It can be observed, that 72.9% off all household related expenditures are performed by the low income population, and that the highest share of national expenditures is paid by the second lowest income group.

Table 35: Distribution of expenditures among BOP segments at country level (total and rural share)

[99] World Resource Institute, 2006: http://pdf.wri.org/n4b_chapter7.pdf

BOP(USD) per year	Total (mio)	Share (% of national)	Rural (% of segment)
BOP3000	222.6	3.2	14.1
BOP2500	305.8	4.4	29.3
BOP2000	488.0	7.0	52.3
BOP1500	820.4	11.8	80.2
BOP1000	1,789.6	25.7	92.0
BOP500	1,451.3	20.8	98.2
BOPtotal	**5,077.7**	**72.9**	**80.9**



(WRI 2007, The Next 4 Billion – country fact sheet based on data from 2005)

Data on household expenditures obtained by the NDBP Baseline survey are presented in the following table.

Table 36: Distribution of expenditures among BOP segments in NDBP Baseline Survey

BOP(USD) per year	Expenditures (up to) FRw/month	% of sampled hh
BOP3000	150,000	3.67
BOP2500	125,000	2.75
BOP2000	100,000	18.35
BOP1500	75,000	18.35
BOP1000	50,000	29.35
BOP500	25,000	15.59
BOP total		**88.06**

Comparing official 2005 country data and NDBP 2007 baseline data leads to the conclusion that the expenditure schemes of the NDBP target group corresponds in general to the distribution patterns of rural low income population in Rwanda. The following chart demonstrates the data performance:

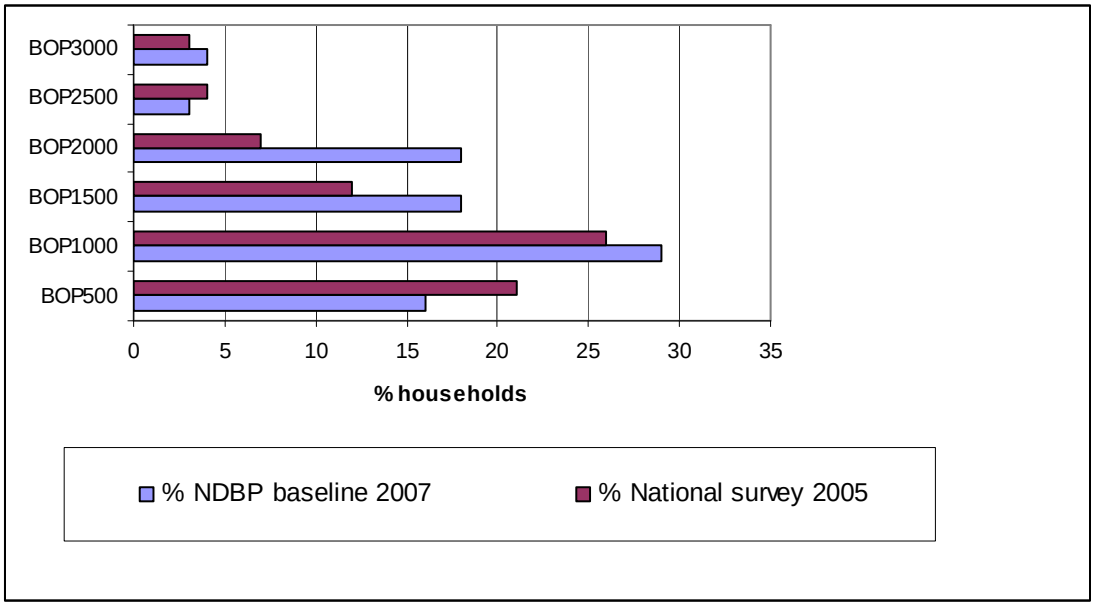


Chart 22: Expenditure patterns according to National Survey Data 2005 and the NDBP 2007 Baseline households

Credits

48% of the surveyed households have received a credit at least once. Out of these, 71.6% have received the credit from a bank while 22% have received it from their cooperative or village group. The following chart shows what the credit was used for:

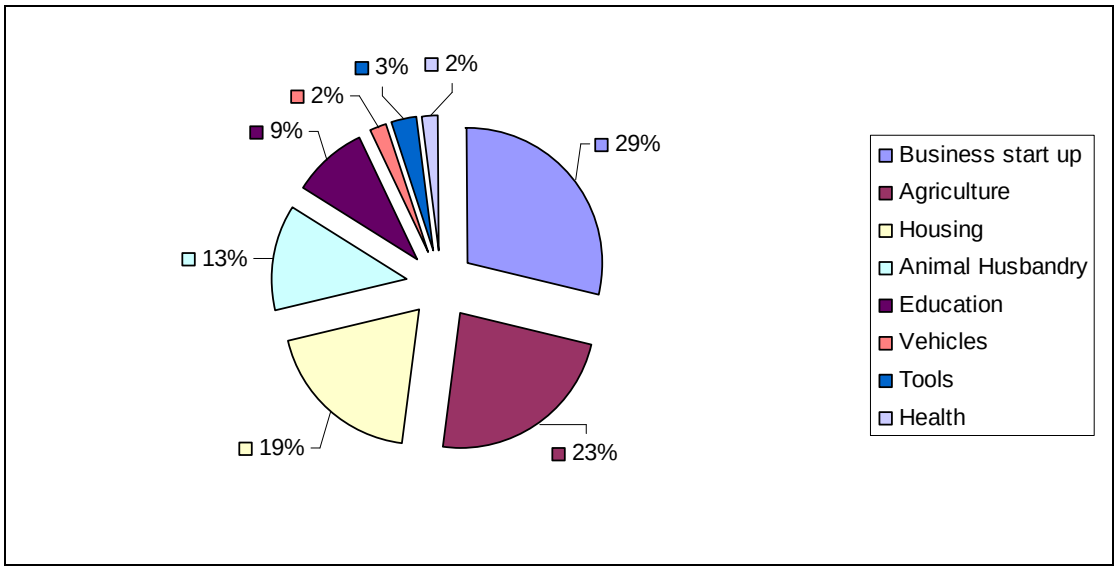


Chart 23: Use of credits

Business start up (29%), agriculture (23%), house construction (19%) and animals (13%) are by far the main areas people are willing to invest in and to ask for a credit. Since the NDBP plans to integrate a micro credit scheme for financing of the biogas plant, the baseline survey focussed also on the amount people are able to receive and repay, and on the required pay back period.

Table 37: Amount of Credit received

Credit (FRw)	1-100,000	100,001-250,000	250,000 – 800,000	> 800,000
Sampled HH	36.7%	18.3%	30.5%	14.5%

Table 38: Payback periods

Period	Up to 1 year	Up to 2 years	More than 2 years	Not yet paid back
Sampled HH	51.5%	27.4%	10%	11%

NDBP is currently in discussion with banking experts concerning the design of a micro credit scheme with payback periods of up to 5 years. Baseline data reveals that payback mentality among the target group is trustworthy, and that the time frame could be probably adapted to the credit amount required for financing of the domestic biogas plant.

Savings

77.3% of the surveyed households have a saving account. Out of them 80.9% keep it at a bank, 11.3% keep it at their cooperative or village group[100].

5.4.2 Aimed impact of the NDBP

The aimed impacts of the NDBP on the household economy can be divided into different aspects:

- Households can save expenses otherwise spent on firewood or kerosene;
- The time formerly spent collecting or buying firewood can be used for other activities;
- More hours a day can be used productively if the lighting situation is improved;
- Access to market for low-income households in the BOP segment as clients for services and goods, and as producers of food and fertilizer.

[100] *The baseline team didn't want to provoke distrust among the interviewed households; therefore the question "how many money do you have already on your saving account" has not been asked.*

Beyond the household level the NDBP aims at creating employment in rural areas in construction companies supplying the households with biogas plants and maintaining quality focussed after-sales services.

5.4.3 Lessons learned about challenges and opportunities for the NDBP

The data gathered on the household economy in the surveyed districts provides a baseline for estimating the market potential of the NDBP and for estimating the potential economic impacts on household level.

- The analysis of household's assets shows that 87% of the surveyed households own a radio and already 40% a mobile phone. This indicates that for the promotion of the NDBP emissions on radio and by modern communication means might be adequate tools. The current ownership of assets will serve as baseline to be compared in some years with the situation of households having invested in a biogas plant. If national data will be available at that time comparison should be made to countrywide trends.
- Data on monthly income and expenses on household level shows, that it is difficult to get exact and reliable data, because people tend to misestimate their income and expenses, or because they are not willing to share information on how much they earn and spend. However what have been learned from the sample, even if people in individual interviews estimate their expenses higher than their income, the statistic result correspond to official data on economic strata. This underlines further the individually expressed feeling of NDBP target households that there is no considerable amount of money left to spend at the end of the month after the regular expenses have been paid. It is therefore very important for the NDBP to promote biogas plants as a desirable good, from which the households will economically benefit in the long term.
- 67% of the sample households currently do not pay for firewood and only 19% of those 33% that pay for firewood spend more than 2,500 FRw per month to purchase it or to pay labourers to gather it. NDBP is challenged to emphasize not only the fact of economic savings on cooking fuel through installing a biogas plant, but also the reduction of time spent collecting firewood, and the long-term impact on the environment.
- It is also visible that a considerable amount of money is spent monthly on buying kerosene, batteries or candles to provide household lighting. The NDBP therefore should include lighting, i.e. the connection of gas lamps as a central offer of their Programme. This will make a biogas plant much more attractive because lighting

will not only be improved and probably available for more hours, but monthly expenses are cut down more visibly than through replacing firewood only.

- A challenge for the NDBP might be the fact that almost 40% of all households are currently paying for their water. According to the Training Manual of SNV[101] the feeding of a biogas plant requires additional water to be mixed with the cow dung. If households have to pay more for fetching more water, the economic benefit of the biogas plant will be significantly reduced.
- Since 48% of the sampled cattle owning households have already taken a credit once, it is likely that they are able and willing to take a credit again for improving their cooking and lighting situation if they are convinced of the advantages. The data also shows that 45% of households have already taken a sum of credit above 250,000 FRw which would be sufficient for a biogas plant at current cost[102]. The fact that 80% of the households already have general experiences with a bank either for saving accounts or credit purposes indicates that preferably a credit scheme for the biogas programme should be available through banks which are present or at least very close to the locations where biogas plants will be constructed.
- For successful promoting the biogas plants NDBP should not focus on direct economic benefits only, but to promote their installation as status symbols for development. A biogas plant might reduce costs for cooking or lighting energy, it might produce fertilizer, but above that it also conveys a message to neighbours about the progressive or modern attitude of its owner and his financial ability to buy a biogas plant. This might be an opportunity as well as a challenge for the NDBP: the programme could count on “model families” trying to impress their neighbours, but it might also mean that a biogas installation further widens the gap between them and poor families.

NDBP applies a market-oriented approach towards the large segment of the low income population, the so called “Base of Pyramid” or BOP economic segment[103]. BOP population segments are economically poor, and only at a small share integrated into the market economy. But most of these households are motivated to achieve a better life for themselves and for their children, as also stated in the

[101] SNV Trainee’s Manual for Training of Trainers for Construction and Supervision of Biogas Plants, 2007

[102] SNV Trainee’s Manual for Training of Trainers for Construction and Supervision of Biogas Plants, 2007
Further observation: prices for cement have increased within few months from 8,000 FRw/25kg bag to 11,000 FRw/25kg bag

[103] WRI 2007: The Next 4 Billion

following chapter. Providing biogas plants as technical solution to several environmental, energetic, economic and social problems of the rural low income population, NDBP could contribute significantly to improve rural livelihood systems by the integrated biogas system approach "livestock, agriculture, energy and sanitation" to

- meet needs specifically in sanitation and energy,
- provide income generation for craftsmen in construction and service,
- increase food production for both market and family consumption,
- strengthen local organizations through biogas training, information on related aspects, and micro financing schemes,
- protect local environment by reducing firewood consumption.

More reflection about challenges for NDBP in regard to economic development of its target group is related to the households' development plans, willingness and ability to investment in improvements, described in the following chapter.

5.5 Development plans, investments and expected impacts

5.5.1 Future plans and projects

Households have been asked for their own development plans – or five priority projects for the next years - thus providing to this Baseline Study a perception of urgent needs to be addressed. The existing ability and willingness to play an active role or at least participate in changes is a benchmark for intended improvements.

As first priority for future improvements the interviewed households listed improvements in livestock keeping (53%), lighting and cooking energy (15%), agriculture (11%), housing conditions (11%), sanitation, water, health (6%), and education (4%).

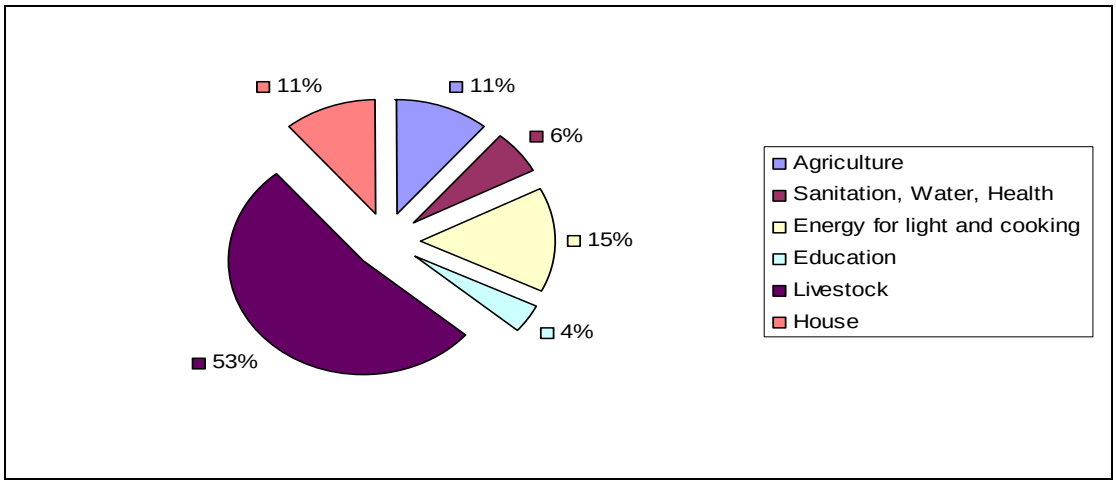


Chart 24: First priorities for rural household development

Within the second to the fifth priority improvement plan, lighting and cooking energy occupied prominent places. 86.2% of all interviewed households listed energy supply among its five most urgent priorities or needs; energy for lighting was given a higher priority than cooking fuel supply, as the following table and chart illustrate:

Table 39: Priorities in energy needs within the next years

Energy source or purpose	% households
Biogas	1,8
Energy	9,1
Lighting	41,2
Cooking fuel	34,1
TOTAL	86,2

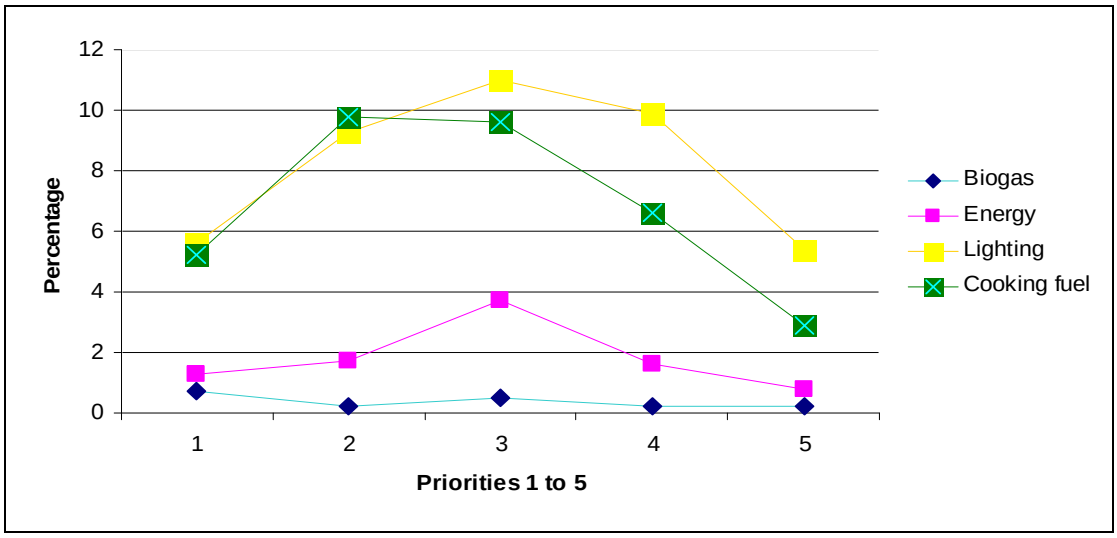


Chart 25: Priorities in energy demand

Other priorities listed on the second to fifth rank for future improvement are (1) agriculture and animal husbandry, (2) energy supply, (3) infrastructure esp. road access, and (4) water and sanitation.

5.5.2 Investments: willingness and ability

The willingness to invest in the projected improvements is obviously not at the same level as the financial ability. It is remarkable that the willingness to invest more than 500,000 FRw does not correspond to the financial ability in this segment, which could be estimated as to be in the range between 10,000 to 250,000 FRW.

If the ability to invest is cross-checked with the real purchase power indicated by currently existing assets in the households, the ability to invest in cash must be estimated at a low level, resulting in a median cash investment capacity of 30,000 FRw per household.

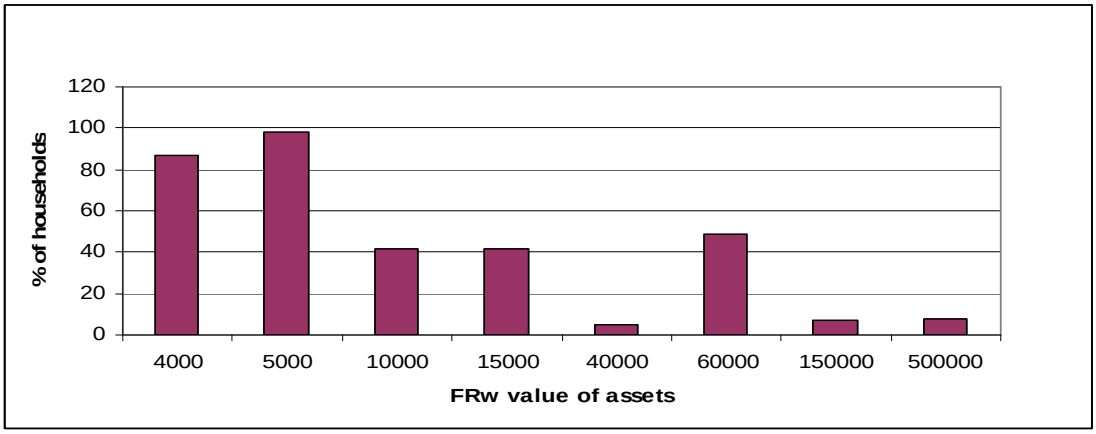


Chart 26: Financial value of durable goods as indicator for household's cash investment capacity

Apart from the lowest income group BOP500, which represents about 50% of the sample, data based investment capacity calculation per household rises at a median value of 98,000 FRw; separating the highest BOP segment, data based calculated investment capacity per household achieves about 500,000 FRw.

There is a remarkable large group of respondents, who did not specify the possible amount they would and could contribute to improvements, but 50% of them announced that they would contribute in labour and in material.

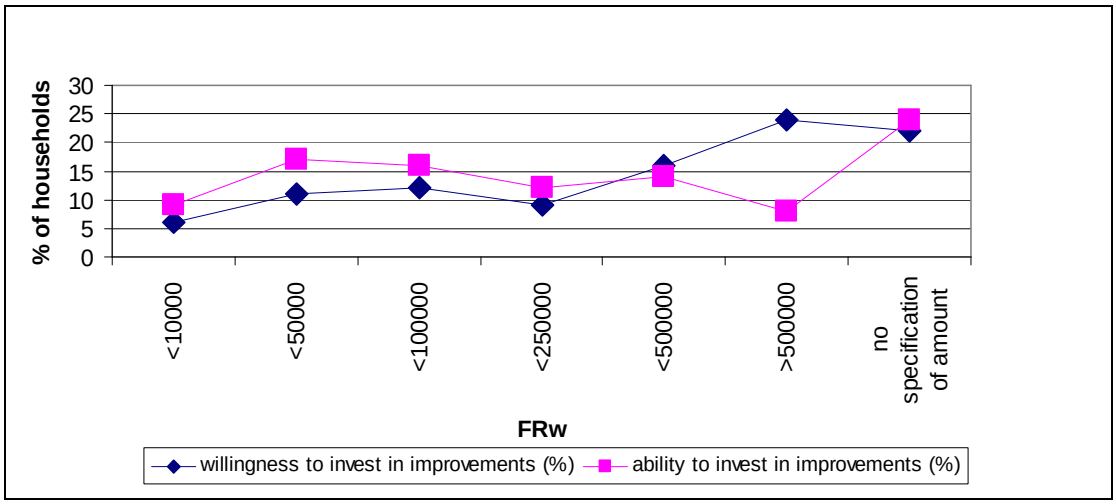


Chart 27: Willingness and ability to invest in improvements

Other than for the investment in general improvements, willingness and ability to invest in a biogas plant are matching in nearly 100%. Those respondents, who did not want to fix a sum of possible investment, offered work and material as their contribution to the plant set-up. This method of participation in project implementation is common in rural areas and corresponds to the financing alternatives already included in the proposal of NDBP.

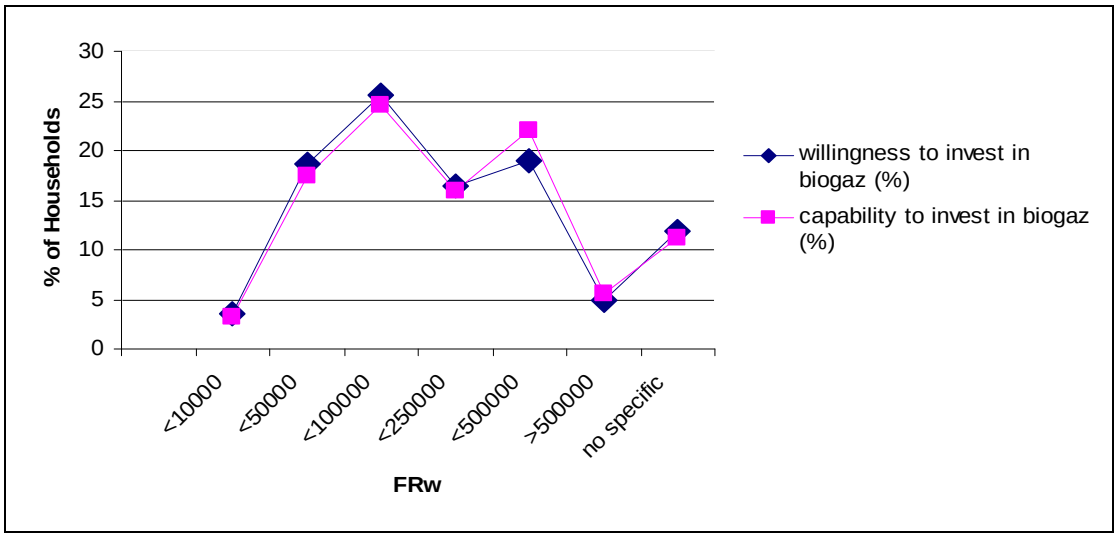


Chart 28: Willingness and ability to invest in biogas

To achieve the financial ability to invest in energy sources for cooking and lighting, 84% of the households are willing and ready to apply for credit.

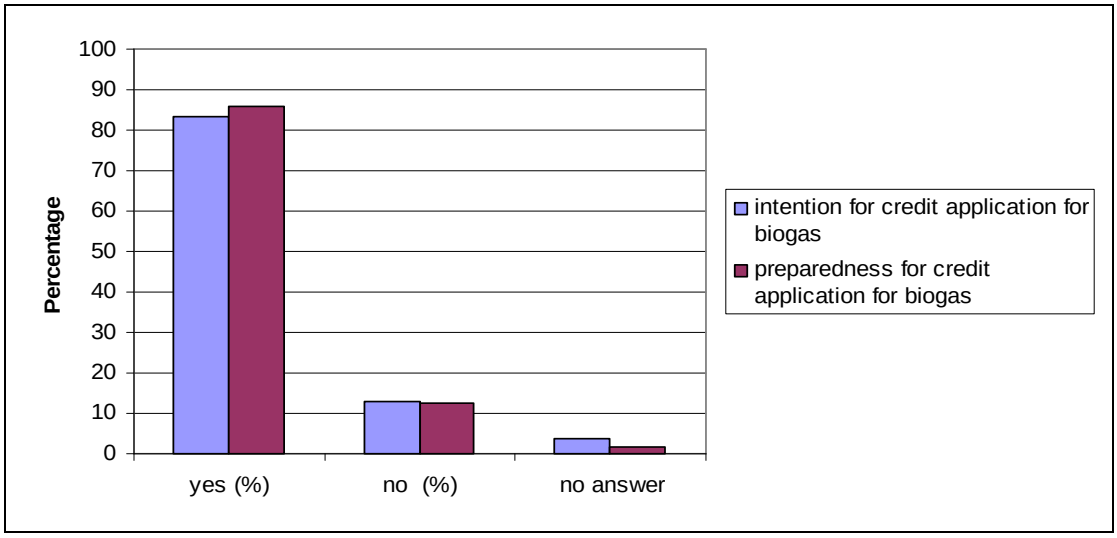


Chart 29: Intention and preparedness for credit application for biogas

The estimated necessary credit sum for the investment in biogas varies significantly, with its peak at 500.000 FRw. In case of application for a biogas plant, this aspect should further be cross-checked in detail with the economic situation of the specific households and the loan conditions of the involved credit institutions.

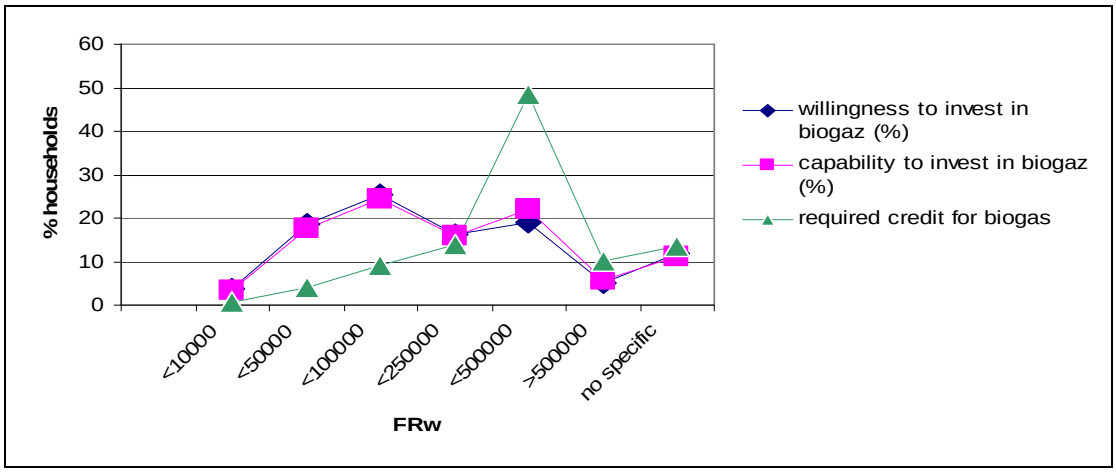


Chart 30: Willingness, capability and credit needs for biogas

5.5.3 Aimed impacts, challenges and opportunities for NDBP

NDBP aims at providing a significant improvement in the quality of life of rural families by establishing a sustainable and commercial domestic biogas sector and the reduction of biomass resource depletion. Skilled construction staff, job creation as contribution to local economic development and more convenience in the living conditions of rural households are intended outcomes of the programme.

In order to achieve its objectives and the aimed impacts, NDBP will be obliged to offer farmer households a range of reasons – financial, economical, social, environmental – why they should join the programme and invest in a biogas plant. A detailed and specific cost-benefit analysis facilitates the justification for programme supporting financial instruments like subsidies and micro credit schemes.

Estimates of Financial and Economic Internal Rate of Returns

NDBP should elaborate a simple calculation sheet that enables trained staff to calculate with the biogas applicant on-site the potential financial and economic internal rate of returns FIRR and EIRR. The following example of a generalized financial and economic benefit calculation is based on the value of 1 hour corresponding to an average of 0.25USD as the 1-hour wage for unskilled labour. All data about costs for a domestic biogas plant are based on information obtained from SNV. At present financial and economic aspects of domestic biogas systems include the following cost and benefits[104]:

[104] The categories and calculation follow the categories and formula given by Winrock International: Cost-Benefit Analysis Biogas 2007

Table 40: Financial costs (USD) of a domestic biogas plant

Average plant size	$6m^3$
Total cost of the plant	859 USD
Proposed subsidy	300 USD
In-kind contribution	86 USD
Annual repair and maintenance cost to households	12,9 USD
Net financial capital cost to household	473 USD

Economic costs include the total financial costs plus:

- Value of unskilled labour contribution
- Value of household time to operate the plant including collection of dung and water
- Cost of credit (if applicable)

In the following table data obtained from the NDBP baseline survey are combined with data and formulas applied in the basic economic calculation for the National Domestic Biogas Programme Rwanda presented by Winrock International in April 2007[105].

Table 41: Financial and economic value of direct and indirect benefits

Benefit **Data from Baseline (BL)** **Data from Winrock International (WI)**	**Financial value (USD) per household**	**economical value (USD) per household**	**Time Unit**
Fuel cost savings (BL)	*36.95*		
Savings in time for collection & cooking (BL)	*7.20*	*36.40*	*Per year*
Toilet access savings (WI)	*328.5*		*Total lifecycle*
Access to fertilizer (WI &BL)	*347.00*		
Increase in agricultural yield (WI & BL))	*5552.86*		
Health expenditure savings (WI)	*144.59*	*561.60*	
Health-related increase in productivity (WI)	*3.96*	*37.15*	
Value of Saved Lives (WI)	*6.73*	*5655.97*	
Lighting benefits (BL)	*405*	*427.57*	

[105] Winrock International: Cost-Benefit Analysis Biogas 2007

Benefit Data from Baseline (BL) Data from Winrock International (WI)	Financial value (USD) per household	economical value (USD) per household	Time Unit
Local environmental benefits (WI&BL)		*131.40*	
Global environmental benefits (WI)		*891.16*	

Still there are some uncertainties in impacts and benefit values, for example

- saved time is not always used for increased productivity or income generation,
- time saved for firewood collection could be needed to spend for additional water collection
- money saved from reduced firewood purchase or health expenditures could be needed to spend for additional water purchase
- fertilizer could have been never purchased before, so no real saving happens
- the Value of Saved Lives is generally difficult to determine
- households in need of cash money will not appreciate indirect benefits.

Investment in a biogas system does not directly generate income, but saves on household's expenditures and indirectly could generate improved livelihood through more convenience, increased food production, comfortable sanitation conditions, healthy and clean living environment, and time saving. Therefore NDBP is challenged to promote biogas systems not only for financial and economical reasons but should develop a promotion campaign which motivate investment for convenience and increased living standard like improved sanitation and fertiliser, more food, health, smokeless kitchen, cleanliness in house, toilet, stable and yard, and bright light after sunset.

5.6 First Biogas Applicants

In addition to the main questionnaire, the 101 surveyed households that have already applied for a biogas plant have been asked a number of additional questions. 83% of those applicants have come to know about the programme through either Heifer of LWF and have submitted their application through them to SNV. The following chart shows what expectations households are holding towards the biogas plant:

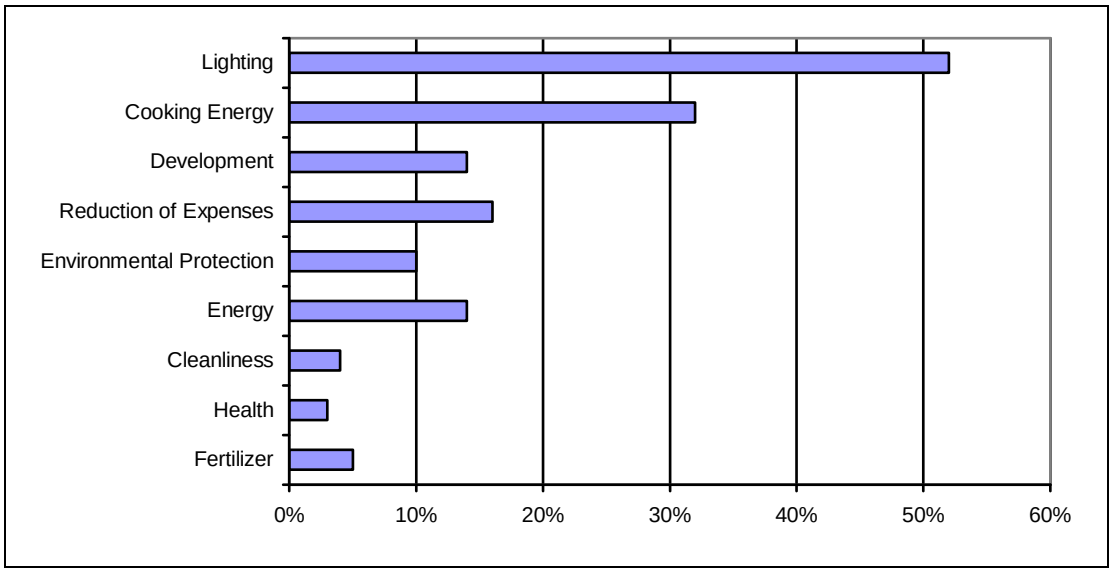


Chart 31: First Applicants' expectations towards biogas

It is very obvious that lighting is most household's first priority, even before cooking energy. It is therefore very important for the NDBP to provide gas lamps and satisfy these expectations.

79% of the interviewed households would recommend the installation of a biogas plant to others, and the ones being hesitant about doing so say, they cannot recommend it, because they do not have experience with the biogas themselves yet. The following chart shows that so far the neighbouring household's reactions were very positive.

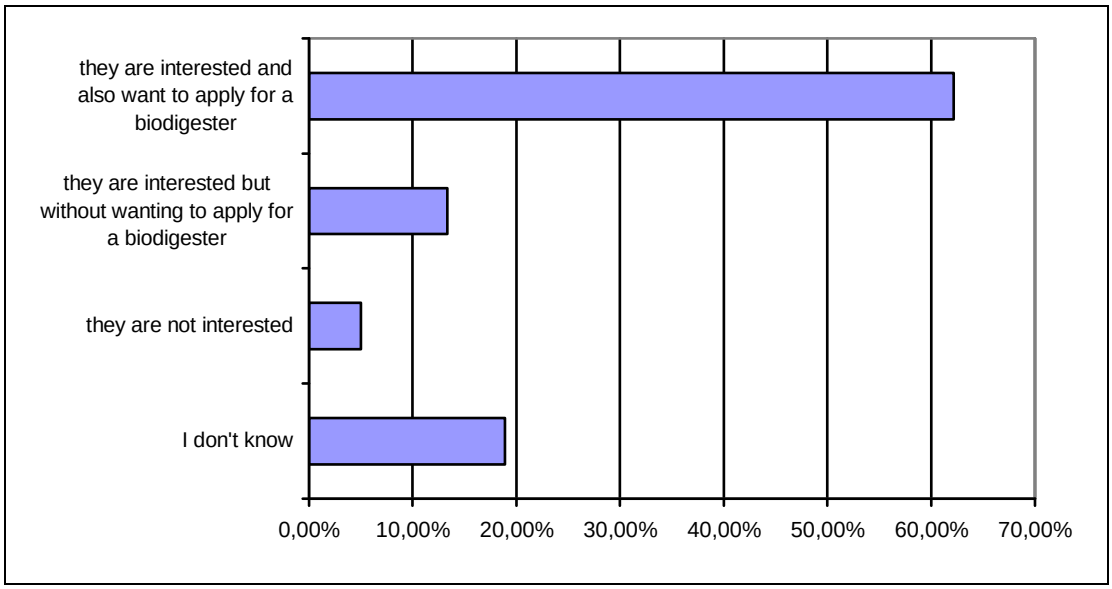


Chart 32: Neighbours' reaction to the NDBP

One of the central concerns for the implementation of the NDBP is the availability of cash for the initial investment. The following chart shows how the first applicant families are planning to finance their biogas digester[106]. It illustrated clearly how important a micro credit programme will be for the successful implementation of the NDBP. It also needs to be borne in mind that the first applicants' financial contribution towards their biogas plant is lower than it will be for future families: only building materials and unskilled labour needs to be provided for the first 100 biogas plants that are currently being build under the MININFRA programme which will be completed by end 2007.

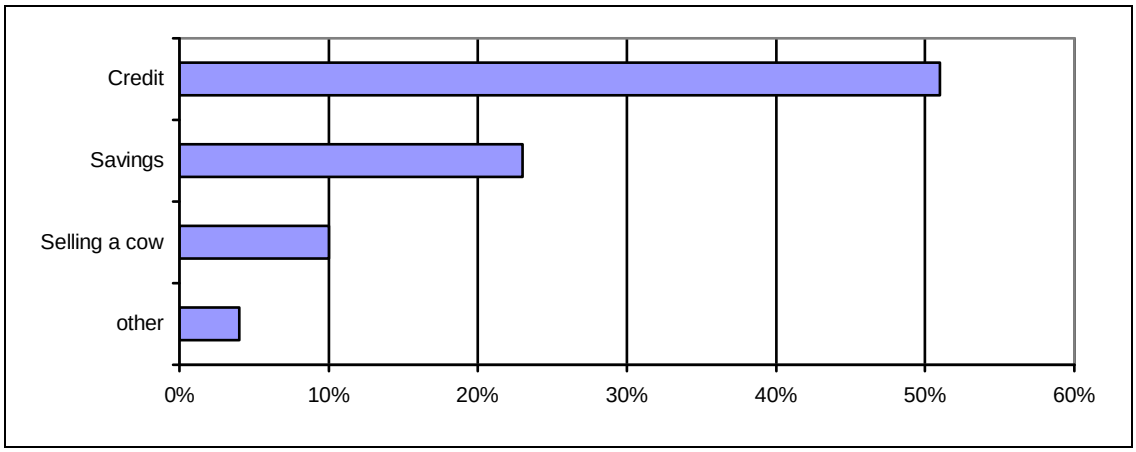


Chart 33: Ways to finance the biogas digester

[106] "Selling a cow" is only recommendable if the household owns more than the required cows for biogas production

6. Conclusions and Recommendations

As determined in the Terms of Reference, the findings of this Baseline Study will serve as data base for planning, monitoring and evaluation of the NDBP.

Lessons learned and challenges are presented and discussed in detail in Chapter 5.

6.1 Conclusions

The main conclusions are:

1. A reliable database on household energy demand includes mainly firewood consumption for cooking purposes and kerosene for lighting. For 67% of households targeted by NDBP, firewood is still available for free, whereas kerosene and any other energy source for lighting require expenditures.

2. To determine the level of the subsidy the Programme should grant to households to make biogas plants affordable for the relevant number of households depends on the households' economical situation, their ability and willingness to pay, and on NDBP's marketing strategy. According to the findings of the baseline survey 89% of the households are willing and able to invest in a biogas plant; in this group the ability is limited to 100,000 FRw (25%), 250,000FRw (15%) and 500,000FRw (20%). 84% are prepared to apply for a credit for biogas.

3. The results of the baseline data analysis as presented in this report show that the planned interventions are appropriate. In order to emphasize special aspects and complementary activities some details are addressed in the chapter below. The same applies to the analysis of criteria for the selection of regions which offer predominantly market opportunities for the NDBP.

4. The benchmark data for a future Impact Assessment of the NDBP are now accessible; these data need to be integrated into the M&E system.

5. A market-oriented approach starts from the recognition that being part of the low-income population does not eliminate commerce and market processes: virtually all poor and low-income households trade cash or labour to meet much of their basic needs. The low-income households are interested in the biogas market as long as they can benefit as consumers and producers.

6. The long-term financing strategy needs to be elaborated with professional support from micro finance and banking institutions: the household biogas plant is a new product in Rwanda, and new business models like rural and special trained construction enterprises are required to provide high quality products and services at affordable prices.

6.2 Recommendations on activities of the NDBP

Below are grouped together the main recommendations which have been discussed in more detail in the previous chapters. Many of the recommendations are already part of the project's implementation plan and are only repeated here to highlight their importance to the programme.

(1) A NDBP promotional campaign should focus on environmental and energy issues involving radio and television programmes as well as district authorities, cooperatives and community-based organizations. This campaign should present integrated biogas systems as modern, future oriented technology that can improve significantly the living standard of rural households, especially by providing fuel for lighting. This campaign should firstly be oriented to those districts that have been selected by NDBP as starting points.

(2) User training should be not only the task of constructors but should be developed also in cooperation with women groups, breeder unions, agricultural and veterinary extension technicians, schools and local NGOs. User training should integrate not only technical aspects for operation and maintenance, but also cooking techniques, slurry application and hygiene topics.

(3) A well developed credit and subsidy scheme is crucial for market penetration, as the majority of the potential NDBP clients belong to the low income segment of Rwanda's economy pyramid. Together with banks and micro finance institutions, which should be located near to the biogas plant owners, an affordable credit system should be developed and implemented. Additional benefits like improved toilets, improved stables, rain water harvesting facilities could be added to the credit conditions and included in the credit amount to demonstrate the integration of the biogas plant into the farming system, and to motivate farmers to invest.

    Subsidies should be transparent and clearly structured, in the best case they should be already included in the cost calculation of the biogas plant so that all clients know the net financial cost they have to pay for the different plant sizes.

(4) A quality oriented after-sales-service is crucial for satisfied clients and positive word-of-mouth-propaganda. Only if the biogas plant produces at the optimum clients will recommend the technology to their neighbours.

(5) The private enterprises which will be responsible for construction need to be trained, accompanied and supervised by biogas experts during at least 1 year or 10 plant constructions. Every 2nd year, the biogas constructors should participate in an update training; each construction has to be checked by a quality supervisor

and certified; only certified construction enterprises should be allowed to build biogas plants that are financed with credits and subsidies. The clients should benefit from a technical guarantee for operation.

(6) In order to accomplish 15.000 biogas plants which will contribute as planned to environmental protection, energy supply and food security in rural Rwanda, a well enforced quality control system has to be set up from the beginning of the construction activities. The first 100 biogas plants are already part of the promotion campaign and their quality in construction, operation and gas production is “under public control”.

(7) To achieve its objectives by carrying out a wide range of activities required for a successful biogas program it is recommended that NDBP make use of an indicator based monitoring system. As the programme objectives these indicators should derive from and focus on the sectors (i) energy, (ii) sanitation, (iii) health, (iv) environmental protection, (v) economy and income generation.

NDBP stakeholders should decide in which sector specific agricultural aspects are to be integrated: organic fertiliser use will play an important role for achieving food security.

6.3 Recommended alliances for accompanying activities

NDBP can advance faster in achieving its objectives if entering in strategic alliances with local development actors in the districts. Especially for promotion, training and accompanying improvements in the farms cooperation with partners from the following sectors are suggested:

- Cooperatives, in particular those that bring together dairy and livestock farmers
- NGOs like Heifer Project and Lutheran World Federation which have well developed training modules for farmers and a well established presence in the field
- Schools - secondary and technical schools in the first place
- Agricultural and veterinary services at districts and national level
- Health and sanitation services
- Agricultural research institutes such as ISAR
- Organisations promoting rain water harvesting
- Construction enterprises

- International biogas experts

This list is not exhaustive.

6.4 Selection criteria for areas with high implementation potential

In order to facilitate and maintain a successful market penetration, NDBP should continue to concentrate its activities in regions where

- zero-grazing stabling systems are largely practiced;
- manure application is common among the farm households;
- firewood is scarce or expensive;
- water is available at no or low cost;
- MFIs or banks are established
- NGOs or cooperatives offer training and extension services.

These indicators appear to be widely applicable in Rwanda; most reliable sources for the required information are to be obtained from the NISR, MINAGRI, MINITERE, MINISANTE, MININFRA, MINECOFIN and MINICOM, and concerned district authorities.