ALTERNATIVE ENERGY: BIO GAS PRODUCTION AND SUSTAINABLE USE

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 ISSN 1923-6654 (print)
ISSN 1923-6662 (online). Available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract : Uganda is facing an energy crisis. Its population of about 30 million people is increasing at an alarming rate of 3.4% per annum. The ever increasing population without matching financial prosperity is putting excessive strain on energy needs. Biomass (wood) is Uganda's main source of energy contributing about 92%of the total energy. The country's dependence on wood fuel is a source of great concern. Both gazetted and non gazetted forest resources are depleting rapidly due to very high demand for wood. There is a need to improve people's livelihood and to also explore other alternative energy sources to supplement the present commercial alternatives which are increasingly becoming very expensive and scarce. The idea of integrating modern pig farming and large scale biogas production will help reduce the gap in energy availability. Its production will reduce pressure on wood fuel, cut green house gas emissions, enhance people's incomes, increase employment generation, provide enriched manure and supplement the government's programme of rural electrification. The project will set up a demonstration farm with 7400 pigs giving 40 m^3 manure daily and this manure converted to approximately 2400m^3 gas. The gas will be used to generate 200kw power and 370 kw heat per day. The farm will keep both porkers for sale and sows for reproduction. Some of the piglets will be distributed to small scale farmers in rural areas who will be expected to rear them whilst the remaining ones kept on the farm to replace the porkers being sold off to slaughter houses. Over 40,000 piglets will be given out to rural farmers per year. For project economic sustainability, the surplus power (2,568Mwh per year) will be sold off to the public grid and income generated from both this power and the sold off porkers used to run the farm.

Keywords: Energy crisis, Biomass, Alternative energy source, Electricity, Bio-gas

I. INTRODUCTION

Uganda is a developing country which has continued to have energy shortages over the years. This has turned into an energy crisis. It has a population of about 30 million and the national population growth rate for the past decade is about 3.4% per annum. 87% of the total population live in rural whilst 13% live in the urban areas. The urban population growth rate currently stands at about 5.0% per annum whilst its 3.1% in rural areas per annum. The ever increasing population without matching financial prosperity is putting excessive strain on the energy needs. The energy shortages are severely affecting livelihood of the poor majority Ugandans and it largely contributes to their low standards of living.

Biomass constitutes 92% of Uganda's total energy and this is mainly wood. (Charcoal and firewood) Wood fuel through renewable is not a sustainable energy source since its rate of harvesting exceeds the growth rate.

The country's dependence on this energy source is increasingly becoming a source of great concern. Both gazatted and non gazetted forest sources are getting depleted due to very high pressure for wood for both industrial and house hold fuel.

Electricity from the national grid does not meet the national demand. This has resulted in load shedding during peak hours. Villages are severely affected since most of them have total in accessibility to electricity.

The other present commercial alternatives are non renewable and non local. In recent years, their prices have increased sharply and their availability is limited.

The country could improve its living standards by increasing its energy sources and establishing appropriate Industries. These would lead to employment generation and poverty alleviation which are key to rural development.

Uganda is an agricultural country endowed with tremendous potential for endless generation of Bio-derived energy. The idea of integrating modern pig farming and large scale Biogas production for co-generation is believed to have a big impact in addressing the above mentioned problems.

II. BACKGROUND TO THE PROJECT

2.1. Project Context

2.1.1 Uganda's energy consumption and sources

Uganda's total energy in 2002 was estimated to be 3.016×10^{17}Joules. The total energy consumption in the household sector was estimated at 2.44×10^{17}joules. Commercial energy namely, electricity, Kerosene and LPG contributed less than 2% to the total household energy consumption.

Biomass is Uganda's main source of energy contributing about 92% followed by petroleum products 5%, then hydro electricity 1-3% and lastly solar less than 0.2% (Ministry of energy and mineral development, 2008-2009).

Wood fuel (charcoal and firewood) contributes more than 90% of the total biomass energy. Firewood is mainly used in rural households while charcoal is a favorite fuel in Urban households. Charcoal is easier to store than firewood and also has a higher calorific value. However, the conversion efficiency by mass of firewood to charcoal using the present traditional kilns is just about 12%.

The electricity generation capacity does not meet the national demand. Electric consumption in the domestic sector in the last decade was estimated to have risen to 1.3×10^{15}joules and that 33% of the electric energy produced is lost through transmission and non technical losses like theft.

The use of LPG is about 2×10^{13}joules per annum while that of solar and biogas is negligible.

Most people in both rural and urban areas use kerosene for lighting.

Most agricultural industries in Uganda use biomass as their main source of energy. These include construction (for baking bricks and tiles), palm oil refineries, tobacco, tea, lime and fish processing industries.

2.1.2 Poverty level and its alleviation Strategy

Poverty is a big challenge is Uganda with about 31% of the population reported to be living on less than one US dollar per day. The gap between the rich and the poor is increasing day by day and its partly attributed to the growing levels of unemployment and poor service delivery to the people.

The majorities of Ugandans live in rural communities and cannot afford the scarce present commercial alternative sources of fuel whose prices have shot up in recent years.

Tackling the issue of unemployment, modernizing agriculture and increasing income generating activities are key to reducing poverty.

2.1.3 Agriculture Sector

The contribution of agriculture sector to GDP in 2008/2009 was estimated to be 32.3% at factor cost. The share of the sector in GDP has been declining consistently, partly due to its slower growth relative to other sectors and partly as a consequence of the process of structural transformation. Overall, the growth rate of agricultural output in 2008/2009 was estimated at 2.0% but still the sector was the second contributor to GDP after services and the largest contributor to rural employment and incomes. The slow rate of growth of the agriculture sector output was due to poor and erratic rains, poor soils that affected crop and livestock production, hence low productivity and reduced output. Other factors include low levels of technology, pests and diseases. Although the sector has experienced low growth rate, still it contributes 80% of employment and most industrial services in the country are dependent on it, hence its modernization is key to the economy.

2.1.4. The rural development strategy

The government of Uganda is trying to implement a sub county based RDS whose main objective is to enhance incomes of the people in rural areas with the households as the main target beneficiaries. It is expected that the households will utilize their available resources (Land, labour and capital) to produce more goods which they would sell and earn more income. A project aimed at creating conducive environment for these households to utilize their available resources well supplements the government's rural development strategy.

Integrating biogas production and modern pig farming will increase energy availability, lower poverty levels, increase agricultural output as well as enhancing rural development.

Biogas consists of about 2/3 methane, 1/3 carbon dioxide and a little hydrogen sulphide. It is produced through an anaerobic decomposition/ fermentation of manure and other forms of organic wastes by a complex bacteria culture. In order to optimize production,

the process must be stable with only gradual changes in the supply of organic material and temperature to ensure an optimal adaptation of the bacteria culture.
It is important to note that the biogas plant is a production facility similar to a stable system. The functionality can be guaranteed, but the production depends upon the operation, including the quantity of the feed.
Technology, Raw materials and operation & care are the three main factors to be put into account to successfully operate biogas plants.
Biogas production can be enhanced by having a feed of at least 90% manure and 10% fodder.

III. PROJECT

3.1 Description of the project

Biogas Energy for Poverty Reduction and Sustainable Development.

Uganda's failure to adopt biogas technology is partly attributed to its poor methods of farming and lack of vision for the potential of this bio-derived energy. The project is designed to demonstrate the potential of integrating modern pig farming and large scale biogas production.

3.1.1 A demonstration farm

This will be setup on 1500x1500m landscape in the southern part of Uganda particularly in Masaka district, Kabonera subcounty. The farm will employ about 60 people including administration, Veterinarians, Engineers, technicians, operators and Trainers. The farm will consist of the following major sections; Animal, Biogas, Manure, Technical and Administration sections.

3.1.2 The animal Section

This will consist of about 7,400pigs sheltered in proper stables. The stables will be constructed in such a way to have different stalls for separation of sows from porkers. There will be about 2000 sows and 5,400 porkers. About 40m^3 manure will be produced daily and will be cleaned from the pig shelters using hydraulic flashing units and pumped to the manure handling section.
The sows will produce over 48,000 piglets per year 40,000 of which will be given out to different small scale farmers per year, each receiving utmost 2 piglets. The porkers will be sold off to slaughter houses and replaced by the remaining piglets. Pigs that can produce 40 m^3 manure daily will be the only ones kept on the farm.

3.1.3 The biogas Section

The biogas plant will consist of 2 horizontal digesters 300 m^3 capacity each giving a total volume of 600 m^3, which corresponds to the capacity necessary to digest the daily production of 40m^3 manure. Each digester will therefore, receive 20 m^3 manure daily. The digester will be equipped with 2 slowly rotating horizontal agitators with low capacity motors of 1kw which will keep the manure mixed and homogeneous. The motors will work in interval operation; say 2 minutes ON and 10 minutes OFF. Except for the agitators and support, the digesters will be completely empty and smooth inside to allow no sedimentation and blocking of flow. In order to keep the digesters at the right process temperature, its external body surface will be covered with some heating channels containing hot water. The whole digesters will then be insulated with 100 mm mineral wool and finally covered with weather protected aluminium coated Steel Sheets. It will be inclined at 2^o in order to guide sedimentation to the lower end at the manure inlet and to guide biogas to the upper end at the manure outlet. Sand and other sediments will be taken out through 2 sand outlets under the digester. The gas will ascend through the gas dome at the top of the digester. Approximately 2400 m^3 gas/day will be produced.

3.1.4. Manure section

The manure will be taken from the stables to the manure pre-tank from where it will be pumped to the mixer tank at the digester. From the mixer tank, the manure will be pumped in sequence into the digester, for example 3-12 times per day. On pumping the manure into the digester, an equivalent volume will be displaced through the manure outlet by a simple overflow principle.

3.1.5 Technical section

This section will consist of a technical building in which the boiler, CHP and the other technical equipment will be installed. The control system and laboratory will also be in the building. The gas will ascend from the gas dome which will be in the upper top end of the digester. From the digester it will be led in to technical building where the gas produced will be metered and then led to the boiler, CHP and gas holder. The weight of the gas will create a counter pressure in the system, sufficient for operating the boiler and CHP without any additional energy equipment such as a compressor.

3.1.5.1 CHP Unit

A CHP with capacity 200kw will be installed and will have a complete control system including grid protection and grid connection. The engine will be of the dual fuel type. i.e. standard diesel engine modified to run on a combination of diesel and Biogas. 5% diesel creates the basis and ignition of the combustion. Biogas will be mixed with the inlet air to the engine and will increase the output power from 5% to 100% of normal capacity. The CHP will be equipped

with an automatic power regulator so as to maintain the chosen power output, even if the gas composition changes.

3.1.5.2 The boiler unit
The boiler will have capacity 50kw and will be equipped with a gas burner, which will utilize the surplus gas exceeding the consumption of the CHP and the whole gas production when the CHP is stopped for maintenance.

3.1.5.3 Heating system
The waterborne heating system will supply the biogas process with heat from the boiler or CHP. Excess heat will be pumped to any other necessary heating facility on the farm.

3.1.5.4 Laboratory equipment
The plant will also be equipped with instruments for measuring simple indicators used for the daily operation and optimization of the biogas process. For measuring the amounts of solids and volatile matter in the manure and the organic wastes, a scale, a kiln and a furnace will be used.

A pH meter will be used for measuring the pH value of the biogas process and the motor oil from the CHP. A gas sample pump will be used for measuring hydrogen sulphide and methane levels in the biogas.

3.1.5.5 Control and data acquisition system
A computer with extension for data acquisition and control of the system.

3.1.6 The estimated Biogas Production

The table below shows the estimated daily power production from the plant.

Limit	Consumption		Production	
	M^3 gas/hr	M^3gas/day	Heat, kw	Power ,kw
50 kw Boiler	8	192	50	-
200 kw CHP	92	2208	320	200
Total capacity	100	2,400	370	200

Table 3.1.6.1 production figures

As it appears in the above table, the daily production will be sufficient to run both the 50kw boiler and 200kw CHP unit continuously and the total power produced will be more than enough for the farm. Therefore the surplus will be sold to the main grid.

3.1.7 Effective annual power production figures.

Unit	Operation hours	Effective production kw		Animal production Mwh	
		Power	Heat	Power	Heat
50 kw boiler	8,760	-	50	-	438
200kwCHP	8,760	200	320	1,752	2,803
Total gross				1,752	3,241
Reduction for process power and heat	8,760	-3	-40	-26	-350
Reduction ignition oil 5%				-87	-162
Total net				1,639	2,729

Table: 3.1.7.1 Effective annual power production to be produced.

The estimated total annual production of power will be 4,368Mwh. The estimated annual power consumption of the farm is 1000Mwh of power and 800Mwh of heat giving a total 1800Mwh. Therefore, the surplus power of 2,568Mwh will be sold off.

3.2 objectives
Development objective
The overall development objective of the project is; "to contribute to improved livelihood of people in rural communities.

Main indicators:
Improved health, reduced deforestation, increase in enrolment of children in schools, reduced school dropouts, reduced domestic violence, improved housing structures, reduced crime levels and others.

The project objectives;
- Employment generation
- Increased incomes of small scale farmers.
- Reduction in deforestation
- Increased supply of organic / enriched manure
- Reduction in deforestation.
- Increased supply of electricity.

3.3 Expected outputs
- Reduction in unemployment levels.
- Reduction in un employment levels
- People's living standards improved
- Agricultural production and productivity increased.
- Carbon emissions reduced
- More industries established in rural areas.

Indicators:
- Reduction in the cost of agricultural produce due to increase in supply
- Increased demand for other domestic products.
- Reduction in green house gas effects.
- Reduction in hunger / famine cases.

3.4 activities

3.4.1 Project planning, back stopping, monitoring and evaluation:
i) Identify where the demonstration farm will be set up.
ii) Mobilize and sensitize on the project
iii) Conduct baseline study.
iv) Develop a monitoring system.
v) Identify , recruit and train service providers
vi) Train project staff in critical areas.
vii) Procure equipment.
viii) Construct / setup the farm
ix) Facilitate information sharing and publicity.
x) Supply piglets to farmers.
xi) Supply enriched manure.
xii) Train farmers in agro forestry, energy saving technologies.
xiii) Promote farm mechanization.
xiv) Organize study tours and exchange visits.
xv) Facilitate implementation and monitoring of all farm activities.
xvi) Audit the project
xvii) Evaluate the project

IV. PROJECT STRATEGY

The project will aim at setting up demonstration pig farm on which both sows and porkers will be reared. Porkers will be sold off to slaughter houses and income obtained used to run the farm.
Sows will be mainly kept for reproduction such that some of the piglets are given out for free to small scale farmer in rural area.
Obtained manure from the pig farm will be used for biogas production. The gas produced will then be used for co-generation. Some of the power produced will be consumed by the farm whilst the surplus sold off to the main grid. The income obtained will also be used to run the farm.
The government will be expected to replicate the project such that the idea covers all the rural areas in Uganda.

Approaches and methods
The project will involve many people from all levels including biogas experts as well as those experts in pig farming, local leaders and many others. Study seminars will be arranged such that many people from different communities are taught about the above project.
Documentation of production data and all other farm activities will be done and given out to the public. This will be done for the purpose of learning and replicating the project.

A - Reduction of unemployment levels
Reduction in unemployment levels will result from the following;
The project itself will employ quite a number of people ranging from engineers, chemists, veterinarians, accountant, supervisors, technicians, operators and many others.
The project will increases power supply which will attract agricultural industries which will in turn employ the people.
Increased agricultural productivity will also help in reducing unemployment. More people will be employed in agricultural sector right from harvesting to distribution of agricultural products.

B - Agricultural Production and productivity increased.
Increased agricultural production and productivity will result from a number of interrelated actions. These include, provision of enriched manure, mechanization and integration of environment management, including cutting green house gas emissions. Many farmers will be expected to go for commercial farming because it will be more profitable.

C - People's Living standards improved
Enhancing people's income automatically improves their living standards. Piglets will be given out free of charge to farmers who will rear them for reproduction. They will then sell off some and increase their incomes. Farmers will be given free consultation concerning pig farming and how best to make it profitable. Creation of employment will also enable many to earn more income.

D - Carbon emissions reduction
Reduction of carbon emission will result from reduced use of fossil fuels as well as reduced deforestation. Biogas is a renewable energy source and environmental friendly. Successful exploitation of this energy will increase energy availability. Less trees will be cut down so more carbon dioxide will be trapped and fossil fuel usage will be lowered.

E - **Industries established**
Increase in power supply in rural areas will attract more investors who will be willing to invest in agriculture. These investors will then set up more Agricultural industries.

V. ASSUMPTIONS

A number of assumptions have been made in the project and these include;

- That the project will not be interfered with by the Moslem minority.
- There will be functional rural roads and market infrastructure in place.
- There will be enough Biogas production for co-generation.
- Farmers will be willing to adopt modern agricultural technologies.

VI. IMPLEMENTATION

6.1 Project organization and Management.
For implementation, the project will be dived into two units. Animal unit and Biogas unit each of which is headed by the manager. These managers will be responsible to the General manager to whom they will give periodic reports and who in turn will report to the board. The responsibilities of managers will include planning and doing whatever is required to see that the resources in this project, both human and material are deployed in a way that will achieve the objectives.
In addition to the manager, the animal unit shall have 3 sections. i.e. veterinarians, Technical supervisors and pigs distribution. These sections will also have foremen for unskilled work.
For the case of Biogas unit, there will be 2 sections under the manager. I.e. Engineers and chemists who will ensure that the equipment is properly installed and other technical problems solved. These sections will also have technical operators who will be guided by the engineers and chemists on what to be done. For general administration and financial services, the project will have an administrative assistant, an accountant and drivers. These will serve the two units.

6.2 Means and inputs
The inputs for this project will include human resources consisting of staff, vehicles and motorcycles, office premises, computers, communication facilities, equipment for biogas production and installation, equipment and machinery for power production, management and infrastructure support to organization, pigs shelter equipment, tractor, staff salaries, management systems and others.
The government of Uganda is expected to fund a certain portion of these inputs and other funding will come from international bodies.
Some consultancy services will be secured locally while international technical experts will be looked for through international conferences and over the internet.

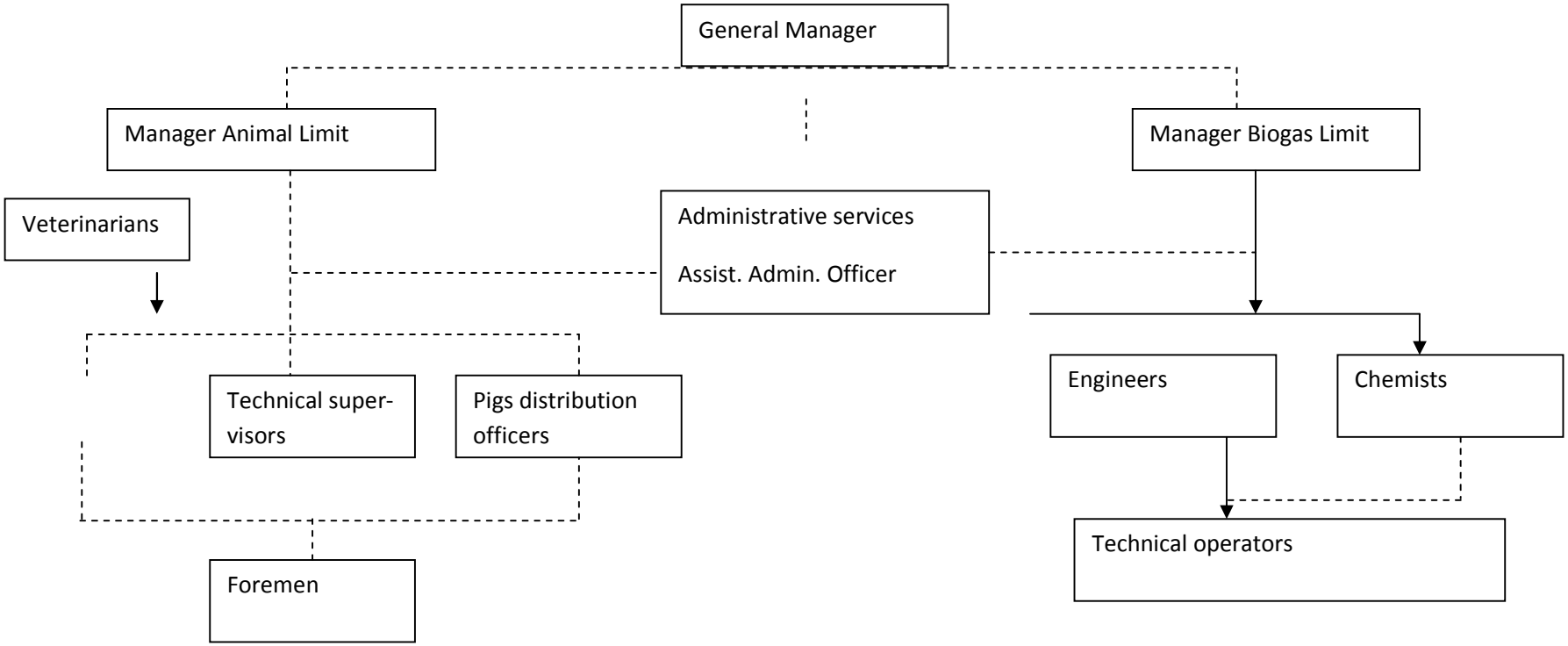
VII. PROJECT SUSTAINABILITY

The sustainability of the project will depend directly upon the success of its implementation as well as the actual power produced. This implies to both environmental and economic sustainability.

7.1 Economic sustainability
The estimated total annual production of power is 4,368Mwh and the estimated power consumption of the farm is 1,800Mwh. This shows that there will be surplus power which will be sold off and the income generated used to run the farm activities.
Also some of the porkers will be sold of daily and the income generated still be used to run the farm activities.
The project will also sell of its carbon credits.
There is a strong belief that this project will perfectly sustain itself economically.

7.2. Environmental Sustainability
The high content of volatile solids in the raw manure (Pig manure) will be converted to a more stable organic matter with a higher value of manure as a fertilizer. This will not only increase soil fertility, but will reduce ground water pollution.
There will be reduction in carbon dioxide equivalent obtained through 'biogas production for energy'**.** There will be reduced usage of fossil fuel as well as reduced wood burning.

Organizational chart for the implementation of BEPRSD



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IX. MONITORING AND EVALUATION

A baseline study will be one of the very first activities to be carried out in this project to provide benchmarks on the basis of which the progress of the project will be measured. Monitoring tools that capture both qualitative and quantitative data will be adopted to measure the impact of project interventions at all levels.

The information and data collected will provide inputs to periodic overall assessments or evaluations of the relevance, performance, efficiency and impact of the project. These events will be highly participatory.

External competence and experience will sometimes be called for during these evaluations, but the main input will come from the internal human resource base.

Meetings will be held regularly among all stakeholders to assess the progress of the project activities and review the methods being used in terms of appropriateness, cost effectiveness and replication.

9.0 DURATION OF THE PROJECT (TIME CHART)

BEPRSD CHART	**2011**				**2012**				**2013**				**2014**			
Programme management	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Identify where demonstration farm will be set up																
Mobilize and sensitize on the project																
Conduct baseline study																
Develop a monitoring system																
Identify, recruit and train service providers																
Train project staff in critical areas																
Procure equipment /machinery																
Construct /setup the farm																
Facilitate information sharing and publicity																
Supply piglets to farmers																
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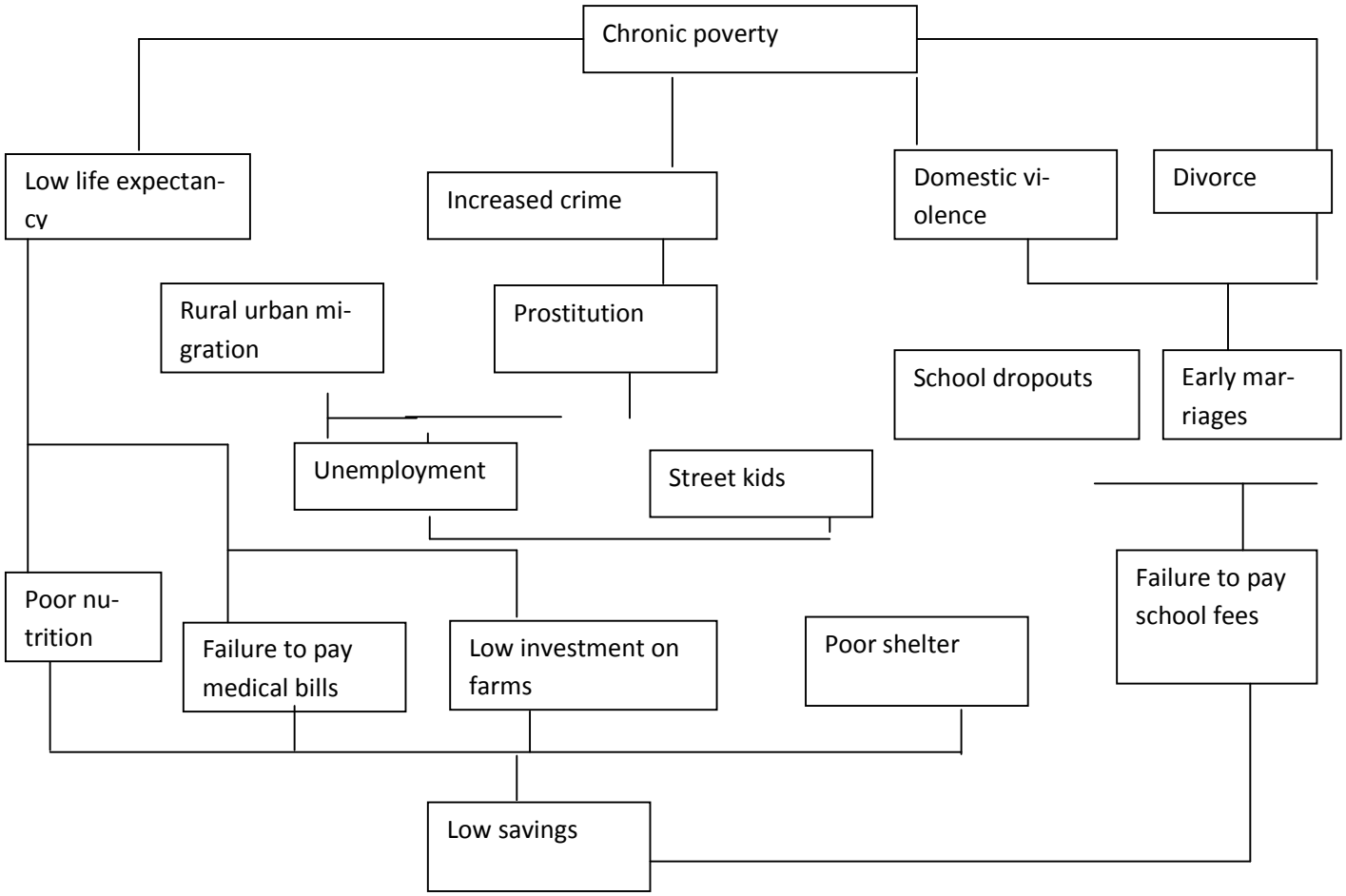
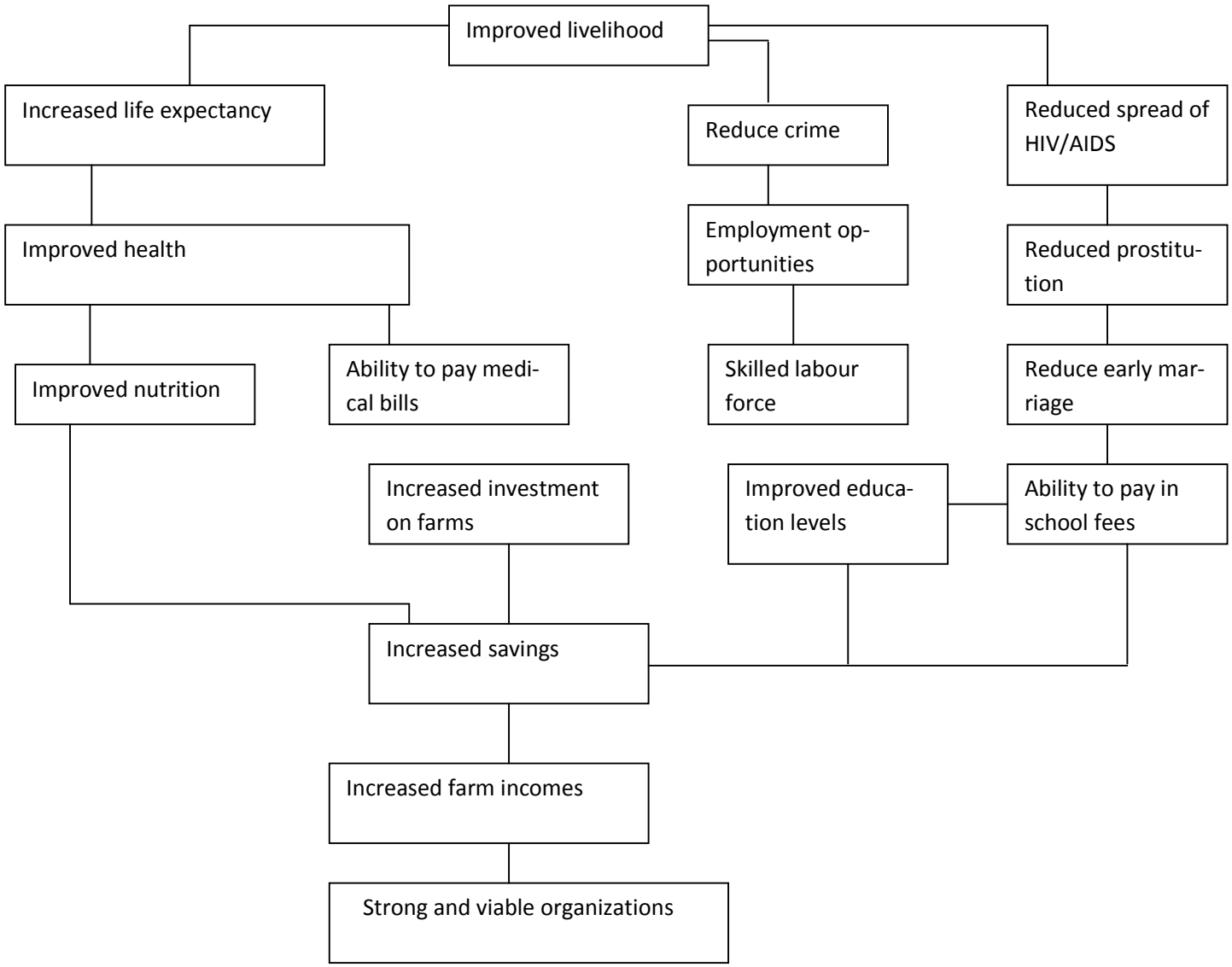
Train farmers in agro forestry, energy saving technology																
Promote farm mechanization																
Conduct study tours and exchange visits																
Facilitate implementation and monitoring of all farm activity																
Audit the project																
Evaluate the project																

ANNEX A: PROBLEM TREE



ANNEX B: OBJECTIVE TREE



ABBREVIATIONS

BEPRSD – Biogas Energy for Poverty Reduction and Sustainable Development
CHP – Combined Heat and Power Unit
GDP- Gross Domestic Product
RDS- Rural Development Strategy

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